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ABSTRACT BOOK

ROME 1-4 JULY, 2013

SAPIENZA
UNIVERSITÀ DI ROMA

TECHNICAL SESSIONS

Monday, 8:30-10:00

■ MA-02

Monday, 8:30-10:00
O1-2

Discrete Optimal Control, Multi-objective Control of Discrete Processes and Dynamic Positional Games

Stream: Discrete Optimal Control
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Vladimir Zubov*, Mechanics of continuum media, Institution of Russian Academy of Sciences Dorodnicyn Computing Centre of RAS, Vavilova 40, 119333, Moscow, Russian Federation, zubov@ccas.ru

1 - Application of OR to the Control of Metal Crystallization Process in Casting
Alla Albu, Applied Optimization Problems, Institution of Russian Academy of Sciences Dorodnicyn Computing Centre of RAS, Vavilova 40, 119333, Moscow, Russian Federation, alla.albu@mail.ru, *Vladimir Zubov*

The process of metal crystallization in casting is considered. To obtain a model of a good quality it is desirable the shape of solidification front to be close to a plane and its law of motion to be close to a preset one. To find a regime of metal solidification that will satisfy the technological requirements the optimal control problem is posed. The speed at which the mold moves is used as the control. The optimal control problem was solved numerically using gradient methods. This work was supported by RFBR N12-01-00572-a and by the Program for Fundamental Research of Presidium of RAS P18.

2 - Determining the solutions for dynamic pozitional games with informational extended strategies.
Boris Hancu, Faculty of Mathematics and Informatics, Moldova State University, Mateevici str., 60, MD-2009, Chisinau, Moldova, Moldova, Republic Of, boris.hancu@gmail.com

We study the non informational extended games which are generated by the two directional flow informational extended strategies of the players. The theorem about the existence of the Nash equilibrium profiles in this type of the games is proved. The static game with informational extended strategies can be treated as a dynamic game with incomplete information and non informational extended strategies, where nature makes the first move, but not everyone observes nature's move. A parallel algorithm for determining the optimal strategies in this dynamic game is elaborated

3 - Investigation of the Fast Automatic Differentiation Technique
Vladimir Zubov, Mechanics of continuum media, Institution of Russian Academy of Sciences Dorodnicyn Computing Centre of RAS, Vavilova 40, 119333, Moscow, Russian Federation, zubov@ccas.ru, *Alla Albu*

The generalized FAD-methodology allows to obtain the precise value of the functional gradient. However, the discrete conjugate problem may not approximate the continuous conjugate problem, thus the discrete gradient wouldn't approximate the gradient of the continuous problem. The consequence of this can be a convergence to a discrete optimal control, which doesn't approximate the continuous optimal control. It is proposed to use approximations of the cost functional and differential constraints that will allow to avoid this problem. The work was supported by RFBR N12-01-00572-a.

■ MA-03

Monday, 8:30-10:00
O1-3

Managing service systems

Stream: MSOM Service Management SIG Stream
Invited session

Chair: *Jan Van Mieghem*, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Jacobs Center, 5th Floor, 60208, Evanston, IL, United States, vanmieghem@kellogg.northwestern.edu

1 - Server Scheduling in Large Overloaded Queueing Systems with Impatient Customers
Nahum Shimkin, Electrical Enginnering, Technion, Israel, shimkin@ee.technion.ac.il

We consider an overloaded multi-class queueing system with multiple homogeneous servers and impatient customers. Customers of different classes are assigned to servers with the goal of minimizing the waiting and reneging costs. For the case of exponential patience and linear waiting costs, a certain index rule (the c-mu/theta rule) is optimal in an asymptotic, fluid-limit sense. In this talk we provide several extensions of the asymptotic model, that include non-linear waiting costs, general waiting distributions, and constraints on the waiting times in the different queues.

2 - Does the Past Predict the Future? The Case of Delay Announcements in Service Systems
Rouba Ibrahim, University College London, WC1E 6BT, London, United Kingdom, rouba.ibrahim@ucl.ac.uk, *Mor Armony*, *Achal Bassamboo*

We investigate ways of making delay announcements in large service systems, such as call centers. We consider announcing the delay of the last customer to enter service (LES) to delayed customers, upon arrival. Customers typically respond to delay announcements by becoming more or less patient, and their response alters system performance. We explicitly model announcement-dependent customer behavior. We study the accuracy of the LES announcement in single-class multi-server Markovian queueing models with customer abandonment. We supplement our results with simulation.

3 - Speed Quality Trade-offs in a Dynamic Model
Vasiliki Kostami, Management Science & Operations, London Business School, Regent's Park, NW1 4SA, London, United Kingdom, vkostami@london.edu, *Sampath Rajagopalan*

An important trade-off organizations face is one between quality and speed. Working faster may result in greater output and less delay but may result in lower quality and dissatisfied customers. In this work, we consider dynamic models in a monopoly setting to explore the optimal balance among the multiple dimensions of speed, price and wait time. The impact of quality is captured via the market demand potential which is a function of quality. We obtain several noteworthy results under three scenarios: When only one feature can be changed and when both can be changed.

4 - Collaboration in Service Networks: Architectures and Throughput
Jan Van Mieghem, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Jacobs Center, 5th Floor, 60208, Evanston, IL, United States, vanmieghem@kellogg.northwestern.edu

Motivated by the trend towards collaboration, we study processing networks where some activities require the simultaneous collaboration of multiple human resources. Collaboration introduces resource synchronization requirements that are not captured in the standard procedure to identify bottlenecks and theoretical capacity. We introduce the notions of collaboration architecture and unavoidable idleness, due to which the theoretical capacity exceeds the maximal achievable throughput or actual capacity. We identify a special class of collaboration architectures that have no unavoidable idleness.

■ MA-04

Monday, 8:30-10:00
O4-4

Complementarity Problems and Variational Inequalities 1

Stream: Mathematical Programming
Invited session

Chair: *Goran Lesaja*, Mathematical Sciences, Georgia Southern University, 203 Georgia Ave., 30460-8093, Statesboro, Georgia, United States, goran@georgiasouthern.edu

1 - Interior point methods for sufficient LCP in a wide neighborhood of the central path
Florian Potra, Mathematics & Statistics, University of Maryland, MD 21250 , Baltimore, United States, potra@umbc.edu

We present three interior-point methods for solving sufficient horizontal linear complementarity problems using the wide neighborhood of Ai and Zhang. The algorithms do not depend on the handicap of the problem. They are superlinearly convergent and have optimal complexity. The first method is Q-quadratically convergent for problem that have a strict complementarity solution. The second order method is Q-superlinearly convergent with Q order 1.5 for general problems, and with Q order 3 for problems that have a strict complementarity solution.

2 - Full NT-Step Faesible Interior-Point Method for the Cartesian P(kappa)-Linear Complementarity Problem over Symmetric Cones
Goran Lesaja, Mathematical Sciences, Georgia Southern University, 203 Georgia Ave., 30460-8093, Statesboro, Georgia, United States, goran@georgiasouthern.edu

A feasible interior-point method (IPM) for the Cartesian P(kappa)-linear complementarity problem over symmetric cones (SCLCP) is presented. The method uses Nesterov-Todd (NT) search directions and full step updates of iterates. With appropriate choice of parameters the algorithm generates a sequence of iterates in the small neighborhood of the central path which implies global convergence of the method and local quadratic convergence of iterates. The iteration complexity of the method matches the currently best known iteration bound for IPMs solving P(kappa)-SCLCP.

3 - Convergence of stochastic average approximations for a class of stochastic optimization problems
Bogdan Gavrea, Faculty of Automation and Computer Science, Department of Mathematics, Technical University of Cluj-Napoca, 15 Constantin Daicoviciu Street, 400020, Cluj - Napoca, Romania, Bogdan.GAVREA@math.utcluj.ro

We present convergence results of sample average approximations to stochastic optimization problems with mixed expectation and per-scenario constraints. The convergence results are obtained by performing a sensitivity analysis for a mixed nonlinear equations-variational inequality problem. This is a joint work with Mihai Anitescu (ANL). Acknowledgment: The work of B. Gavrea was supported by the Sectoral Operational Program Human Resources Development 2007-2013 of the Romanian Ministry of Labor, Family and Social Protection under the Financial Agreement POSDRU/89/1.5/S/62557.

■ MA-05

Monday, 8:30-10:00
O4-1

Dynamic Programming I

Stream: Dynamic Programming
Invited session

Chair: *Lidija Zadnik Stirn*, Biotechnical Faculty, University of Ljubljana, Vecna pot 83, 1000, Ljubljana, Slovenia, lidija.zadnik@bf.uni-lj.si

1 - Multiobjective and dynamic programming procedure for group decision making in resource management
Lidija Zadnik Stirn, Biotechnical Faculty, University of Ljubljana, Vecna pot 83, 1000, Ljubljana, Slovenia, lidija.zadnik@bf.uni-lj.si

Resource management problems are characterized by multiple and non-commensurable objectives over a long time horizon, by uncertainty and participation of different stakeholders and interest groups. Hence, issues related to compromise, negotiation and conflict are central to this dynamic decision process. This paper describes the procedure in which group AHP method is integrated in a discrete dynamic programming system. A new method for aggregating individual judgments is proposed and a theorem about acceptable consistency is proved. A numerical example is used to illustrate the procedure.

2 - Stochastic Dual Dynamic Programming and CVaR Applied to Long Term Energy Operation Planning
Andre Marcato, Electrical Engineering Department, UFJF, CAMPUS UFJF - Faculdade de Engenharia, Sala 206 - PPEE, 36036-900, Juiz de Fora, MG, Brazil, andre.marcato@ufjf.edu.br, *Rafael Brandi*, *Reinaldo Souza*, *Bruno Dias*, *Tales Ramos*, *Ivo Chaves Silva Junior*

This paper presents the use of CVaR (Conditional Value at Risk) together with Stochastic Dual Dynamic Programming for calculation of hydrothermal dispatch on long term horizon. The Brazilian data base comprising all hydro-thermal system was used for to validate both the CVaR as the risk aversion curve (CAR) methodologies. The CAR methodology has been used for many years in the Brazilian energy operation planning. It will be shown that using the CVaR is more appropriate for this problem getting operational scenarios safer.

3 - A Novel Dynamic Programming Approach for Solving the Container Pre-Marshaling Problem
Matthias Prandtstetter, Mobility Department, Dynamic Transportation Systems, AIT Austrian Institute of Technology GmbH, Giefinggasse 2, 1210, Vienna, Austria, matthias.prandtstetter@ait.ac.at

The Pre-Marshaling Problem (PMP) arises in container terminals where the goal is to find an operation plan with as few container movements as possible for pre-ordering containers according to specified priorities such that containers with higher priorities are not blocked by containers with lower ones. We propose a new dynamic programming approach for solving the PMP. Computational experiments emphasize that this is the first exact approach being capable of solving (almost) all benchmark instances of real-world size available in literature to proven optimality within only a few milliseconds.

■ MA-06

Monday, 8:30-10:00
O4-2

Recent Advances in Global Optimization 1

Stream: Global Optimization
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id
Chair: *Elise del Rosario*, OSSFFI, 14A CyberOne Bldg., Eastwood, Libis, 1110, Quezon City, Metro Manila, Philippines, elise.del.rosario@stepforward.ph
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Direct search approach for solving non-convex mixed-integer non linear programming problems
Hardi Tambunan, Mathematics, Quality University, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, harditambunan29@yahoo.com, *Herman Mawengkang*

The mixed integer nonlinear programming problem addressed in this paper has a structure characterized by a subset of variables restricted to assume discrete values, which are linear and separable from the continuous variables. The basic idea is to use a strategy of releasing nonbasic variables from their bounds found in the optimal continuous solution in such a way to force the appropriate non-integer basic variables to move to their neighbourhood integer points. Some computational experience are presented.

2 - Stochastic programming model for Land use management problems
Siti Rusdiana, Mathematics, University of Syiah Kuala, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, srusdiana10@yahoo.com

Land is used to meet a multiplicity and variety of human needs and to serve numerous, diverse purposes. Our study is focused finding an optimal land/resources portfolio composition through time, in the presence of future market uncertainty. In this paper we formulate a scenario-based stochastic integer programming model, which takes into account the uncertainty related to the market value of revenues accruing from the land in different states In order to take into account the non-constant incremental benefits accruing from different land allocations.

3 - Sampling and integer programming approach for solving water distribution network with reliability consideration
Asrin Lubis, Mathematics, Unimed/Graduate School of Mathematics, University of Sumatera Utara, FMIPA USU, 20155, Medan, Sumatra Utara, Indonesia, lubis.asrin@yahoo.com

We propose a nonlinear stochastic optimization model for tackling a WDN under the consideration of reliability in water flows. The nonlinearities arise through pressure drop equation. We adopt sampling and integer programming based approch for solving the model. A direct search algorithm is used to solve the integer part.

4 - Scrambling index of a class of 2-digraphs
Mulyono Mulyono, Mathematics, University Negeri Medan/Grad. School of Math. USU, Fmipa usu, 20155, Medan, Indonesia, mulyonomulyono162@yahoo.com, *Saib Suwilo*

A 2-digraph D is a digraph in which each of its arcs is colored by red or blue. The srambling index of 2-digraph D, denoted k(D), is the smallest positive integer s+t over all nonnegative integers s and t such that for each pair of vertices u and v in D there is a vertex w with the property that there is walks from u to w and from v to w consisting of s red arcs and t blue arcs. We discuss the scrambling index for 2-digraph consisting of two cycles whose lengths differ by 1.

■ MA-07

Monday, 8:30-10:00
O4-3

Vector and Set-Valued Optimization I

Stream: Vector and Set-Valued Optimization
Invited session

Chair: *César Gutiérrez*, Departamento de Matemática Aplicada, Universidad de Valladolid, E.T.S.I. Informática, C°. Cementerio s/n, Campus Miguel Delibes, 47011, Valladolid, Spain, cesargv@mat.uva.es
Chair: *Vicente Novo*, Matematica Aplicada, Universidad Nacional de Educacion a Distancia, Juan del Rosal no. 12, 28040, Madrid, Spain, vnovo@ind.uned.es

1 - Generating epsilon-optimal solutions in multiobjective optimization by genetic algorithm
Marcin Studniarski, Faculty of Mathematics and Computer Science, University of Lodz, ul. S. Banacha 22, 90-238, Lodz, Poland, marstud@math.uni.lodz.pl, *El-Desouky Rahmo*

In [1], some stopping criterion for a genetic algorithm was established, which enables one to find, with a prescribed probability, all minimal solutions in a finite multiobjective optimization problem. In this paper, we show how to apply the above-mentioned result to generate epsilon-optimal solutions to some continuous multiobjective optimization problem.

[1] M. Studniarski, Finding all minimal elements of a finite partially ordered set by genetic algorithm with a prescribed probability, Numerical Algebra, Control and Optimization 1 (2011), 389-398.

2 - Coercivity, stability, and well-posedness in multiobjective optimization
Ruben Lopez, Departamento de Matematica y Fisica Aplicadas (DMFA), Universidad Catolica de la Santisima Concepcion, Alonso Ribera 2850, 409-0541, Concepcion, VIII Region, Chile, rlopez@ucsc.cl

In this talk we show how the notions of coercivity, stability, and well-posedness are related in multiobjective optimization theory. To do this, we employ a recent notion of variational convergence for vector-valued functions.

* This work has been supported by Proyecto FONDECYT 1100919 through CONICYT-Chile.

3 - Approximate proper solutions of vector optimization problems. Properties and limit behaviour
Lidia Huerga, Applied Mathematics, UNED, C/Juan del Rosal, 12, 28040, Madrid, Spain, lhuerga@bec.uned.es, *César Gutiérrez*, *Bienvenido Jiménez*, *Vicente Novo*

We present a new notion of approximate proper solution for a constrained vector optimization problem on a locally convex topological vector space. We study the properties of this type of approximate proper solutions when the error is fixed and also when it tends to zero. In particular, we show that these solutions are useful in order to obtain outer approximations of the efficient set without considering convexity assumptions.

4 - A new concept of solution in vector optimization defined via improvement sets
César Gutiérrez, Departamento de Matemática Aplicada, Universidad de Valladolid, E.T.S.I. Informática, C°. Cementerio s/n, Campus Miguel Delibes, 47011, Valladolid, Spain, cesargv@mat.uva.es, *Bienvenido Jiménez*, *Vicente Novo*

In this talk we introduce a new notion of solution for vector optimization problems based on improvement sets. This notion generalizes the most usual concepts of non-dominated solution for this kind of optimization problems. We characterize these solutions by scalarization in convex and non-convex problems. In the first case, the results are obtained by assuming generalized convexity assumptions, and in the second one, they are consequence of characterizing the improvement sets as sublevel sets of nonlinear mappings.

■ MA-11

Monday, 8:30-10:00
G5-3

System Dynamics Modelling and Simulation Session 1

Stream: System Dynamics Modeling and Simulation
Invited session

Chair: *Rogelio Oliva*, Mays Business School, 301C Wehner - 4217 TAMU, 77843-4217, College Station, Texas, United States, roliva@tamu.edu

1 - Modeling bounded rationality: analysis of the consumer choice in the adoption of alternative fuel vehicles
Laura Ardila, Computer and Decision Science Department, Universidad Nacional de Colombia, Carrera 80 No 65-223, Medellín, Antioquia, Colombia, laardilaf@unal.edu.co, *Carlos Jaime Franco*

This paper presents an approximation to the modeling of bounded rationality (BR) in the adoption of alternative-fuel vehicles in the Colombian Market. In order to do this, a simulation model was built. From the results is possible analyze the importance of including BR in the modeling process. The formulated model using BR explains adequately the behavior within the system; the model allows a better comprehension of the consumer decisions, and helps with strategy's construction. The model can be adapted for other economies with similar characteristics to the Colombian market.

2 - Analysis of the mechanism Reliability Charge in the Colombian electricity market: a system dynamic approach
Estefany Garcés Arango, Ciencias de la computación y la decisión, Universidad Nacional de Colombia, Colombia, egarces@unal.edu.co, *Carlos Jaime Franco*, *Isaac Dyner Rezonzew*

One of the main problems facing liberalized electricity markets is to establish how the generators must be paid to guarantee the investments in new capacity and to ensure the system reliability. Therefore, the market regulator has decided to implement a security mechanism called Reliability Charge. The results of this new regulation are not obvious, because Colombia has a high dependence on hydro-electric plants. In this paper, we explain a System Dynamic model build for analyzing the effects involving the implementation of this Reliability Charge in the Colombian electricity market.

3 - Three strategic views of organizations. Implications for their dynamics.
Bent Erik Bakken, Norwegian Defence University College, St. Georgs vei 4, 0280 OSLO, 0280 OSLO, Norway, Oslo, Norway, beerikba@online.no

A common strategic view of organizations as value chains has been challenged by two complementary value configuration views; value shops and value networks. This paper discusses where each perspective adds value, and the advantages and disadvantages of allowing 1, 2 or 3 configurations to be used in parallel. One system dynamics model portraying each of the three perspectives are provided for a defence organization. Reference modes and sensitivity analysis are provided for each value configuration, and implications for organizational design discussed.

4 - Structural dominance in large and stochastic system dynamics models
Rogelio Oliva, Mays Business School, 301C Wehner - 4217 TAMU, 77843-4217, College Station, Texas, United States, roliva@tamu.edu

Duggan and Oliva (2013) report a significant effort to develop methods for identifying structural dominance in system dynamics models. To date, however, the testing of these methods has been in small (less than 10 stocks) deterministic models that show smooth transitions. While the analysis of simple models is necessary step for proof of concept, the methods have become stable enough to be tested in a wider domain. In this paper we report the findings from expanding the application these methods in two dimensions: increasing model size and incorporating stochastic variance in model variables.

■ MA-12

Monday, 8:30-10:00
G5-4

Facility location

Stream: Transportation and Logistics
Invited session

Chair: *Bernard Gendron*, DIRO/CIRRELT, Université de Montréal, C.P. 6128, succ. Centre-ville, H3C 3J7, Montréal, Québec, Canada, gendron@iro.umontreal.ca

1 - Dynamic Facility Location with Generalized Modular Capacities
Sanjay Dominik Jena, CIRRELT, Université de Montréal, Canada, sanjay.jena@cirrelt.ca, *Bernard Gendron*, *Jean-François Cordeau*

We introduce a facility location problem with multiple time periods and multiple capacity levels, where the costs for capacity changes are based on a cost matrix. A strong mixed integer programming model is presented that unifies several existing problems found in the literature. We apply our model to three special cases. Computational experiments show that our model can obtain optimal solutions in shorter computing times than the existing specialized formulations. Furthermore, we present a Lagrangean Relaxation heuristic to find good quality solutions in even shorter computation times.

2 - A primal heuristic and a Lagrangian relaxation for an industrial two-echelon location-distribution problem
Paul-Virak Khuong, DIRO/CIRRELT, Université de Montréal, H3C 3J7, Montreal, Canada, pvk@pvk.ca, *Bernard Gendron*

We describe practical methods to solve an industrial location-distribution problem approximately, with solution quality estimates. The problem pertains to the operation of an adaptive multi-echelon distribution system: intermediate locations consolidate flows, and are adjusted in response to changes in demand. A MIP formulation captures the problem's complex costs, but is very large. We present a multilayer variable neighbourhood search and a Lagrangian decomposition method for the same model: the former quickly yields feasible solutions, while the latter proves their quality.

3 - Lagrangian Relaxation Approaches for Multicommodity Uncapacitated Network Design
Enrico Gorgone, DIMES - Dipartimento di Ingegneria Informatica Modellistica Elettronica e Sistemistica, Università della Calabria, Via Bucci, CUBO 41c, VI piano, 87036, Rende, Cosenza, Italy, egorgone@deis.unical.it, *Antonio Frangioni*, *Bernard Gendron*

We present several algorithms for solving the multicommodity uncapacitated network design problem. We report the results obtained by using different Lagrangian relaxation approaches, a classical specialized dual-ascent method and combinations of these algorithms. We solve the Lagrangian duals by using different variants of non differentiable optimization approaches like (incremental, deflected, projected) subgradient-type methods and (disaggregated, generalized) bundle type methods.

4 - The Impact of Filtering in a Branch-and-Cut Algorithm for Multicommodity Capacitated Network Design
Bernard Gendron, DIRO/CIRRELT, Université de Montréal, C.P. 6128, succ. Centre-ville, H3C 3J7, Montréal, Québec, Canada, gendron@iro.umontreal.ca, *Mervat Chouman*, *Teodor Gabriel Crainic*

We study the impact of different filtering methods embedded into a specialized branch-and-cut algorithm for the multicommodity capacitated network design problem. Contrary to the preprocessing techniques used in state-of-the-art MIP solvers, these filtering methods exploit the structure of the problem, while being applicable to a very large class of network design problems. Three types of filtring methods are developed: preprocessing and postprocessing at each node of the tree, as well as domination rules among different nodes of the tree. Computational results will be presented.

■ MA-13

Monday, 8:30-10:00
G5-5

Facility Logistics and Order-Picking in a Warehouse

Stream: Facility Logistics
Invited session

Chair: *Pierre Baptiste*, de mathématiques et de Génie Industriel, École Polytechnique de Montréal, CP. 6079, succ. centre-ville,, H3C 3A7, Montréal, Québec, Canada, pbaptiste@polymtl.ca

1 - Ergo-picking: multi-objective approach to consider ergonomics aspects in picking systems design and management

Fabio Sgarbossa, Department of Management and Engineering (DTG), Univerity of Padova, 36100, Vicenza, Italy, fabio.sgarbossa@unipd.it, *Daria Battini*, *Alessandro Persona*

One of the most time consuming activities in the logistics, with important energy expenditure, is picking. Traditional optimization approaches considers only time variables. In this paper an innovative multi-objective model has been developed to design picking systems considering also the ergonomics aspect, defined by energy expenditure, based on main features of these systems, such as: location, characteristics of the piece and handling systems. Several real case studies have allowed the validation using an innovative motion capture system with an integrated ergonomic evaluation tool.

2 - A multi period order picking approach to a multi stage logistic system

Rifat Gürcan Özdemir, Industrial Engineering Department, Istanbul Kültür University, Atakoy Campus, Atakoy-Bakirkoy, 34156, Istanbul, Turkey, rg.ozdemir@iku.edu.tr, *Ezgi Nilay Uzun*, *Nihan Topuk*

In this paper, a multi period order picking approach to a multi stage logistic system is developed and aimed to determine optimal order picking strategy. The logistic system involves three components as follows: A plant that sends items to the warehouse in which orders are picked and shipped to the customers. The most critical issue for the entire system is planning order picking process in the warehouse efficiently. For this purpose, a mathematical model is developed for minimizing number of pickers subject to lumpy orders received from customers, and dynamic shelf capacities.

3 - Integrated Batching and Routing in Warehouses with Orders and Returns

Susanne Wruck, Distribution and Supply Chain Logistics, VU University Amsterdam, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, s.wruck@vu.nl

We present an iterated local search approach for the simultaneous optimization of order batching and order picker routing in warehouses. Thereby we incorporate deadlines of customer orders and schedule a working shift for multiple order pickers simultaneously. Furthermore, we incorporate the restoring of potential product returns during the picking tours. We demonstrate that significant cost savings can be achieved by the integration of order and return processing and that joint batch and route optimization can lead to better order picking performance.

4 - Multiple doors cross docks scheduling

Pierre Baptiste, de mathématiques et de Génie Industriel, École Polytechnique de Montréal, CP. 6079, succ. centre-ville,, H3C 3A7, Montréal, Québec, Canada, pbaptiste@polymtl.ca, *Mohammad yousef Maknoon*

Material handling inside cross dock plays a critical role. To have efficient handling plan, transferring decisions should be simultaneously considered with the trucks processing order, incoming and outgoing.We present a mathematical model of the material handling in a cross dock with multiple doors (optimal solution up to 6 doors, 20 trucks with Cplex) and an heuristic for bigger size problems. Numerical results depict the stability of this heuristic and compare both approaches. Finally, we investigate various loading scenarios and provide some recommendations on material handling decisions.

■ MA-14

Monday, 8:30-10:00
G5-6

Metaheuristics

Stream: Metaheuristics
Invited session

Chair: *Alok Choudhary*, Management School, University of Sheffield, IWP Building, Mushroom Lane, S10 2TN, Sheffield, United Kingdom, a.choudhary@sheffield.ac.uk

1 - GRASP and Path Relinking based on structured solution clustering

Arne Løkketangen, Molde University College, Britveien 2, 6411, Molde, Norway, arne.lokketangen@himolde.no, *Jianyong Jin*

Solution clustering based on structural similarity is a novel way to partition elite solutions found during a search. The structural information captured provides superior guidance for later intensification phases. We explore different structurally based solution distance measures, as well as novel variants of GRASP and Path Relinking based on utilizing information from structured solution clustering. Both in-cluster and between-cluster guidance is investigated. The methods are tested on large benchmark VRPs from the literature.

2 - Optimization of microchannels for liquid cooling of electronic chips

Tuba Okutucu, Mechanical Engineering, Middle East Technical University, Makina Mühendisliği Bölümü, A-143, ODTU, 06800, Ankara, Turkey, okutucu@metu.edu.tr, *GÖker TÜrkakar*

Dimensional optimization of silicon microchannel heat sinks is performed by minimizing the total thermal resistance. Intel Core i7-900 Desktop Processor is considered as the reference chip to be cooled. The study is unique in that the optimization has been performed for localized multiple heat sources. The results of the optimization agreed very well with available ones in the literature. Grid search is utilized to obtain the minimum value of the objective function. The optimization procedure may be improved using a meta-heuristic algorithm such as Tabu search.

3 - Progressive multi-objective optimization

Kenneth Sörensen, Faculty of Applied Economics, University of Antwerp, Prinsstraat 13, 2000, Antwerpen, Belgium, kenneth.sorensen@ua.ac.be, *Johan Springael*

PMOO is a novel technique that includes the decision maker's preferences into the multi-objective optimization process instead of tackling these steps sequentially. In this talk, we present a PMOO method for the multi-objective knapsack problem. This approach integrates the well-known PROMETHEE multi-criteria method into a simple tabu search method.

4 - A carbon-footprint optimization model for integrated forward-reverse logistics

Alok Choudhary, Management School, University of Sheffield, IWP Building, Mushroom Lane, S10 2TN, Sheffield, United Kingdom, a.choudhary@sheffield.ac.uk

This research proposed a MILP optimization model for forward-reverse logistics with carbon-footprint considerations. This research extends the traditional model by both minimizing cost and carbon footprint across the supply chain and incorporates carbon emission parameters with various operational decision-making variables related to facility layout decisions, procurement and production. We provide a series of insights that highlight the impact of operational decisions on carbon emissions. An efficient forest data structure algorithm is used to solve the optimization problem.

■ MA-15

Monday, 8:30-10:00
G5-2

Genetic Algorithms and Genetic Programming

Stream: Metaheuristics (contributed)
Contributed session

Chair: *Derya Dengi*, Department Industrial Engineering, Yasar University, Yasar University Selcuk Yasar Kampusu No:35-37, Agacliyol Bornova, 35100, Izmir, Izmir, Turkey, deryadengi@gmail.com

1 - Comparative Analysis of Differential Evolution, Firefly and Genetic Algorithms on Dynamic Environments
Burcin Ozsoydan, Industrial Engineering, Dokuz Eylul University, Turkey, burcin.ozsoydan@deu.edu.tr, *Adil Baykasoğlu*

Most of the real-life problems require a dynamic optimization arising from the uncertainty of future events, which makes optimization harder. Genetic Algorithms (GA) and Differential Evolution (DE) have been widely used for static optimization. Their applications to dynamic optimization problems are rare. In the present work an improved Firefly Algorithm (FA) is presented for dynamic optimization along with comparisons via GA and DE. Results demonstrate that, the proposed FA significantly achieves superior results for both stationary and dynamic problems in comparison to GA and DE.

2 - Optimizing intrusion detection system performance in ubiquitous environments using genetic algorithm approach
Lynda Sellami, computer science, University of Bejaia, route de targua ouzemou, 06000, Bejaia, Algeria, slynda1@yahoo.fr

The objective of ubiquitous computing is to give the users the ability to communicate and provide information regardless of their location in the Internet network, The success of these distributed computing depends largely on a strong security mechanism such as intrusion detection. This article presents a review to understand, examine, and critique the current state of its applications in various fields and proposing a solution to this problem by using genetic algorithm approach.

3 - Internet decision system for combinatorial optimization problems under permutation
Lamia Trabelsi, Laboratoire ROI Ecole Polytechnique, Tunisia, lamia_tr2001@yahoo.fr, *Talel Ladhari*

In this work, we propose a web-based decision support system to solve combinatorial optimization problems under permutation (COPP) using genetic programming. The REST (Representational State Transfer) architecture style is used to allow the new system to communicate with researcher applications over the net. REST avoids inter-operability problem. It allows accessing resources by URI (Universal Resource Identifier). Via the URI, researchers are able to reuse or to evaluate at run-time their operators with the available operators.

4 - A Genetic Algorithm Based Approach for Operator Allocation Problem in Garment Industry with the Consideration of Labour Skill Levels
Derya Dengi, Department Industrial Engineering, Yasar University, Yasar University Selcuk Yasar Kampusu No:35-37, Agacliyol Bornova, 35100, Izmir, Izmir, Turkey, deryadengi@gmail.com, *Gonca Tuncel*

Sewing lines in garment industry are complicated assembly lines due to the labour intensive work nature with great number of operations, various types of machines, and different labour skill levels. In this study, we considered operator allocation problem in an international garment factory. Labour skill levels in each of the operation are also taken into account to improve the workload balance. The problem is solved by using a genetic algorithm based approach. The experimental results for different product models are presented and discussed.

■ MA-16

Monday, 8:30-10:00
G5-7

Network Flows I

Stream: Routing Problems
Invited session

Chair: *Paola Festa*, Dept. of Mathematics and Applications, University of Napoli Federico II, Compl. MSA - Via Cintia, 80126, Napoli, Italy, paola.festa@unina.it
Chair: *Francesca Guerriero*, D.E.I.S.: Department of Electronics, Computer Science and Systems, University of Calabria, Via P. Bucci, 87036, Rende, Italy, guerriero@deis.unical.it

1 - Solving the Shortest Path Tour Problem and Some of Its Variants
Paola Festa, Dept. of Mathematics and Applications, University of Napoli Federico II, Compl. MSA - Via Cintia, 80126, Napoli, Italy, paola.festa@unina.it, *Daniele Ferone*, *Francesca Guerriero*, *Demetrio Laganà*

The shortest path tour problem consists of finding in a weighted digraph a shortest path from a given origin node to a given destination node, crossing a sequence of disjoint and possibly different-sized node subsets, given in a fixed order. In this talk, a polynomial-time reduction of the problem to a classical shortest path problem over a modified digraph is illustrated. Several exact solution methods are proposed and their performances are compared with the state-of the-art solving procedure. Some variants of the problem and their properties are analyzed.

2 - Maximizing the propagation of the advertisements in social networks
Ciriaco D'Ambrosio, Department of Computer Science, University of Salerno, Italy, cirodamb@gmail.com, *Francesco Carrabs*, *Raffaele Cerulli*

We study the problem of maximizing the propagation of an advertisement in a social network where a node represents a user and an edge represents the friendship relation. The problem is to identifying a set of nodes in which to publish an advertisement in order to maximize its propagation without wasting ad spaces. Moreover, we analyze another problem where the aim is to maximize the number of selected nodes ensuring a fixed propagation level. Two formulations and a metaheuristic approach are presented.

3 - Fast Shortest Path Queries in Road Networks
Leonid Antsfeld, NICTA, 223 Anzac Pde., NICTA, Level 4, Reception, 2052, Kensington, NSW, Australia, leonid.antsfeld@nicta.com.au, *Philip Kilby*, *Andrew Verden*, *Toby Walsh*

Our new algorithm, identifies key nodes in a road network. Initially, we identify all major nodes, i.e., nodes which have at least one endpoint as a highway. Next, we divide our map to clusters. Then for every cluster, we identify the furthest major node, such that there is no other major node on a shortest path from this cluster. The set of access nodes of a cluster is defined as a hitting set of all major nodes which are on a shortest paths originating from the convex hull of the cluster. On average a cluster has 5 access nodes, therefore the query translates to just a few table lookups.

4 - Network interdiction by dynamic interdictor using shortest path
Ahmet Kabarcik, Industrial Engineering, Cankaya University, Eskisehir Yolu 29.km, Yenimahalle, 06810, Ankara, Turkey, a.kabarcik@cankaya.edu.tr, *Levent Kandiller*, *Haluk Aygunes*

This study considers a network interdiction problem in which arcs are disabled by a dynamic interdictor. Its assumed that the network is composed of two interconnected networks. One of the networks is used by the user and the other one is used by the interdictor. An interdictor's node may either be deployed on an arc or on a node of the network user. Nodes on the interdictor's network are candidate points for destruction. Here, it's aimed to find the shortest path that can be used by the interdictor while destroying all paths between origin and destination nodes of network user.

■ MA-17

Monday, 8:30-10:00
G5-8

Green Vehicle Routing

Stream: Sustainable Transport Planning
Invited session

Chair: *Esben Linde*, DTU Transport, Technical University of Denmark, Bygning 115, Bygningstorvet, 2800, Kgs. Lyngby, Denmark, esli@transport.dtu.dk

1 - Environmental Vehicle Routing Problem (VRP)
Georgios K.D. Saharidis, Mechanical Engineering, University of Thessaly, Pedion Areos, 38334, Volos, Thessaly, Greece, saharidis@gmail.com, *George Liberopoulos*

The vehicle is a very important component for the evaluation and estimation of environmental externalities in the transport sector. However, there is another important component that affects the amount of emissions that has been taken either partially or not at all under consideration. This component is related to the characteristics of the transportation network (TN). In this research, we develop a novel objective function for the environmental VRP that takes as input several data and estimates the Environmental Externalities Score (EES) of a route.

2 - Demand Management and Vehicle Routing in E-fulfilment
Richard Eglese, The Management School, Lancaster University, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, R.Eglese@lancaster.ac.uk, *Xinan Yang*, *Arne Karsten Strauss*, *Christine Currie*

For many customers, ordering goods over the internet for home delivery offers a more sustainable way of shopping than making a special trip by car to a retail outlet. However attended home delivery services face the challenge of providing narrow delivery time slots to ensure customer satisfaction, whilst keeping the delivery cost under control. Dynamic pricing policies based on a customer choice model are proposed to determine how much incentive (discount or charge) to offer for which time slot. A simulation study based on real data shows the effectiveness of the approach.

3 - An Algorithm for Sustainable Vehicle Routing
Fernando Oliveira, Operations MAnagement, ESSEC Business School, Cergy, France, oliveira@essec.fr, *Anne Liret*

The vehicle routing problem is known for being NP-hard. In this article we analyze this problem from a perspective of a company that wants to introduce vehicle sharing in an attempt to increase efficiency and reduce CO2 emissions. We provide a formulation of the problem considering multiple depots and time windows. We propose an algorithm to approximate the solution is a real-case study and analyze its main properties.

4 - Routing of Electric Vehicles: City Distribution in Copenhagen
Esben Linde, DTU Transport, Technical University of Denmark, Bygning 115, Bygningstorvet, 2800, Kgs. Lyngby, Denmark, esli@transport.dtu.dk, *Allan Larsen*, *Anders Vedsted Noerrelund*, *Stefan Ropke*, *Min Wen*

In this work, a Vehicle Routing Problem with Time Windows considering EV constraints of limited driving range and freight capacity is addressed (EVRPTW). The EVs are allowed to recharge at certain locations, and aspects of intelligent location of these recharging points are considered. The objective is to find the least cost plan for EV routing and compare this to conventional routing. A heuristic method is developed and tested on data based on real-life collected data on distribution vehicles in central Copenhagen, Denmark. The EVRPTW has so far received little attention in the literature.

■ MA-19

Monday, 8:30-10:00
G5-10

Advanced Inventory Control in SCM

Stream: Business Excellence in Logistics
Invited session

Chair: *Sebastian Langton*, Logistics Management Department, Helmut-Schmidt-University, 22041, Hamburg, Germany, langton@hsu-hh.de
Chair: *Johannes Siebert*, Business Administration, University of Bayreuth, Universitätsstr. 30, 95440, Bayreuth, Bayern, Germany, Johannes.Siebert@uni-bayreuth.de

1 - Inventory optimization for a recoverable manufacturing system with product substitution
Semra Sebnem Ahiska, Industrial Engineering Department, Galatasaray University, Ciragan Cad. No:36 Ortakoy, 34349, Istanbul, Turkey, sahiska@gsu.edu.tr, *Emre Kurtul*, *Rusty King*

The periodic-review inventory control problem for a stochastic manufacturing/remanufacturing system with product substitution is studied. A remanufactured item has a lower selling price than a manufactured (i.e., new) item, thus separate demand streams exist for those products. A product substitution strategy is considered where the demand for a remanufactured item is satisfied by a new item if no remanufactured item is left in stock and new item inventory is available. Through a Markov decision analysis, we find the optimal inventory policies, and determine the value of product substitution.

2 - Decision Making under Bounded Rationality Terms: Application in a Transportation Problem
Maria Giannopoulou, Industrial Management & Technology, University of Piraeus, Department of Industrial Management & Technology University of Piraeus — 18534 Piraeus, GREECE, 18534, Piraeus, Greece, mgiannopulu@gmail.com, *Dimitrios Emiris*

Decision makers operate under cognitive, emotional and computational constraints in unstable and complicated environments. The Bounded Rationality (BR) theory takes into account such constraints and weaknesses to provide a more realistic decision making framework. This work presents a Fuzzy Cognitive Map (FCM) for a simulation problem of strategy optimization in transportation contracts sold by e-auctions. The model inputs are concepts concerning BR elements affecting bidders' behavior and generates data concerning the interactions between these concepts and potential correlations among them.

3 - A Two-Loop Machine Learning Approach for Evaluating Supply Chain Stockout Events
Sebastian Langton, Logistics Management Department, Helmut-Schmidt-University, 22041, Hamburg, Germany, langton@hsu-hh.de, *Johannes Siebert*, *Martin Josef Geiger*

Despite the relevance of stockout cost parameters in many logistics models, a need for practicable cost quantification methods can still be stated. As a methodologically new idea we present an interactive machine learning approach for estimating such costs. Previous experiments revealed that the consistency of data from the decision maker (DM) is essential for satisfying machine learning results. In line with this, we introduce an idea of inconsistent data elimination by re-integrating the DM in a second learning loop. The talk completes with presenting experimental work and numerical results.

■ MA-20

Monday, 8:30-10:00
G5-11

Routing in Public Transport Networks

Stream: Optimization in Public Transport
Invited session

Chair: *Gianpaolo Oriolo*, Universita' Roma Tor Vergata, Italy, oriolo@disp.uniroma2.it
Chair: *Giuseppe Italiano*, Department of Civil Engineering and Computer Science Engineering, University of Rome "Tor Vergata", via del Politecnico 1, 00133, Rome, Italy, italiano@disp.uniroma2.it

1 - Stochastic Route Planning in Public Transport
Alpár Jüttner, IBM-ELTE Center for Applied Mathematics, Dept of Operations Research, ELTE, Pázmány P. sétány, 1/C, H-1117, Budapest, Hungary, alpar@cs.elte.hu, *Kristof Berczi*, *Mátyás Korom*, *Jacint Szabo*, *Tim Nonner*, *Marco Laumanns*

There are plenty of public transport planners that help passangers to find a route satisfying their needs. However, a common weakness

of these methods that they assume a deterministic environment. Vehicles in public transport are typically behind or before time, hence making the availability of a given journey in real life questionable. We present an algorithm that overcomes this uncertainty by using a stochastic model for departure and travel times. The output of the algorithm is not a single route but a policy for each node that defines which services to take at a given time.

2 - Stochastic on-time arrival problem on public transportation networks
Sebastien Blandin, IBM Research Collaboratory – Singapore, IBM Singapore Pte Ltd, 9 Changi Business Park Central, The IBM Place, 486048, Singapore, Singapore, Singapore, sblandin@sg.ibm.com, *Samitha Samaranayake*, *Alex Bayen*

We formulate the stochastic on-time arrival problem on public transportation networks. Link travel times are estimated according to a route-based headway diffusion model, which allows the computation of associated waiting times at connection nodes. We prove that this formulation leads to efficient computations tractable for large networks, even in the case of time-varying headway distributions. Additionally, robustness to recurrent variability as well as unexpected events is very naturally represented under this formulation. Algorithm performance is illustrated using realistic transit data.

3 - When Algorithms Come True: A Dynamic Multimodal Route Planner for Rome
Luca Allulli, Centrale della Mobilità, Roma servizi per la mobilità srl, Piazzale degli Archivi, 40, 00144, Rome, Italy, luca.allulli@agenziamobilita.roma.it

"Roma servizi per la mobilità" is the municipal agency for public and private transport in Rome. The agency recently developed a dynamic multimodal route planner (http://muovi.roma.it). Real-time data is collected from GPS bus trackers, which cover the vast majority of buses in Rome. We present the main challenges our small development team had to face: creating a simple, yet flexible framework for dynamic multimodal routing, which allows us to rapidly prototype and integrate diverse means of transport; dealing with raw data from bus trackers; and tuning code to obtain adequate performance.

4 - Real-Time Public Transportation Route Planners
Federico Santaroni, Department of Civil Engineering and Computer Science Engineering, Tor Vergata, Via Politecnico 1, 00133 , Roma, Italy, federico.santaroni@gmail.com, *Luigi Laura*, *Federico Cosentino*, *Emanuele Paracone*

In the last years we have seen a huge contribution to routing algorithms in large transportation networks, especially focusing on road networks. Despite many results in this direction, if we switch our attention to public transportation networks, this is a completely different scenario in which one cannot directly apply the same algorithmic techniques. In this talk we will discuss the challenges arising in designing a public transportation route-planner, in particular in the case where one can use data provided by the GPS vehicles' devices in real time.

■ MA-21

Monday, 8:30-10:00
G6-1

Scheduling Approaches for Complex Manufacturing and Service Systems

Stream: Scheduling
Invited session

Chair: *Lars Moench*, FernUniversität in Hagen, 58097, Hagen, Germany, lars.moench@FernUni-Hagen.de

1 - A Reinforcement Learning Approach to Solving Hybrid Flexible Flowline Scheduling Problems
Dmitry Borodin, Optimization, OM Partners, Koralenhoeve 23, 9000, Wommelgem (Antwerp), Belgium, dk.borodin@gmail.com, *Bert Van Vreckem*, *Ann Nowe*, *Kris Dockx*, *Wim De Bruyn*

This research presents a technique based on Learning Automata (LA) to solve Hybrid Flexible Flowline Scheduling Problems with additional constraints like sequence dependent setup times, precedence relations between jobs and machine eligibility that occur in complex real-life problems like those in process industry. In the proposed method, LA play a dispersion game to determine the order of jobs to be processed so that makespan is minimized while avoiding illegal permutations. Computational results on benchmark problems indicate that LA can yield better results than the ones known until now.

2 - Missing operations in reentrant flow-shop problems
Richard Hinze, TU Dresden, Germany, richard.hinze@mailbox.tu-dresden.de, *Dirk Sackmann*, *Udo Buscher*, *Gerhard Aust*

We propose a model for the reentrant flow-shop scheduling in order to minimize makespan. Reentrant flow shop scheduling problems occur in practical applications, such as the manufacturing of semiconductors, airplane engines, and petrochemical production. The formulation considers missing operations. Compared to traditional formulations the values of makespan are significantly reduced, due to an appropriate dealing with processing times equal to zero. Computational tests with different problem sizes reveal that computation times are mainly influenced by the total number of jobs.

3 - A new method for the evaluation of a neighbor solution in local search procedures for solving the JSPTWT
Jens Kuhpfahl, School of Economics and Business, Chair of Production and Logistics, MLU Halle-Wittenberg, Germany, jens.kuhpfahl@wiwi.uni-halle.de, *Christian Bierwirth*

Efficient local search in job shop scheduling requires estimating the success of possible neighborhood moves. Typically, a lower bound is calculated for a new schedule by estimating heads and tails of the operations affected by the neighborhood search operator. In this talk we show how this technique can be improved for the JSPTWT regarding reliability and computation time. It allows us to determine the true objective function value of the neighbor solution instead of just verifying a necessary condition for descent moves in the local search.

4 - An Instance Generator for Scheduling Problems with Alternative Process Plans
Oleh Sobeyko, University of Hagen, 58097, Hagen, Germany, Oleh.Sobeyko@FernUni-Hagen.de, *Roman Capek*, *Zdenek Hanzalek*, *Lars Moench*

We consider scheduling problems with alternative process plans. A new generator for problem instances is proposed. The generator is designed for both resource constrained project scheduling problems and problems based on the integrated process planning and scheduling model while the data representation for both classes of problems is unified. We propose a common model for scheduling problems with alternatives and fill the gap in existing tools for generating problem instances. Structural properties, the resource environment, and the attributes of activities are defined as input parameters.

■ MA-22

Monday, 8:30-10:00
G6-2

Scheduling & Project Management

Stream: Scheduling, Time Tabling & Project Management (contributed)
Contributed session

Chair: *Ching Chih Tseng*, Business Administration, Dayeh University, 168 University Rd., Dacun, Taiwan, R.O.C., 51591, Changhua, Taiwan, cctseng@mail.dyu.edu.tw

1 - A heuristic approach for profit oriented disassembly sheduling problem
Melike Kaya Akça, METU-Industrial Engineering Dept., Graduate School of Natural and Applied Sciences, Turkey, kamelike@metu.edu.tr, *Z. Pelin Bayindir*, *Ferda Can Cetinkaya*

We consider a disassembly scheduling problem for multiple products with parts commonality and ample supply of discarded products. We propose a heuristic algorithm which is based on the idea of sequentially solving a relaxed version of the problem and single-period integer programming models. In a computational study, the performance of the heuristic approach is assessed. The results of the computational experiments indicate that the heuristic algorithm solves the problems in a reasonable computational time and generates near optimal solutions.

2 - On an algorithm of multicriteria scheduling problem
Ketevan Kutkhashvili, Mathematics, University of Georgia, 77 Kostava Street, 0102, Tbilisi, Georgia, kkutkhashvili@yahoo.com, *Liana Qaralashvili*

On the basis of general theory methods mathematical model is constructed for such scheduling theory problems for which tasks implementation is possible by single-step multiprocessing system in which processors are half interchangeable and additional resources and sets of partial order are empty. The new multicriteria optimization algorithm (from the viewpoint of speed of acting and other certain criteria) is constructed.

3 - A bayesian approach to preventive maintenance optimization in unreliable systems
Dincer Goksuluk, Biostatistics, Hacettepe University, Sıhhiye Campus, Faculty of Medicine, Department of Biostatistics, Ankara - TURKEY, 06590, Ankara, Turkey, dincer.goksuluk@gmail.com, *Selma Gürler*, *Deniz Türsel Eliiyi*

In this study, we present a sequential preventive maintenance (PM) model for a component subject to failure. We assume an age reduction model for imperfect PMs, performed whenever the component's reliability falls below the threshold level, R. We consider the problem under lack of data where Bayesian methods are more appropriate than the frequentist view. We model the total expected cost over all cycles, and the optimal preventive maintenance plan until replacement is found dependent on the threshold value. A numerical study is also conducted for sensitivity analysis of the developed model.

4 - Minimizing the total weighted completion time for time-dependent jobs
Krzysztof Ocetkiewicz, Department of Algorithms and System Modelling, Gdansk University of Technology, 11/12 Gabriela Narutowicza Street, 80-233, Gdańsk, Poland, Krzysztof.Ocetkiewicz@eti.pg.gda.pl, *Marek Kubale*

We consider a single machine time-dependent scheduling problem with linear deterioration and Sum wiCi objective. We present a branch-and-bound algorithm improved by elimination of dominated partial schedules. Such an algorithm makes possible to deal with huge memory requirements of the elimination while retaining running time speedup. Also,it is capable of finding all Pareto optimal solutions subject to Sum wiCi and Cmax criteria and scheduling jobs with precedence constraints. Our algorithm allows to double the size of instances that can be solved to optimality in a reasonable time.

■ MA-23

Monday, 8:30-10:00
G6-3

Realistic Production Scheduling

Stream: Realistic Production Scheduling
Invited session

Chair: *Cyrus Siganporia*, Biochemical Engineering, University College London, United Kingdom, cyrus.siganporia.09@ucl.ac.uk

1 - New lower bounds for minimising the total completion time in a two-machine non permutation flowshop scheduling problem
Sabrine Chalghoumi, Economie, Ecole supérieure des sciences économiques et commerciales de Tunis, 4, Rue Abou Zakaria El Hafsi, 1089 Montfleury, Tunis, Tunisia, chalghoumisabrine@yahoo.fr, *Mrad Mahdi*, *Talel Ladhari*

The presented work addresses the two-machine non-permutation flow shop scheduling problem with the objective of minimizing the total completion time subject to release dates. We proposed two new mixed integer linear programming formulations. The first proposed MILP formulation is based on the Completion Time Variable formulation while the second one is based on a time indexed formulation. Moreover, two new derived lower bounds are obtained by linear relaxation technique. Our computational experiments provide evidence that these new lower bounds present interesting and significant results.

2 - Solution Approaches For Flexible Job Shop Scheduling Problems
Serife Aytug Balci, Industrial Engineering, Graduate School of Natural and Applied Sciences, Ankara, Turkey, acelik@roketsan.com.tr, *Meral Azizoglu*, *Cemal Oguzsoy*

In this study, we consider FJSP existing in discrete parts manufacturing industries. We are motivated by the production environment of a company, operating at Turkish defense industry. Our objective is to minimize the total weighted completion times of the jobs in the system. We formulate the problem as a mixed integer linear program and find that our model could find optimal solutions only to small sized problem instances. For medium and large sized problem instances, we develop heuristic algorithms with high quality approximate solutions in reasonable solution time.

3 - A genetic algorithm for flexible job shop scheduling with overlapping in operations
Yunus Demir, Industrial Engineering, Ataturk University, Erzurum Turkey, 25240, Erzurum, Outside US, Turkey, yunusdemir83@gmail.com, *Selçuk Kürşat İşleyen*

Flexible job shop scheduling problem (FJSP) is extension of job shop scheduling problem (JSP) which allows an operation to be performed by any machine among a set of available machines. In this paper we handled FJSP with overlapping in operations. To solve this problem a genetic algorithm (GA) is proposed. The proposed algorithm was tested on benchmark problems taken from literature of different scales. Obtained results were compared with the results obtained by other algorithms.

4 - Multi-objective optimisation of biopharmaceutical production plans using a state task network representation
Cyrus Siganporia, Biochemical Engineering, University College London, United Kingdom, cyrus.siganporia.09@ucl.ac.uk, *Lazaros Papageorgiou*, *Suzanne Farid*

Biotech firms face mounting pressure to meet demands for multiple commercial therapeutics whilst minimising costs. Obtaining optimal capacity plans across multiple sites is complicated by conflicting objectives and products with batch and semi-continuous modes of production. This presentation describes development of a multi-objective STN MILP model to help decide whether to outsource manufacturing, build a new facility, or do both as capacity limits are reached. An industrial case study is presented showing how better long-term capacity plans can be generated when including various criteria.

■ MA-24

Monday, 8:30-10:00
G6-4

Airport Operations Management

Stream: Project Management and Scheduling
Invited session

Chair: *Jeroen Belien*, Center for Informatics, Modeling and Simulation, Hogeschool-Universiteit Brussel, Warmoesberg 26, 1000, Brussels, Belgium, Jeroen.Belien@kuleuven.be

1 - A rolling horizon framework for an aircraft line maintenance problem
Jorne Van den Bergh, HUBrussel, Belgium, jorne.vandenbergh@hubrussel.be, *Jeroen Belien*, *Liesje De Boeck*, *Erik Demeulemeester*

We present a rolling horizon framework for an aircraft line maintenance scheduling problem. The procedure starts with the creation of a "robust' base schedule in order to deal with the stochasticity in the release times of the jobs. In the rolling horizon procedure, flight delays are simulated and we check whether the base schedule can handle these delays with the available capacity and/or time buffers or whether the base schedule needs to be adjusted. When rescheduling is needed, we search for the cheapest solution that results in the smallest number of changes to the base schedule.

2 - Flight and Crew Rescheduling in Post Perturbation Situation
Peiman Alipour Sarvari, Industril engineering, Gazi University, Yunus Emre ogrenci yurdu, Altindag-Ulus, 06500, Ankara, Select, Turkey, peyman.alipour@gmail.com

Abstract- Airline operations are disrupted frequently. The most important factors are unstable weather conditions and unpredictable technical aeronautics problems. In a disrupted situation, an airline operator needs to quickly adjust the timetable and the resource schedules so the importance of re-assignment of facilities to flight is much more clearer. In this study, we considered the re-assignment of aircraft to flight after the emergence of disorder in the initial planning with regard to crew scheduling constraints. We propose a problem formulation and a heuristic solution algorithm.

3 - Aircraft Maintenance Scheduling and Optimization for Summer Period: A Case for Turkish Airlines
Yavuz Ozdemir, Industrial Engineering, Yildiz Technical University, Yildiz Teknik Universitesi Endustri Muhendisligi Bolumu Barbaros Bulvari, Yildiz/Besiktas/Istanbul TURKEY, Istanbul, Turkey, Turkey, yavuzytu@gmail.com, *Ahmet Bolat*, *Merve Karaca*

Decreased ticket prices in airline transportation make a competitive airline market, and forces airline companies to make professional decisions for their activities. In this study, C type maintenance, which is one of the important and long lasting maintenance, is assigned for summer period considering the capacity of hangar with Microsoft Visual Basic. Maximizing the utilization and minimizing the number or required aircrafts are considered as our aims. According to dynamic frame of airline operations and daily irregularities, manual editing is allowed in the code that studied in this paper.

■ MA-25

Monday, 8:30-10:00
G9-1

Retail models

Stream: INFORMS MSOM Stream
Invited session

Chair: *Esra Cinar*, Operations Management, IESE Business School, Cr. Arnús i Garí 3-7, 08034, Barcelona, Spain, Ecinar@iese.edu

1 - A closed-loop approach to dynamic assortment planning
Esra Cinar, Operations Management, IESE Business School, Cr. Arnús i Garí 3-7, 08034, Barcelona, Spain, Ecinar@iese.edu, *Victor Martínez de Albéniz*

Firms offering short-lived products are constantly trying to keep the customers interested by refreshing their assortments, for example in fashion retailing. We model these dynamics by assuming that products lose their attractiveness over time and we let the firm enhance the assortment at a cost, e.g., with new product introductions. We characterize the optimal closed-loop policy that maximizes the revenue obtained by increasing the attractiveness of an assortment, minus the associated cost of the adjustments. Interestingly, we find that an assort-up-to policy is optimal in some cases.

2 - Optimal Assortment Planning for Retailers Using Transshipments
Nagihan Comez, Faculty of Business Administration, Bilkent University, Bilkent University Isletme Fakultesi MAZ 20, Bilkent, 06800, Ankara, -, Turkey, comez@bilkent.edu.tr, *Alper Sen*, *Hilal Dag*

Transshipments among retailers may help to recover stock-outs timely and economically. In this study, our objective is to find the optimal assortments in a centralized retailer system, where retailers can utilize transshipments for the products they don't keep. Using an exogenous demand model, we show that when all possible products can be ranked according to certain popularity criteria, the products in both the total and common assortments of retailers will be chosen following this popularity list at the optimality. We also show the benefits of transshipments wrt a no-transshipment system.

3 - Assortment Competition with Information Revelation
Victor Martínez de Albéniz, IESE Business School, Barcelona, Spain, valbeniz@iese.edu, *Gurhan Kok*

In industries where customer needs quickly change, retailers can postpone their assortment decisions (amount of variety, balance across categories) if they are quick enough. We study here how assortment competition depends on the postponement capabilities of retailers. We develop a stylized model where two retailers choose their assortment breadth either before or after market characteristics are revealed.

■ MA-26

Monday, 8:30-10:00
G9-7

Combinatorial Optimization: Applications

Stream: Combinatorial Optimization I
Invited session

Chair: *Jan van Vuuren*, Department of Logistics, Stellenbosch University, Private Bag X1, Matieland, 7602, Stellenbosch, Western Cape, South Africa, vuuren@sun.ac.za

1 - Choosing fuel treatment sites to reduce risk of fire
John Hearne, Mathematical and Geospatial Sciences, RMIT University, GPO Box 2476v, 3001, Melbourne, Victoria, Australia, john.hearne@rmit.edu.au, *James Minas*

Reducing fuel loads is a method for reducing the risk of wildfires. Planning for this requires decisions relating to location, extent, and timing of treatment. We formulate MIP problems to deal with this at the landscape-level in the presence of resource limitations. We generate a number of fuel treatment patterns and landscape metrics with a view to modifying the behaviour and effects of large wildfires. Methods for incorporation of a range of ecological, operational and cost constraints are also considered.

2 - An exact dynamic programming algorithm for the aircraft sequencing problem
Martin Kidd, Dipartimento di Elettronica, Informatica e Sistemistica (DEIS), University of Bologna, Bologna, Italy, martin.kidd@unibo.it, *Fabio Furini*, *Carlo Alfredo Persiani*, *Paolo Toth*

We consider the static case of the aircraft sequencing problem on a single runway with constraints on the deviation from the first-come-first-serve order. An exact dynamic programming algorithm is proposed, and the effects of limiting the states in the state space graph are investigated. Completion bounds are computed and are used together with heuristic upper bounds to further limit the number of states. For real world air traffic instances from Milan Linate Airport it is shown that the algorithm is able to outperform the previously best exact algorithm from the literature.

3 - Finding bounds for the minimum number of moves for solving the WrapSlide puzzle
Alewyn Burger, Department of Logistics, Stellenbosch University, Private Bag X1, Matieland, 7600, Stellenbosch, Western Cape, South Africa, apburger@sun.ac.za

WrapSlide is a slide-puzzle consisting of a 6 by 6 grid of tiles in which each quadrant of 3 by 3 tiles are coloured differently. The puzzle can be scrambled by performing a number of moves involving wrapping of tiles. A move consists of sliding either the top, bottom, left or right two quadrants of tiles 1 to 5 units horizontally or vertically. We discuss bounds on the minimum number of moves to unscramble the puzzle.

4 - A linear algorithm for secure domination in trees
Jan van Vuuren, Department of Logistics, Stellenbosch University, Private Bag X1, Matieland, 7602, Stellenbosch, Western Cape, South Africa, vuuren@sun.ac.za, *Alewyn Burger*, *Anton de Villiers*

A secure dominating set of a graph is an assignment of guards to its vertices, at most one guard per vertex, so that (a) every vertex is either occupied by a guard or adjacent to an accupied vertex and (b) there is a guard in the neighbourhood of each unoccupied vertex who can move to that vertex, again leaving a configuration satisfying (a) above. In this talk an algorithm is proposed for finding a secure dominating set of minimum cardinality for any tree in linear time and space.

■ MA-27

Monday, 8:30-10:00
G9-8

Applications of Boolean Functions

Stream: Boolean and Pseudo-Boolean Optimization
Invited session

Chair: *Endre Boros*, RUTCOR, Rutgers University, 08854, Piscataway, New Jersey, United States, Endre.Boros@rutcor.rutgers.edu

1 - Discovery of strong association rules in binary tables based on hypergraph dualization
Kira Adaricheva, Mathematical Sciences, Yeshiva University, 245 Lexington ave, 10016, New York, NY, United States, adariche@yu.edu

Discovery of (strong) association rules, or implications, is an important task in data management, that finds application in artificial intelligence, data mining and semantic web. We introduce the novel approach for the discovery of a specific set of implications, called the D-basis, that provides a representation for a binary table, based on the structure of its Galois lattice. At the core of the method is the D-relation defined in the lattice theory framework, and the hypergraph dualization algorithm that allows to effectively produce the set of transversals for a given hypergraph.

2 - The performance of box-type classifiers in the logical analysis of numerical data
Martin Anthony, London School of Economics, WC2A 2AE, London, United Kingdom, M.Anthony@lse.ac.uk, *Joel Ratsaby*

The use of boxes for pattern classification is a fairly natural way in which to partition data into different classes or categories. It is one of the standard LAD approaches when dealing with numerical (rather than binary) data. We consider the performance of classifiers which are based on unions of boxes. The classification method studied may be described as follows: find boxes such that all points in the region enclosed by each box are assumed to belong to the same category, and then classify remaining points by considering their distances to these boxes.

3 - Quadratic reformulations of nonlinear binary optimization problems
Yves Crama, HEC - Management School, University of Liège, Rue Louvrex 14 (N1), 4000, Liege, Belgium, Y.Crama@ulg.ac.be, *Martin Anthony*, *Endre Boros*, *Aritanan Gruber*

We consider the problem of minimizing a pseudo-Boolean function f(x), i.e., a real-valued function of 0-1 variables. Several authors have recently proposed to reduce this problem to the quadratic case by expressing f(x) as min g(x,y) s.t. y = 0, 1, where g is a quadratic function of x and of additional binary variables y. We establish lower and upper bounds on the number of additional y-variables needed in such a reformulation, both for the general case and for the special case of symmetric functions like positive or negative monomials, k-out-of-n majority functions, or parity functions.

4 - Threshold separability of boolean functions and its application to data discretization
Giovanni Felici, Istituto di Analisi dei Sistemi ed Informatica, Consiglio Nazionale delle Ricerche, Viale Manzoni 30, 00185, Roma, Italy, giovanni.felici@iasi.cnr.it, *Endre Boros*

We consider the conditions for the existence of a Linear Threshold Function that separates two sets of Boolean vectors obtained by discretization of real valued data. We state a combinatorial necessary and sufficient condition for the existence of such function when points belong to the plane, and show its equivalency with a straight-forward interpretation of the Farkas' Lemma. Such equivalency provides interesting insights for our problem in larger dimensions and supports the design of a discretization algorithm, for which we provide computational experience and comparative tests.

■ MA-28

Monday, 8:30-10:00
G9-2

Geometric Clustering 1

Stream: Geometric Clustering
Invited session

Chair: *Belen Martin-Barragan*, Dpto. Estadistica, Universidad Carlos III de Madrid, c/Madrid 126, 28903, Getafe, Madrid, Spain, belen.martin@uc3m.es

1 - On the existence of feasible power diagrams for optimal weighted balanced clusterings
Peter Gritzmann, Mathematics, TU München, Arcisstr. 21, D-80290, Munich, Germany, gritzman@ma.tum.de, *Andreas Brieden*

A highly desirable property of a weighted clustering of points in d-space under balancing constraints is the existence of specific cell complexes that partition the space, and whose defining polyhedra contain the clusters, respectively. We introduce gravity polytopes and more general gravity bodies that encode all feasible clusterings and show that and how their extreme points correspond to strongly feasible power diagrams. Further, we characterize strongly feasible centroidal power diagrams in terms of the local optima of some ellipsoidal function over the gravity polytope.

2 - Soft power diagrams
Steffen Borgwardt, Fakultät für Mathematik, Technische Universität München, Boltzmannstr. 3, 85748, Garching, Bayern, Germany, borgwardt@ma.tum.de

In many applications, the points of a set in d-space are partitioned as a balanced least-squares assignment. Then there is a separating power diagram, for which each cluster lies in its own cell. In practice however, data noise may destroy this nice property. We deal with this problem by showing how to compute an optimal 'soft power diagram' for general data sets: These are power diagrams for which we are able to control the number of points outside of their respective cluster's cell. This leads to efficient algorithms for outlier detection and 'threshold-setting'.

3 - Approximation algorithm for plane polyhedral separability problem
Konstantin Kobylkin, Optimization, IMM UB RAS, Sophya Kovalevskaya st., 16, 620990, Ekaterinburg, Sverdlovskaya, Russian Federation, kobylkinks@gmail.com

We give an efficient approximation algorithm for an NP-hard simplest majority-based polyhedral separation problem for two sets on the plane which embeds minimum line covering problem as a special case. Specifically, we restrict separating lines to have positive constant terms which makes the problem approximately solvable within constant relative accuracy in some cases. Results of experiments will be given in the talk on several problems of interest: polygon and star-like separable integer-valued sets, mixtures of Gaussians, etc..

4 - Nested Variable Neighborhood Search for Classification and Clustering.
Belen Martin-Barragan, Dpto. Estadistica, Universidad Carlos III de Madrid, c/Madrid 126, 28903, Getafe, Madrid, Spain, belen.martin@uc3m.es, *Emilio Carrizosa*, *Dolores Romero Morales*

Model selection is a critical issue in Data Analysis. Such selection involves the choice of a suitable distance, or a kernel. Enriching the models allows us to capture important information in the data, at the expense of tuning more parameters. Existing metaheuristics are effective when the dimension of the parameter space is low, but tend to fail when it is high. We customize a continuous VNS that is able to cope with complex and flexible models that involve a larger number of parameters. We do it by exploiting the fact that rich models can be usually seen as generalization of simpler ones.

■ MA-29

Monday, 8:30-10:00
G9-3

Management and control of queues

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Dieter Claeys*, Department TELIN, Ghent University, B9000, Ghent, Belgium, dclaeys@telin.ugent.be
Chair: *Joris Walraevens*, Department of Telecommunications and Information Processing, Ghent University, B9000, Ghent, Belgium, jw@telin.ugent.be

1 - Performance evaluation of an overload control mechanism in clustered servlet applications
Marie-Ange Remiche, University of Namur, 5000, Namur, Belgium, mre@info.fundp.ac.be, *Laurent Schumacher*

Convergent Java Servlet infrastructure are key component in today's cluster computing. They support services for many different types of protocols and applications. However, to remain reliable, an admission control algorithm is needed. One is defined based on the actual load of the servlet processor. A simple and efficient Markov model is build up to measure the performance of this admission control mechanism. Performance measures of interest are then obtained by means of matrix analytic technics. We validate our model in case of SIP traffic.

2 - Analysis and applications of coupled queues
Eline De Cuypere, TELIN, University Ghent, St-Pietersnieuwstraat 41, 9000, Ghent, Belgium, eline.decuypere@telin.ugent.be, *Koen De Turck*, *Dieter Fiems*

A coupled queueing system consists of multiple queues, served by a single server such that in every queue a customer leaves upon service completion, and such that service is blocked if any of the queues is empty. Coupled queueing systems are frequently encountered in various contexts including assembly, production and communication networks. While conceptually simple, the analysis and performance of coupled queues is a challenging task, which draws upon different analysis methodologies. We focus on several numerical techniques and develop a novel Taylor series expansion.

3 - Size-aware MDP approach to dispatching problems
Samuli Aalto, Networking Laboratory, Helsinki University of Technology, P.O.Box 3000, FIN-02015, TKK, Finland, samuli.aalto@tkk.fi, *Esa Hyytia*

Dispatching problems are related to parallel server systems where new jobs arrive dynamically and each job is assigned to one of the servers upon its arrival. Assuming Poisson arrivals, any static dispatching policy can, in principle, be improved by the policy iteration technique developed in the MDP theory. We summarize many recent studies where the state of the queueing system is described based on the size information of jobs. In addition, we give illustrative examples where these iterated policies are compared to well-known dynamic dispatching policies (such as JSQ and LWL).

4 - A queueing model for group-screening facilities
Dieter Claeys, Ghent University, Belgium, Dieter.Claeys@telin.ugent.be, *Joris Walraevens*, *Herwig Bruneel*

Classification of items can often be achieved more economically by screening the items in groups rather than individually. We model a group screening facility by a batch-service queueing model where the service (screening) time of a batch (group) is dependent on the number of customers (items) within it. We calculate the fraction of time the screening facility is screening and the average delay of items. These performance measures enable to evaluate every possible screening policy by defining the dependency between the service time of a batch and the number of items within it appropriately.

■ MA-30

Monday, 8:30-10:00
G9-10

Combinatorial Optimization & Applications

Stream: Discrete and Global Optimization
Invited session

Chair: *Mikhail Goubko*, Institute of Control Sciences RAS, Russian Federation, mgoubko@mail.ru
Chair: *Xianping Guo*, Zhongshan University, China, mcsgxp@mail.sysu.edu.cn

1 - Optimization of Cable Cycle: A Tradeoff between the Safety and Cost
Barsam Payvar, School of Technology and Business Studies, University of Dalarna, Plogstigen 20 C, 78451, Borlänge, Dalarna, Sweden, h09barpa@du.se, *Hasan Fleyeh*

In networks, length of the path is a factor which plays a central role in the evaluation of the best path. In ring networks finding the shortest path is very hard. The problem is not a variation of the Traveling Salesman Problems (TSP) because the existence of Hamiltonian Cycle cannot be guaranteed. In such cases, the cycle may include more than one route which means increasing risk of losing more nodes during a failure. Thus, beside the cable length risk is another crucial factor. This work aims to optimize the network in order to find the shortest path with minimum risk.

2 - Charging Station Allocation for Selfish Electric Vehicles
Takashi Tsubota, Department of Industrial and Systems Engineering, Aoyama Gakuin University, Chuo-ku,Fuchinobe,5-10-1, 2298558, Sagamihara, Kanagawa, Japan, c5612128@aoyama.jp, *Shao-Chin Sung*

We are concerned with an allocation problem of charging stations for electric vehicles (EV). Since EV's batteries have limited capacities, plan of charging and delays caused by charging itself and by queuing for charging have to be taken into consideration for routing of EVs. Hence, routing of EVs depends strongly on charging station allocation. We propose a game theoretical approach based on an extended model of selfish routing game, in which each charging station is considered as a player whose location is decided based on its incentive, and the allocations are provided by stable solutions.

3 - On Communication Network Topology Problem with Node Costs
Mikhail Goubko, Institute of Control Sciences RAS, Russian Federation, mgoubko@mail.ru
The communication network topology problem is studied with no edge costs and node costs depending on the node degree and capacity. If cost depends on the degree only, the optimal network is shown to be the tree T of known cost. If capacity only matters, a two-layered network N is optimal where secondary nodes form a complete graph. When both degree and capacity matter, LB and UB are constructed using costs of T and N networks. A branch-and-bound procedure is designed. The local search heuristics is suggested and tested on a collection of random networks.

4 - Network Optimization Models for Resouce Allocation in Developing Military Countermeasures
Boaz Golany, Industrial Engineering & Management, Technion - Israel Institute of Technology, Technion City, 32000, Haifa, Israel, golany@ie.technion.ac.il, *Moshe Kress*, *Michal Penn*, *Uriel G. Rothblum*
We consider an arms race where an attacker introduces new weapons to gain some advantage and a defender develops countermeasures that mitigate the weapons' effects. We address the defender's problem: given limited resources, which countermeasures to develop and how much to invest in them to minimize the damage caused by the weapons over a certain horizon. We formulate several models, corresponding to different operational settings as constrained shortest path problems and variants thereof. We then demonstrate the potential applicability and robustness of our approach in various scenarios.

■ MA-31

Monday, 8:30-10:00
G9-11

Retail Assortment Planning

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Heinrich Kuhn*, Operations Management, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, Bavaria, Germany, heinrich.kuhn@ku-eichstaett.de

1 - Assortment planning and inventory management under stock-out based substitution for perishable products
Rob Broekmeulen, OPAC, TU Eindhoven, P.O. Box 516, Pav. E10, 5600 MB, Eindhoven, -, Netherlands, r.a.c.m.broekmeulen@tue.nl, *Karel van Donselaar*
We study a combined assortment planning and inventory optimization problem for perishable products in a retail environment with stock-out based demand substitution. We develop a fast heuristic which enables the joint determination of optimal assortments and optimal reorder levels. We evaluated the impact of demand substitution on expected profit, outdating, assortment size and product availability. The impact of demand substitution on profit and outdating is large for product subcategories with a large assortment size, low total demand for the assortment, and small product lifetimes.

2 - Retail assortment, shelf space and inventory planning
Alexander Hübner, Operations Management, Catholic University Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, Germany, alexander.huebner@ku-eichstaett.de, *Heinrich Kuhn*, *Sabine Raettig*
Managing assortment, shelf space and inventory is a core decision in retail, as increasing product variety is in conflict with the limited shelf space. A retailer needs to define assortment size, assign shelf space and define reorder volume which then meets stochastic consumer demand. Our goal is to describe the underlying planning problem and develop a Newsboy-model. We describe a capacitated multi-product assortment, shelf space and inventory management problem under stochastic demand and substitution effects. Our numerical examples show significant impact of substitution effects.

3 - Modeling Category Captaincy with Asymmetric Manufacturers
Udatta Palekar, Business Administration, University of Illinois at Urbana-Champaign, 350 Wohlers Hall, 1206 S. Sixth Street, 61820, Champaign, Illinois, United States, palekar@illinois.edu, *Erik Bushey*
Retailers are increasingly using category captains to manage multi-brand categories. We consider the asymmetric case where one brand has more brand-loyals than other. We develop a game-theoretic model to study the optimal strategy for the retailer and the two manufacturers. We present results that show when it is optimal for the retailer to select the smaller or larger manufacturer as a category captain. We find that for some situations it is not optimal for the retailer to have a category captain. We also discuss the gains/losses incurred by each player due to introduction of this category.

■ MA-32

Monday, 8:30-10:00
G8-1

Supply Network Dynamics and Disruption Management

Stream: Supply Chain Optimization
Invited session

Chair: *Dmitry Ivanov*, Supply Chain Management, Berlin School of Economics and Law, Germany, divanov@hwr-berlin.de

1 - Modeling and Analysis of Supply Chain Viability
Scott Mason, Clemson University, 124 Freeman Hall, 29634, Clemson, SC, United States, mason@clemson.edu, *Mariah Magagnotti*, *Kasin Ransikarbum*
Supply chain viability is a network's ability to grow, expand, recover, and/or develop. Today, the degree to which a supply chain possesses these important characteristics that we believe facilitate multi-dimensional performance is unmeasured. We present our research focusing on the question of how and where should organizations spend available resources in order to improve the viability of their supply chain? We motivate our research using a variety of different supply chain types: functioning supply chains, damaged/interrupted networks, and disturbed/re-organized chains.

2 - Disturbances and plan deviations: Process control loops and quantitative analysis
Dmitry Ivanov, Supply Chain Management, Berlin School of Economics and Law, Germany, divanov@hwr-berlin.de, *Boris Sokolov*
Integrated supply chain (SC) planning has been a visible research topic over the past two decades. Plan execution is subject to uncertainty. Disturbances may occur both in the flow/job shops and in the master planning environment and cause deviations in both schedules and master plans, influencing operative and tactical performance. Based on the mutli-disciplinary theory of quantitative analysis and practical cases, this study presents models and corresponding control processes for the control and adaptation of master plans and schedules in centralized multi-stage SCs.

3 - A State-space Model for Chemical Production Scheduling
Christos Maravelias, Univeristy of Wisconsin - Madison, United States, maravelias@wisc.edu, *James Rawlings*, *Kaushik Subramanian*
We express a general mixed-integer programming (MIP) scheduling model in state-space form, and show how common scheduling disruptions, which lead to rescheduling, can be modeled as disturbances. We also discuss how a wide range of scheduling models, with different types of decisions and processing constraints, can be expressed in state-space form. We hope that the proposed framework will lead to the development of scheduling solution methods with desired closed-loop properties, a topic that has received no attention in the process operations literature.

4 - Outsourcing negotiation under ambiguity and trustworthiness: A Real Options Approach
Yongling Gao, Business School, Central University of Finance and Economics, Haidian District Xueyuannan Road 39, 100081, Beijing, China, gyl@cufe.edu.cn, *T Driouchi*

We present an iterative negotiation method for partial outsourcing under ambiguity using real options with multiple-priors and bilevel programming. We obtain the lowest offer price for the vendor and optimal outsourcing proportion for the client, providing new insights into the role of (probabilistic) ambiguity in decision-making. We find that an increase in pessimism raises the vendor's offer price under NPV but has an equivocal effect on the price when considering real options effects. Meanwhile, the client unequivocally increases her optimal outsourcing proportion under more pessimism.

■ MA-33

Monday, 8:30-10:00
G8-3

Inventory management

Stream: Production and the Link with Supply Chains
Invited session

Chair: *Lionel Amodeo*, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie BP2060, 10000, Troyes, France, lionel.amodeo@utt.fr
Chair: *Jairo Montoya-Torres*, Universidad de La Sabana, Colombia, and University of Leeds, UK, Leeds University Business School, Woodhouse Lane, LS2 9JT, Leeds, United Kingdom, jrmontoy@yahoo.com

1 - Software design to storage centers, automation and optimization implementing EPC-RFID technologies
Luis Ramirez, Fundacion Centro de Investigacion en Modelacion empresarial del caribe, Cra 53 No 74-86 ofic 402, Barranquilla, Atlantico, Colombia, lramirez@fcimec.org, *Diana Ramirez*, *Jairo Montoya-Torres*, *Erick Maldonado*, *Miguel Jimenez*, *Lauren Castro*

This paper shows the development of a decision support system for managing storage centers, with radio frequency technology for automation and traceability and integrating optimization mechanisms and internal control processes. The paper shows in detail the system design and how to operate the software integration with storage center based on RFID-WMS multi-criteria optimization Involving processes like picking, slotting and routing, seeking the improvement of management practices, enhancing product traceability and showing process automation result of an applied research project.

2 - Solving the stochastic location-routing problem with ACO and Discrete-Event Simulation
Nilson Herazo, Universidad de la Sabana Colombia and FCIMEC Colombia, Barranquilla, Atlántico, Colombia, ing.nilsonherazo@gmail.com, *Santiago Nieto*, *Jairo Montoya-Torres*, *Luis Ramirez*, *Andres Munoz Villamizar*

We consider the minimisation of total travel cost in the location-routing problem (LRP) in which travel times and costs are both stochastic. A hierarchical solution approach based on Ant Colony Optimisation and Discrete-Event Simulation is proposed. Experiments are carried out using random data. Since this version of the problem has not been previously studied in the literature, the proposed ACO-DES approach is compared against the non-stochastic version. Results are discussed in order to assess the actual impact of the system's stochastic behaviour.

3 - Two-Stage Supply Chain Integration: Inventory Management and Liner Service Optimization
Ali Cheaitou, College of Engineering - Industrial Engineering and Management Department, University of Sharjah, Sharjah University City, 27272, Sharjah, United Arab Emirates, ali.cheaitou@graduates.centraliens.net, *Pierre Cariou*

When determining the optimal speed and number of vessels in a liner service, shipping companies would maximize their profit, although this choice may lead to significant increase in the transit time and consequently to a rise in inventory holding costs incurred by shippers. This paper proposes a model to investigate this trade-off in liner shipping market, through a comparison of a decentralized and a centralized system. Assuming that transport demand is normally distributed, this article provides an optimization procedure along with an application to Europe/Far East services.

4 - Continuous Time Control of Make-to-Stock Production Systems
Murat Fadiloglu, Industrial Engineering, Yasar University, Yasar Universitesi Endustri Muhendisligi Bolumu, Universite Caddesi Bornova, 35100, Izmir, Turkey, murat.fadiloglu@yasar.edu.tr

We consider the problem of production control and stock rationing in a make-to-stock production system with multiple servers —parallel production channels–, and several customer classes that generate independent Poisson demands. At decision epochs, in conjunction with the stock allocation decision, the control specifies whether to increase the number of operational servers or not. Previously placed production orders cannot be cancelled. We both study the cases of exponential and Erlangian processing times and model the respective systems as M /M /s and M /Ek /s make-to-stock queues.

■ MA-34

Monday, 8:30-10:00
G8-4

Supply Risk and Reliability

Stream: Supply Chain Risk Management
Invited session

Chair: *Suresh Sethi*, Jindal School of Management - ISOM, University of Texas at Dallas, 800 W. Campbell Rd. SM30, 75080, Richardson, TX, United States, sethi@utdallas.edu

1 - How Does Pricing Power Affect a Firm's Sourcing Decisions from Unreliable Suppliers?
Suresh Sethi, Jindal School of Management - ISOM, University of Texas at Dallas, 800 W. Campbell Rd. SM30, 75080, Richardson, TX, United States, sethi@utdallas.edu, *Tao Li*

We study sourcing decisions of price-setting and price-taking firms with unreliable suppliers. We define a supplier's reliability in terms of the "size' or "variability' of his random capacity. With a price-setting firm, a supplier wins a larger order by increasing reliability. It is not always so with a price-taking firm.

2 - A reference model for analyzing corporate supply risk regarding scarce resources and components
Mario Dobrovnik, Institute of Transport and Logistics Management, Vienna University of Business and Economics, Nordbergstrasse 15, 1090, Vienna, Vienna, Austria, mario.dobrovnik@wu.ac.at

This paper introduces a reference model for analyzing corporate supply risk. It is an instrument for evaluating risk-mitigating strategies and serves as a source of information for knowledge-based risk decisions. It is based on product-related and environmental aspects as well as on the supply chain's structure. Furthermore, a company's knowledge about product composition, purchasing markets, and its supply chain are considered. The presented model enables firms to holistically assess their purchasing practices in a standardized way and to take strategic action within its risk appetite.

3 - Critical Social Networking Project Team Attributes for Successful New Product Development
Stamatia Kylindri, Institute of Technology and Innovation, University of Southern Denmark, Niels Bohrs Allé 1, DK-5230, Odense, Denmark, skilindri@gmail.com, *George Blanas*, *Stoyan Tanev*, *Leif Henriksen*

The paper reviews the literature and identifies the social networking team attributes in relation to successful new product development projects and normalizes the outcome into a list of well defined attributes that are evaluated by project management professionals using the Critical Success Factors methodology and Delphi reiteration. The short list of critical attributes contributes to the development of a theoretical model for successful new product development.

■ MA-35

Monday, 8:30-10:00
G8-2

Production Management & Supply Chain Management 1

Stream: Production Management & Supply Chain Management (contributed)
Contributed session

Chair: *Moueen Salameh*, Engineering Management, American University of Beirut, POBox 11-0236, Bliss Street, Beirut, Lebanon, msalameh@aub.edu.lb

1 - Response to Stockout: Lateral Transshipment versus Emergency Order Policies

Yi Liao, Southwestern University of Finance and Economics, China, yiliao@swufe.edu.cn

Stockout has a significant impact on firms' profitability. When stockout takes place, a retailer may adopt two strategies: placing an emergency order, or arranging lateral transshipment. This research is to analyze the optimal decisions for each strategy, as well as to provide criteria for selecting the best strategy. Our work distinguishes itself with existing literature by incorporating customers' reaction into the model - we assume that a customer facing stockout may choose to give up purchase, or wait for delivery, or may go to a partner store to search for the product.

2 - Myopic control of stochastic inventories with intermittent updates: continuous versus periodic replenishment

Matan Shnaiderman, Management, Bar-Ilan University, 52900, Ramat-Gan, Israel, shnidem@biu.ac.il

A manufacturer who is responsible for supplying a retailer with a single product is considered. The retailer sells the product in response to stochastic demand and provides the manufacturer with periodic updates about his inventories. The manufacturer, who is responsible for the retailer's inventories, can replenish them continuously or periodically. The myopic replenishment policies are of a base-stock type. The selected policies become optimal as the number of review periods tends to infinity. The two replenishment alternatives are compared in terms of base-stock levels and expected costs.

3 - Launching Experiential Products: Implications of Social Learning in a Market of Heterogeneous Consumers

Yiangos Papanastasiou, London Business School, nw14sa, London, United Kingdom, yiangosp.phd2010@london.edu

We consider a monopolist offering a new product of unknown quality to a market of customers with heterogeneous preferences, over two periods. First period buyers experience and review the product, while customers remaining in the market observe the early reviews, update their beliefs over product quality and make purchasing decisions in the second period. We investigate the firm's optimal pricing and inventory policy. We identify the trade-offs associated with the firm's decisions and derive a number of interesting insights, including the optimality of early firm-induced supply shortages.

4 - Joint Replenishment Model with Substitution

Moueen Salameh, Engineering Management, American University of Beirut, POBox 11-0236, Bliss Street, Beirut, Lebanon, msalameh@aub.edu.lb, *Bacel Maddah*, *Ali Yassine*

Traditional multi-item inventory systems use the joint replenishment model (JRM) to determine optimal inventory levels, where the amounts to order are designed to minimize the joint holding and ordering costs. This paper extends the work on the JRM by introducing substitution between products by determining the optimal number of units to order for each product so that demand is met and the total cost associated with the delivery and storage of the products is minimized.

■ MA-36

Monday, 8:30-10:00
G7-1

Preference Learning I

Stream: Preference Learning
Invited session

Chair: *Willem Waegeman*, NGDATA, Dok-Noord 7, 9000, Ghent, Belgium, willem.waegeman@ugent.be

1 - Preference Learning from Different Perspectives

Krzysztof Dembczynski, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, kdembczynski@cs.put.poznan.pl, *Roman Slowinski*, *Willem Waegeman*

This is an introductory talk of the stream on Preference Learning. The aim of the stream is to bring together researchers that have been working on preference learning and related research topics in different domains such as multicriteria decision aiding, artificial intelligence, recommender systems and machine learning. Therefore in this talk we will discuss similarities and differences between these domains in understanding and dealing with preference learning problems. We will also try to characterize the main challenges of preference learning from the viewpoint of these different domains.

2 - Multiple criteria ranking with additive value models and holistic pair-wise preference statements

Tommi Tervonen, Econometric Institute, Erasmus University Rotterdam, PO Box 1738, 3033HA, Rotterdam, Netherlands, tervonen@ese.eur.nl, *Milosz Kadzinski*

We consider a ranking problem where the decision alternatives are evaluated deterministically on multiple criteria. We apply additive value models with indirect DM preferences in form of pair-wise comparisons of reference alternatives. These define a set of compatible value functions that is analyzed for describing the possible and necessary preference relations, probabilities of the possible relations, ranges of ranks the alternatives may obtain, and the distributions of these ranks. We show how the different results complement each other, discuss extensions, and present an application.

3 - Elicitation of Non-linear Utility Models

Paolo Viappiani, CNRS - LIP6, LIP6, UPMC, Case 169, 4 Place Jussieu, 75005, Paris, France, paolo.viappiani@gmail.com, *Patrice Perny*, *Christophe Gonzales*

Recently there has been a growing interest in non-linear utility models to represent the preferences of a decision maker. Such models are expressive as they are able to represent synergies between criteria, such as compensatory effects. This is the case of the discrete Choquet integral, a very flexible aggregator that subsumes linear models, leximin/lexicographic, the OWA operator. A key question is how to assess the parameters required in order to use such models. In this work, adopting a principled decision-theoretic approach, we consider adaptive elicitation with minimax regret.

4 - New perspectives on the problem of learning how to order high dimensional data

Nicolas Vayatis, Mathematics, CMLA - ENS Cachan, CMLA - ENS Cachan, 61, av. du Président Wilson, 94230, Cachan, France, nicolas.vayatis@gmail.com, *Stephan Clémençon*

We consider the scoring approach for the inference of an order relationship from high dimensional data when ordinal labels (ratings) are available. In this setting, few algorithms are known with theoretical

guarantees for consistency and well-posedness. In the talk, key issues will be addressed such as the functional character of the performance measure (e.g., ROC surfaces) and the principle of aggregation of decision rules when local averaging is meaningless. Recent advances on optimality and aggregation for nonparametric scoring opens new perspectives of the design of efficient algorithms.

■ MA-37

Monday, 8:30-10:00
G7-4

Robust and Uncertain Multiobjective Optimization

Stream: Multicriteria Decision Making
Invited session

Chair: *Erin Doolittle*, Department of Mathematical Sciences, Clemson University, O-110 Martin Hall, Box 340975, 29634, Clemson, South Carolina, United States, edoolit@clemson.edu
Chair: *Margaret Wiecek*, Department of Mathematical Sciences, Clemson University, Martin Hall O-208, 29634, Clemson, SC, United States, wmalgor@clemson.edu

1 - Robustness for multi-objective optimization and its relation to set-valued optimization

Jonas Ide, Fakultät für Mathematik, Georg-August-Universität Göttingen, Germany, j.ide@math.uni-goettingen.de, *Anita Schöbel*, *Christiane Tammer*

Robust optimization deals with uncertainties of the input data of a given optimization problem and in single objective problems many different definitions of robustness exist. In this talk we present different concepts of robust efficiency for multi-objective problems. We show that these concepts are closely connected to set-valued optimization problems and can be obtained by different set orderings for these problems. We investigate connections of these concepts, present algorithms for computing robust efficient solutions and conclude the talk by pointing out possible areas of application.

2 - Robust Pareto Points in Multiobjective Programming

Erin Doolittle, Department of Mathematical Sciences, Clemson University, O-110 Martin Hall, Box 340975, 29634, Clemson, South Carolina, United States, edoolit@clemson.edu, *Hervé Kerivin*, *Margaret Wiecek*

Traditional approaches to robust optimization deal with uncertain coefficients in the problem constraints no matter where these coefficients are located in the original problem. In multiobjective programmming, not only the coefficients but the number of objective functions may be uncertain. An uncertain multiobjective program (UMOP) with an uncertain, possibly infinite, number of objective functions is considered. Under some conditions, the UMOP can be reduced to a problem with a finite number of objective functions while the Pareto set remains unchanged.

3 - Established Approach to Robust Multiobjective Linear Programming

Margaret Wiecek, Department of Mathematical Sciences, Clemson University, Martin Hall O-208, 29634, Clemson, SC, United States, wmalgor@clemson.edu, *Erin Doolittle*, *Hervé Kerivin*

The approach of Ben-Tal and Nemirovski to robust optimization is applied to two classes of uncertain multiobjective linear programs (MOLPs) to yield two types of robust Pareto points. Assuming polyhedral uncertainty, the first class includes MOLPs with uncertain constraint coefficients, while the other class pertains to uncertain parameters scalarizing the MOLP into a single objective program. The robustness of a Pareto point is reflected in the feasibility of this point for any realizable constraint coefficient or in the efficiency of this point for any choice of the scalarizing parameter.

4 - Scenario-Based Approach to Uncertainty in Goal Programming

Theodor Stewart, Statistical Sciences, University of Cape Town, Upper Campus, 7701, Rondebosch, South Africa, Theodor.Stewart@uct.ac.za

We have developed an integrated scenario planning - MCDA approach, introducing the concept of metacriteria as performance measures according to different criteria within distinct scenarios. We apply this general approach to goal programming models, with the aim of generating policies which are satisficing in terms of objectives and scenarios. The objectives are again handled as metacriteria. Constraint violations under different scenarios can be handled as for stochastic programming with recourse, with the recourse variables viewed as additional objective functions in the same model.

■ MA-39

Monday, 8:30-10:00
G7-3

Analytic Hierarchy Process 1

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Sebnem Burnaz*, Management Engineering, Istanbul Technical University, ITU Isletme Fakultesi, Macka, 34357, Istanbul, Turkey, burnaz@itu.edu.tr

1 - Début of MCDM in Museum: Strategic Transformation of the Topkapi Palace Museum

Mine Isik, Industrial Engineering Department, Dogus University, Zeamet S. No:21, Acibadem Kadikoy, 34722, Istanbul, -, Turkey, misik@dogus.edu.tr, *Oguz Baburoglu*, *Y. Ilker Topcu*

As the challenge of managing the balance between preservation and usage of a cultural heritage can be addressed within a long-term perspective incorporated in a strategic plan, this study aims to reveal such a strategic plan that diminishes the threat to lose its cultural value that Topkapi Palace Museum confronted. For this purpose to generate a road map for the transformation of Topkapi Palace Museum into a masterpiece museum through an AHP based decision conference organized upon the European Capitals of Culture Advisory Board request. The conference outputs are explained for that manner.

2 - Application of Analytic Hierarchy Process (AHP) in Supplier selection of Virtual Enterprise

Kamal Hariche, Commercial science, Bejaia University, Bejaia, Algeria, hariche_kamal@yahoo.fr

Supplier selection is a critical issue in the research of virtual enterprises (VE) which is believed to be multi-criteria decision making problem. Indeed, sales entities in VE should select the appropriate suppliers for outsourcing activities to meet their cost and time constraints while maximizing their profits. This paper addresses this challenge and proposes a methodology based on AHP to evaluate the best supplier in a discrete case. To achieve this end, AHP includes the main crucial factors for supplier selection, namely activity cost, delivery and failure risk.

3 - Multi-Criteria Decision Support System for the Selection of Basketball Players

Yildiz Yulugkural, Industrial Engineering Department, Kocaeli University, Turkey, yildiz.yulugkural@kocaeli.edu.tr, *Burcu Ozcan*, *Ozlem Aras*

Decision Support Systems facilitates the process of effective decision-making problems with a large number of criteria. In this context many methods are used and Analytic Hierarchy Process (AHP) is one of the techniques used to solve problems in a complex multi-criteria decision making. In literature, AHP method is applied to many different fields and many decision problems. In this study AHP method was used for basketball team players selection problem. Three different models were built by using data from European Basketball League. Thus, players will take place in the team were determined.

4 - A Decision Model for Preventing Seasonality in Chocolate Purchasing
Sebnem Burnaz, Management Engineering, Istanbul Technical University, ITU Isletme Fakultesi, Macka, 34357, Istanbul, Turkey, burnaz@itu.edu.tr, *Fatma Vatansever*, *Sinem Ipek*, *Y. Ilker Topcu*

This research study proposes a multi criteria decision model which will aid chocolate manufacturers in their decision process for finding an appropriate response to prevent seasonal variation in chocolate purchase intention. For increasing sales of chocolate products in summer, based on the judgments of the managers from two chocolate manufacturers in a local market; the proposed approach reviews, identifies, and prioritizes evaluation factors as well as alternative courses of actions. The paper finally compares the findings for two manufacturers.

■ MA-40

Monday, 8:30-10:00
Y12-1

Decision Analysis, Decision Support Systems I

Stream: Decision Analysis, Decision Support Systems, DEA and Performance Measurement (contributed)
Contributed session

Chair: *Emel Kizilkaya Aydogan*, industrial engineering, erciyes university, erciyes university, department of industrial engineering, 38039, Kayseri, Turkey, ekaydogan@erciyes.edu.tr
Chair: *Ramon Flores*, Universidad Carlos III, 28270, Madrid, Spain, rflores@est-econ.uc3m.es

1 - Branch Location in a reconfigured Bank Branch Community
Maria Mavri, Business Administration, University of the Aegean, 8 Michalon Street, 82100, Chios, Greece, m.mavri@ba.aegean.gr, *Michail Bekiaris*

Based on earlier work, where we had proposed an algorithm for reconfiguring branch network according to the dictates of the market, the internal bank resources and the strategic policy constraints, we have determined the optimum number of branches that should operate in a specified geographical area. In this study we are seeking to define the "location" for each branch in the area under examination. The goal of this study is to develop an algorithm for determining the location of branches in the community and estimate its new optimum performance.

2 - Home Advantage and the Importance of an Away Goal in a Two-legged Knockout Tournament
Ramon Flores, Universidad Carlos III, 28270, Madrid, Spain, rflores@est-econ.uc3m.es

Understanding how the outcome of a sports competition is affected by decisions on its design constitutes a relevant topic in OR.This paper analyzes the issue in the context of two-legged knockout competitions in European football, paying attention to the impact of playing the first leg at home and the importance of an away goal in the first leg. It examines the consequences of the design feature that goals scored away count double in the event that a tie breaker is required because the aggregate scores are equal after the two matches. Impacts from tournament seeding rules are also examined.

3 - A simulation-based model for improving the flow of patients through antenatal clinics in British hospitals
Jorge E. Hernández, School of Management, University of Liverpool, Liverpool, United Kingdom, J.E.Hernandez@Liverpool.ac.uk, *Hossam S. Ismail*, *Ted Adams*, *Andrew Weeks*

The process of delivering healthcare in UK hospitals has become complex with multiple services interacting. Service delays can mean a long wait for patients. Our research has identified operational and decision-making solutions to problems with patient flow. We have examined how patients move through the antenatal clinic in a large freestanding UK National Health Service maternity hospital. Based in a unified simulation-based model, a variety of scenarios are considered and the outputs compared to support hospital managers and the minimisation in patients waiting times and maximise efficiency.

4 - Design of a decision support system (DSS) model for a fault-tolerant control applied in an automatic product handling process line using Petri Net and its extensions.
Joao Campos, Science and Technology Department, Universidade Estadual de Santa Cruz - UESC, Rua Pedro II n. 58, ap. 2 - Pontal, 45654-110, Ilheus, Bahia, Brazil, joaothiagocampos@gmail.com, *Carlos Rodrigues*, *Robson Marinho da Silva*

Due to industrial automation, the decision support tools become required to all manufacturing systems. Faults in an automatic process may cause problems in a line production such as machines breaks, products defects and production time delay. Thus, the development of an integrated support decision and fault-tolerant models become the new solution which reduce costs and provide new informations for the support decision system. By using Petri net technique, a model was designed, integrating the fault-tolerant control and support decision models for an automatic product handling process.

■ MA-41

Monday, 8:30-10:00
Y12-5

DEA Applications VII

Stream: DEA and Performance Measurement II
Invited session

Chair: *Elvan Akturk Hayat*, Statistics, Sinop University, Faculty of Arts and Sciences, Department of Statistics, 57000, Sinop, Turkey, elvanakturk@gmail.com

1 - Explaining inefficiency in nonparametric production models: the state of the art
Luiza Badin, Applied Mathematics, Bucharest University of Economic Studies, Romania, luiza.badin@csie.ase.ro, *Cinzia Daraio*, *Léopold Simar*

The performance of economic producers is often affected by external or environmental factors that, unlike the inputs and the outputs, are not under the control of the Decision Making Units (DMUs). These factors can be included in the model as exogenous variables and can help explaining the efficiency differentials and improving the managerial policy of the evaluated units. In this paper we present a fully nonparametric procedure that allows us to make local inference and to provide confidence intervals for the impact of the external factors on the production process.

2 - Predicting financial distress by panel data: an application of Malmquist DEA models
Zhiyong Li, Business School, University of Edinburgh, Room 3.02, 29 Buccluech Place, EH9 8JS, Edinburgh, Scotland, United Kingdom, zhiyong.li@ed.ac.uk, *Jonathan Crook*, *Galina Andreeva*

Predicting bankruptcy or financial distress in the field of corporate credit risk management is the fundamental task for both academics and the professionals. Corporate efficiency calculated by Data Envelopment Analysis starts to receive many attentions in recent literature. This research focus on panel data and use dynamic models to firstly calculate efficiencies by Malmquist DEA and then make prediction on the probability of distress in the new period. Three industries of Chinese firms are tested. Technical, Pure Technical and Scale efficiencies are found to be significant in prediction.

3 - Using k- nearest neighbor method for determining the weight constraints in data envelopment analysis
Elvan Akturk Hayat, Statistics, Sinop University, Faculty of Arts and Sciences, Department of Statistics, 57000, Sinop, Turkey, elvanakturk@gmail.com, *Olcay Alpay*

In recent years, data envelopment analysis is a method commonly used to measure the efficiency. On the contrary to classical efficiency approaches, the most important advantage of data envelopment analysis is that researchers can determine the weights constraints of inputs and outputs variables. In this study, we aim to use the k-nearest neighbor algorithm at the stage of determining the weights. An application is constructed with an empirical data set depending on the specified weights in data envelopment analysis and the results are interpreted.

■ MA-42

Monday, 8:30-10:00
Y12-3

Decision Processes for Societal Problems

Stream: Decision Processes
Invited session

Chair: *Luis C. Dias*, Faculdade de Economia / INESC Coimbra, INESC Coimbra, Rua Antero de Quental, 199, 3000-033, Coimbra, Portugal, lmcdias@fe.uc.pt

1 - Model specification based validation of decision support for business use: The case of EnRiMa
Aron Larsson, Dept. of Computer and System Sciences, Stockholm University, 16440, kista, Stockholm, Sweden, aron@dsv.su.se, *Martin Henkel*

At the heart of a decision support system exploiting OR methods is a model specification. In the project Energy Efficiency and Risk Management in Public Buildings we use a symbolic model specification to validate the DSS in for future use and business value. On the business level we validate business fit in relation to desires, such that objective functions are in line with business goals and that actions can be taken from decision variable output. On a technical level we validate that parameters are available and sufficient, and can be integrated into existing management systems.

2 - Managing Complex Projects for Industry: developing a new approach to risk management
Susan Howick, Dept of Management Science, University of Strathclyde, 40 George Street, G1 1QE, Glasgow, United Kingdom, susan.howick@strath.ac.uk, *Fran Ackermann*, *Lesley Walls*, *John Quigley*, *Tom Houghton*

This presentation discusses a project undertaken for an energy company. A process is described which assists the company to understand and manage risks involved with the project. The process involves two integrated activities; the first engages a range of stakeholders in surfacing risks and their ramifications in a causal risk map, while the second elicits expert judgement regarding uncertainties so as to understand the likelihood of risks occurring through a decision tree approach. The process has potential across a range of complex project management situations.

3 - Sustainability in multi-criteria decision making: a review of life-cycle assessment applications
Miguel Morgado, INESC Coimbra and Faculty of Economics - University of Coimbra, Portugal, miguel.morgado@sapo.pt, *Ana Rita Domingues*, *Luis C. Dias*

Different tools have been used to evaluate the performance of products in terms of their sustainability, but just a few include all sustainability dimensions (economic, social and environmental). Life-Cycle Assessment (LCA) has been combined with Multi-Criteria Decision Making (MCDM) methods to evaluate decision alternatives with comprehensive information, enabling a complete analysis of the sustainability of a product. We present a literature review and consequent relevant results of the combined use of MCDM and LCA, offering a clear panorama of the current frameworks and practices.

4 - Including Social Choice Fairness Measures in Operations Research
Antonios Glampedakis, Mathematics, University of Portsmouth, Lion Gate Building, PO1 3HF, Portsmouth, United Kingdom, antonios.glampedakis@port.ac.uk, *Dylan Jones*, *Djamila Ouelhadj*, *Simon Martin*

Many operations research (OR) problems judge societies on the frequency distribution of an attribute. Due to the lack of research regarding measures of evaluating societies in OR, those measures can be adopted from other disciplines. A range of potential measures are tested on the criteria of computational cost feasibility and desired social welfare properties. Beside utilitarian and egalitarian measures, combination using MCDM methods is investigated. Hence OR models are augmented with concepts from Social Sciences and Economics, to gain a more in depth view of fairness in problem solving.

■ MA-43

Monday, 8:30-10:00
Y12-2

Experimental Economics and Game Theory 1

Stream: Experimental Economics and Game Theory
Invited session

Chair: *Ulrike Leopold-Wildburger*, Statistics and Operations Research, Karl-Franzens-University, Universitätsstraße 15/E3, 8010, Graz, Austria, ulrike.leopold@uni-graz.at

1 - Transfer of bargaining power in the Serrano-Krishna bargaining game
Haruo Imai, KIER, Kyoto University, Yoshida HOnmachi, Sakyo, 606-8501, Kyoto, Japan, imai@kier.kyoto-u.ac.jp, *Ryosuke Ishii*

We extend one interpretation of the rule of the game in Serrano and Krishna (1996) (one of the papers yielding the unique perfect equilibrium for the multi-person bargaining game), a purchase of bargaining position. From the perfect equilibrium outcomes of a bargaining game with this interpretation, we show that transfers do take place and results differ from the original model, by means of a example. Thus this adds one case for the group behavior affecting the bargaining outcomes. Resulting equilibria are not unique and depend upon ordering, including the one wuite favorable to the proposer.

2 - Solution of the General Equilibrium Models With the Results of the Geometric Programming
Gábor Lovics, Budapest University of Technology and Economics, Hungary, lovixg@gmail.com, *Tibor Illés*, *Marianna Nagy*

Arrow & Debreu proved the existence of the general equilibrium models solution in a very general case. In their paper, no computational method was published. From the results of Eisenbeg & Gale we know that the solution of linear exchange model, can be computed as an optimal solution of a convex optimization problem. Since this paper some generalization of their result has been discovered. In our presentation we discuss the connection of the E & G problem and the geometric programming problem pairs. Furthermore, some possible application of geometric programming problem will be explained.

3 - Strategic delay and optimal contracts for teams
Constantine Sorokin, National Research University Higher School of Economics, Moscow, Russia, Russian Federation, constantine.sorokin@gmail.com

I consider a collective contract problem. First, the principal offers a contract and then the agents decide to either work or shirk; their actions are unobservable by principal. The key feature of the model is that it allows agents to wait before making up their mind; however, the probability of overall success decreases over time. The talk addresses agent discrimination in optimal contract and the possible non-monotonicity of effort as agents' wage increases.

■ MA-45

Monday, 8:30-10:00
Y10-3

Mathematical Models in Macro- and Microeconomics 1

Stream: Mathematical Models in Macro- and Microeconomics
Invited session

Chair: *Alexander Vasin*, Operations Research, Lomonosov Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su

1 - Mechanisms of corruption suppression: role of the moral level of employees
Pavel Nikolaev, Operations Research, Lomonosov Moscow State University, MSU, Faculty of Computational Mathematics and Cybernetics, Russia, 119991, Moscow, GSP-1, 1-52, Leninskiye Gory, 119991, Moscow, Russian Federation, pavel.nikolaev@unicredit.ru, *Alexander Vasin*

Government agencies and large corporations meet similar problems related to control of agents dealing with outsiders: citizens under audit of the agency or clients of the company. In such interaction there typically exists a possibility of collusion. In order to prevent it, agencies and corporations usually organize hierarchical controlling structures. The present paper considers game-theoretic models of such structures with agents who differ by moral level (in terms of voluntary honest behavior) and studies a problem of their optimal organization.

2 - Hierarchical Organizations and Economic Growth
Zvi Winer, Economics, Western Galilee College, P.O.Box 7617, 20692, Yokneam, Israel, ZvikaV@wgalil.ac.il, *Benjamin Bental*

This paper studies the interrelationship between the size of firms, their hierarchical structure and economic growth. Production workers and managers need to be supervised and organizations trade-off the number of production workers and their effort against the overhead associated with the hierarchical structure. This tradeoff is affected by the amount of capital firms employ. Increased capital intensity implies larger firms with longer hierarchical structures. Along the growth path firms are growing, their number is declining, productivity is rising, hierarchies are deepening.

3 - Do we go shopping downtown or in the bubs? Well, why not to both?
Igor Sloev, Management, National Research University Higher School of Economics, Kirpichnaya ul., 33, of. 807, 105187, Moscow, Russian Federation, isloev@hse.ru

We combine spatial competition with monopolistic competition to study market interactions between retailers and a shopping mall located at the endpoints of a linear city. The market solution is the outcome of the interplay between two opposing effects: the market expansion effect and the standard competition effect. Firms' profits increase or decrease with the entry of competitors according to the relative size of the centers. The size of the central business district become arbitrarily small, but it may suddenly vanish when the shopping mall is sufficiently large.

4 - The agent-based simulation of the stock exchange behavior
Lyudmila Egorova, National Research University Higher School of Economics, Moscow, Myasnitskaya street, 20, Moscow, Myasnitskaya street, 20, 101000, Moscow, Russian Federation, lyude@inbox.ru, *Henry Penikas*, *Artem Bondarenko*

We represent a stock exchange as a flow of events of two types — "regular" and "crisis" events. Player does not know in advance the type of coming event and must identify it. Player's welfare depends on the success of its recognition. It was shown that successful identification of regular events in more than half of the time allows the player to have a non-negative average gain. Also we analyze the problem of the threshold separating the events on the stock exchange, and other parameters depending on this threshold and introduce a simulation model based on such framework and its results.

■ MA-46

Monday, 8:30-10:00
Y10-1

Game Theory and Applications

Stream: Game Theory, Solutions and Structures
Invited session

Chair: *Gianfranco Gambarelli*, Management, Economics and Quantitative Methods, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, gambarex@unibg.it

1 - Hierarchical strength on communication structures
Chris Dietz, Econometrics, VU University Amsterdam, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, cdietz@feweb.vu.nl, *Encarnación Algaba*, *Rene van den Brink*

In this paper, we first axiomatize the hierarchical strength for acyclic digraphs, and establish that any positive power measure can be applied to define a solution for acyclic digraphs using the corresponding hierarchical strength axiom. Next, we axiomatize the normalized hierarchical strength for two special classes of digraphs, namely, rooted and sink forest.

2 - On Proper Shapley Values for Monotone TU-Games
Rene Levinsky, Max Planck Institute of Economics, D-07745, Jena, Germany, levinsky@econ.mpg.de, *Rene van den Brink*, *Miroslav Zeleny*

The Shapley value of a cooperative TU-game distributes the dividend of each coalition in the game equally among its members. Given exogenous weights for all players, the corresponding weighted Shapley value distributes the dividends proportionally to their weights. A proper Shapley value (Vorobjev and Liapunov, 1998) assigns weights to players such that the corresponding weighted Shapley value of each player is equal to her weight. In this contribution we prove the existence of proper Shapley values for all monotone TU-games and discuss other properties of this solution.

3 - Understanding the effect of Individual Behaviour in Hierarchical Queues
Vincent Knight, School of Mathematics, Cardiff University, CF24 4AG, Cardiff, United Kingdom, Knightva@cf.ac.uk

Selfish users in queueing systems make busier systems. A measure of the inefficiency caused by selfish agents is often referred to as the Price of Anarchy (PoA). Measuring the PoA in systems of hierarchical queues is the subject of this talk. Various models will be presented and a variety of solution approaches considered. The work presented has a wide variety of applications which include a healthcare setting where patients often make decisions based on waiting lists as they go through a hierarchical system of healthcare services.

4 - Some open problems in Cooperative Games
Gianfranco Gambarelli, Management, Economics and Quantitative Methods, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, gambarex@unibg.it

Some theoretic and applicative problems of cooperative games currently being studied at the Universities of Bergamo, Krakov and Monterey are presented. Short References: Fragnelli, V. and G. Gambarelli (eds.) (2013) Open Problems in the Theory of Cooperative Games, a Special Issue of the International Game Theory Review (forthcoming). Fragnelli, V. and G. Gambarelli (eds.) (2013) Open Problems in Applications of Cooperative Games, a Special Issue of the International Game Theory Review (forthcoming).

■ MA-47

Monday, 8:30-10:00
Y10-2

Pricing Strategies and Consumer Behavior

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Pnina Feldman*, Haas School of Business, University of

California Berkeley, 545 Student Services Bldg #1900, 94720, Berkeley, CA, United States, feldman@haas.berkeley.edu

1 - Pricing Reservations

Pnina Feldman, Haas School of Business, University of California Berkeley, 545 Student Services Bldg #1900, 94720, Berkeley, CA, United States, feldman@haas.berkeley.edu, *Kate Ashley*

Many firms offer reservations for service in future periods. Recently, some firms have started to charge for reservations by implementing different pricing strategies. This paper proposes alternative reservation pricing schemes, characterizes optimal prices and revenues under each scheme, and discusses managerial implications.

2 - A Field Experiment in the Auctioning of Excess Inventory in B2B Markets

Wedad Elmaghraby, R.H. Smith School of Business, University of Maryland, Decision and Information Technology, 20742, College Park, MD, United States, welmaghr@rhsmith.umd.edu

Although product assortment problem has received plenty of attention in the marketing and operations literature in recent years, it is yet unexplored in the auction literature. In this paper, we report on the results of a field experiment that we ran on the auction site of one of the nation's largest online auction wholesale liquidation sites. The design of this field experiment was aimed at understanding how (i) the number of auctions, (ii) the assortment of products auctioned and (iii) the starting price of an auction impact an auction's final.

3 - Dynamic pricing with strategic consumers and social learning

Yuri Levin, School of Business, Queen's University, 143 Union str, K7L 3N6, Kingston, Ontario, Canada, ylevin@business.queensu.ca, *Mikhail Nediak*, *Doulton Wiltshire*

We present a dynamic pricing model for a monopolist offering a durable product to multiple segments of strategic consumers. Consumers use social learning to determine the true quality of the product in order to make their purchase decision. We study the structure of the optimal pricing policy of the monopolist in relation to consumer preference for quality and network parameters. We also evaluate the relative gains of offering free samples to high-influence individuals prior to the beginning of the main selling season, and using price discrimination between different consumer segments.

4 - Price Matching under Conditional Discounts in the Presence of Strategic Consumers

Gustavo Vulcano, Leonard N. Stern School of Business, New York University, 44 West Fourth Street, Suite 8-76, 10012, New York, NY, United States, gvulcano@stern.nyu.edu

We study a RM problem in which a seller operates an internal price match guarantee policy. Upon arrival, each consumer must decide to either buy at the full price or buy later at a discount price and run a supply risk. If there is a markdown in the end, the seller will refund the price difference to claimers who paid the full price. We analyze the equilibrium behavior of the consumers and the optimization problem of the seller, and illustrate with some numerical experiments.

■ MA-48

Monday, 8:30-10:00
Y11-1

Simulation Methods in Finance I

Stream: Simulation Methods in Finance
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Bo Zhang*, IBM T J WATSON RESEARCH CENTER, 1101 Kitchawan Road, 10598, Yorktown Heights, New York, United States, bozhang@gatech.edu
Chair: *Juraj Pekár*, Department of Operations Research and Econometrics, University of Economics, Dolnozemska 1, 85235, Bratislava, Slovakia, pekar@euba.sk

1 - Modelling and forecasting commodity prices using the Kalman filter

Paresh Date, Mathematical Sciences, Brunel University, John Crank building, UB8 3PH, Uxbridge, Middlesex, United Kingdom, paresh.date@brunel.ac.uk, *Suren Islyaev*

As futures contracts on commodities tend to be more liquid than the commodities themselves in the spot market, we can infer the future spot price behaviour by using prices of futures contracts. In our work, we apply Kalman filter to the state space system with log spot price as a latent state and log futures prices as measurements. We extend the model proposed by Manoliu and Tompaidis (2002) by adding seasonality to the spot-price process. We provide extensive in-sample as well as out-of-sample testing on real commodity price data to compare different models on three different commodities.

2 - Maximizing of Portfolio Performance using Evolutionary Approach

Juraj Pekár, Department of Operations Research and Econometrics, University of Economics, Dolnozemska 1, 85235, Bratislava, Slovakia, pekar@euba.sk, *Ivan Brezina*, *Zuzana Čičková*

Various mathematical models, which allow determining capital allocation over the number of assets on the base of performance measurement, can be used to support the decision making process about portfolio selection. Some of the performance measure, e.g., Sortino ratio, Omega function and the Sharpe Omega ratio are difficult to compute due to their substandard structures and therefore an alternative seems to be the use of evolutionary techniques that are considered to be effective tools to search for real-time solutions of many difficult optimization problems.

3 - Repayment Rate and Joint Liability in Supply Chain Financing

Yanhai Li, Department of Production Operation and Logistics Management, School of Management, Huazhong University of Science and Technology, 430074, Wuhan, China, xgliyh@hust.edu.cn, *Shiming Deng*

In cluster supply chain, the enterprise can select different partner to undertake joint liability for its loan from the bank. Joint guarantee loan falls into three types according to the undertaker of joint liability: horizontal liability, vertical liability and cross liability. The repayment rate is studied to compare the three types of joint guarantee loan under different market condition. The repayment rate depends on its risk appetite and system structure/parameters. We give the optimal type of joint liability under different system structure and conditions in terms of repayment rate.

■ MA-49

Monday, 8:30-10:00
Y11-2

Life Related Insurances and Financial Mathematics

Stream: Life Insurance, Risk and Ruin Theory, Financial Modelling
Invited session

Chair: *Busra Temocin*, Middle East Technical University, Turkey, btemocin@metu.edu.tr

1 - A Bayesian Approach to Modelling Turkish Mortality Rates and Pricing a Longevity Bond

Basak Bulut Karageyik, actuarial science, hacettepe university, Beytepe Campus, Cankaya, Ankara, Turkey, basakbulut@hacettepe.edu.tr, *Ayse Arik*, *Erengul Ozkok Dodd*, *Meral Sucu*

In this study we aim to model Turkish mortality rates with stochastic mortality models using a whole population data set. Bayesian approach and extreme value theory is applied to classical Lee-Carter method for estimating the mortality rates. Using these estimates, we employ risk cubic pricing method to price a bond which is written on longevity risk. Finally, we test the performance of the modelling and the pricing. Keywords: Bayesian approach, Lee-Carter method, Extreme value theory, Risk Cubic Pricing Method, Longevity Risk

2 - The dependence as insurable risk: one approach to design an insurance relate to long-term care
Ana M. Martin Caraballo, Economics, Quantitative Methods and Economic History, Pablo de Olvide University, Carretera de Utrera Km. 1, 41013, Sevilla, Spain, ammarcar@upo.es, *Patricia Herranz*, *M. Manuela Segovia-Gonzalez*, *Guerrero Flor*

The aging population has brought as a result the need for a new risk coverage: long-term care.We make an own statistical analysis that is appropriate to calculate the different probabilities of risk and then we will apply suitable actuarial techniques.We base on the Spanish survey of disability and dependency to carry on a study of the prevalence of dependence and construct life tables for dependents using different statistical techniques and based on previous studies using correspondence analysis and multivariate techniques to relate the different dependencies degrees with other variables.

3 - Using Medians in Portfolio Optimization
Stefano Benati, Department of Sociology, University of Trento, Via Verdi 26, 38100, Trento, Italy, stefano.benati@unitn.it

In the stream of Markovitz risk/return analysis, some portfolio optimization models are introduced by adopting the sample median instead of the sample mean as the portfolio efficiency measure. The reasoning is that the median is a robust statistic, which is less affected by outliers than the mean. The optimal median is paired with different risk measures, like VaR, CVaR, MAD and Max-Drawdown, resulting in 4 new Mixed Integer Linear Programming model. These models are tested on real financial data, and we observe that they give better results in terms of concrete profits than other models.

4 - Pension Fund Management for Turkish Individual Retirement System
Busra Temocin, Middle East Technical University, Turkey, btemocin@metu.edu.tr, *Sevtap Kestel*

In this study, we focus on the problem of optimal investment in pension funds in the context of de

fined contribution-individual retirement system. We consider a stochastic model to describe the fluctuating movements of the wealth and solve a stochastic optimal control problem to determine the optimal investment plan. To measure and manage the

financial risk, we assume a specialized stochastic hybrid model, under the real-world probability measure, for the risky asset dynamics.

■ MA-50

Monday, 8:30-10:00
Y11-3

Discrete Choice Modeling and Assortment Optimization

Stream: Discrete Choice Models: Estimation and Assortment Optimization
Invited session
Chair: *Vineet Goyal*, Columbia University, 10027, New York, NY, United States, vgoyal@ieor.columbia.edu

1 - A Markov Chain Approximation to Choice Modeling
Vineet Goyal, Columbia University, 10027, New York, NY, United States, vgoyal@ieor.columbia.edu, *Guillermo Gallego*, *Jose Blanchet*

The main challenges in assortment optimization are model selection, parameter estimation and optimization. We present a choice model capable of accurately approximating under mild conditions all random utility models via a Markov Chain substitution matrix. We show that the assortment optimization problem can be solved efficiently in polynomial time. Theoretical bounds and numerical examples show that the estimated choice probabilities are very accurate and selected assortments are near optimal.

2 - Assortment Optimization and Pricing under Multi-Level Nested Logit Model
Huseyin Topaloglu, School of Operations Research and Industrial Eng., Cornell University, School of ORIE, 223 Rhodes Hall, 14853, Ithaca, NY, United States, huseyin@orie.cornell.edu, *Guang Li*, *Paat Rusmevichientong*

We study assortment optimization and pricing problems under the multi-level nested logit model. In the assortment problem, the prices of the products are fixed and we find a revenue maximizing set of products to offer. In the pricing problem, the set of products to offer is fixed and we find a revenue maximizing set of prices. For the assortment problem, we show how to compute the optimal assortment efficiently. For the pricing problem, we give an iterative algorithm whose iterates converge to a stationary point of the expected revenue function.

3 - Assortment Optimization Under General Choice
Srikanth Jagabathula, IOMS, NYU Stern, 44 W 4th Street, KMC Rm 8-74, 10012, New York, NY, United States, sjagabat@stern.nyu.edu, *Vivek Farias*, *Devavrat Shah*

We consider the problem of finding the assortment of size at most C that maximizes revenues. This problem is provably hard for most of the important families of parametric of choice models, except the multinomial logit (MNL) model and a variant of the nested logit model. We propose a general algorithm to find the optimal assortment assuming access to only a subroutine that gives revenue predictions; this means that the algorithm can be applied with any choice model. We prove that when the underlying choice model is the MNL model, our algorithm finds the optimal assortment efficiently.

4 - Pricing Managed Lanes
Robert Phillips, Nomis Solutions, 1111 Bayhill Dr, 94066, San Bruno, CA, United States, robert.phillips@nomissolutions.com

We consider the problem of dynamically determining the tolls that maximize revenue for a managed lane operator – that is, an operator who can charge a toll for the use of some lanes on a highway while a number of parallel lanes remain free to use. Managing toll lanes for profit is becoming increasingly common as private contractors agree to build additional lane capacity in return for the opportunity to retain toll revenue. A critical consideration is that the toll for the managed lanes will influence congestion on both the managed (toll) and unmanaged (free) lanes.

■ MA-51

Monday, 8:30-10:00
Y11-4

Portfolio optimization 1

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session
Chair: *Jean-luc Prigent*, ThEMA, University of Cergy-Pontoise, 33, Bd du Port, 95011, CERGY-PONTOISE, France, jean-luc.prigent@u-cergy.fr

1 - Optimal portfolio selection with performance evaluation
Cristinca Fulga, Gheorghe Mihoc-Caius Iacob Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy, Calea 13 Septembrie No.13, Sector 5, 050711, Bucharest, Romania, fulga@csie.ase.ro

We propose a quantile- and disutility-based risk measure. We establish its properties and develop a portfolio selection model in the Mean-Risk framework using the proposed risk measure. We give equivalent formulations of the model which generate the same efficient frontier. We investigate the practical performance of the model on a portfolio composed of some of the most representative securities of the NYSE. The advantages of this approach compared to other Mean-Risk models are discussed and empirically proven.

2 - Risk-Return Prediction in the ISE-National Industrial Index and Determining of the Optimal Portfolio with Artificial Neural Networks
Mehmet Yavuz, Mathematics-Computer Science, Faculty of Science, Necmettin Erbakan University, Meram, 42090, Konya, Turkey, mehmetyavuz@konya.edu.tr, *Necati Özdemir*

In this study, risk-return forecasting has been considered by using the monthly average returns for the year 2010 of 140 stocks contained in ISE-National Industrial Index in relation with their active sizes, market capitalizations, trading volumes and equities. Besides, 50 equally weighted portfolios have been established without considering the criteria specified and tried to get the most optimal one of these portfolios. Also, risks and returns of these portfolios have been calculated. An ANN has been trained by using the founded values and testing process has been realized with this network.

3 - A non-uniform nested simulation algorithms in portfolio risk measurement
Saifeddine Ben Hadj, Louvain School of Management, Belgium, saifeddine.benhadj@uclouvain.be

We investigate the complexity of estimating quantile based risk measures, such as the Value at Risk, via nested Monte Carlo simulations. The simulation is nested where two-stage simulations are required. We propose a set of non-uniform algorithms to evaluate risk. The algorithms give more importance to scenarios that are more likely to have an impact on the estimator and considers the marginal changes in the estimator at each scenario. We demonstrate using experimental settings that our algorithms outperform the uniform one and results in a lower variance and bias given the same resources.

4 - Optimal Portfolio Positioning within Generalized Johnson Distributions
Jean-luc Prigent, ThEMA, University of Cergy-Pontoise, 33, Bd du Port, 95011, CERGY-PONTOISE, France, jean-luc.prigent@u-cergy.fr, *Naceur Naguez*

In this paper,we analyze the optimal portfolio positioning when the risky asset follows the generalized Johnson distribution. The solution is characterized for arbitrary utility functions and illustrated in particular for a CRRA utility. We illustrate how the profile of the optimal portfolio depends crucially on the investor's risk aversion and prudence. Our findings have important practical implications since they show how profiles of financial structured products, that are proposed to customers of financial institutions, must be selected when taking account of non Gaussian log-returns.

■ MA-52

Monday, 8:30-10:00
B13-1

Forecasting for Logistics and Supply Chain Management I

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Mohamed Zied Babai*, BEM-Bordeaux Management School, 680 cours de la libération, 33405, Talence, Gironde, France, mohamed-zied.babai@bem.edu
Chair: *John Boylan*, Business & Management, Bucks New University, Queen Alexandra Road, High Wycombe, United Kingdom, john.boylan@bucks.ac.uk

1 - A forecasting method for non-stationary spare parts demand
Laura Turrini, Logistics, Kühne Logistics University, Brooktorkai 20, 20457, Hamburg, Germany, laura.turrini@the-klu.org, *Joern Meissner*, *Cerag Pince*

Demand for spare parts can be strongly influenced by contextual events:for example, the sale of new items might increase the demand of an included component, while the cancellation of a maintenance contract will reduce demand drastically. Consequently, demand does not have to be stationary, as many classic models assume, but might follow a potentially complex lifecycle. We develop a forecasting method that deals with this non-stationarity of demand.Our algorithm implements a learning process for the parameters.We show the numerical experiments demonstrating the practical use of our new method.

2 - Self-Deciding Demand Forecast System for A Spare Parts Company
Başak Özçift, Industrial Engineering, Kocaeli University, Topcular Mah. 3069. Sk., No:3-B D:6 Golcuk, 41950, Kocaeli, Turkey, basakozcift@gmail.com, *Erhan Çiçek*, *Atakan Alkan*, *Zerrin Aladag*

Popular demand forecasting techniques in the literature (exponential smoothing, seasonal, trend & regular) were tried individually for parts. The parts could not be categorized easily. Thus, a self-deciding method has been proposed by corresponding the nearest 3rd months to the forecasting month. Self-deciding mechanism selects the mode of minimum absolute errors. The proposed method has good results for 4 of 7 months in terms of AMAPE in comparison with other methods and presents acceptable results (below 45%) for 5 of 7 months according to literature.

3 - Seasonal intermittent demand forecasting
Jose Luis Carmo, CIO and University of Algarve, Portugal, jlcarmo@ualg.pt, *Antonio Rodrigues*

We address the problem of forecasting irregularly spaced demand processes with seasonal effects. So far, this problem has received little attention in the literature, despite its relevance in several areas, including inventory and supply chain management. For that purpose, we demonstrate the applicability of EXIST, a new forecasting method based on recursive least squares, and assess its performance with both real and simulated time series.

4 - Forecasting Percentiles Using Empirical Distribution Functions
John Boylan, Business & Management, Bucks New University, Queen Alexandra Road, High Wycombe, United Kingdom, john.boylan@bucks.ac.uk

In many inventory management systems, the characterisation of the distribution of demand is challenging, because the data do not conform to any of the standard distributions. In this case, Empirical Distribution Functions may be used to forecast the percentiles required. Three types of Empirical Distribution approaches are examined in this paper: non-overlapping blocks, overlapping blocks and bootstrapping. Their properties are compared, and analyses are conducted to determine the effect of key parameters on estimation performance.

■ MA-53

Monday, 8:30-10:00
B13-2

Energy Economics I

Stream: Energy Economics
Invited session

Chair: *Fabrizio Lacalandra*, QuanTek S.r.L, via teulada, 00195, Roma, Italy, fabrizio.lacalandra@quantek.it

1 - New Zealand electricity spot market with transmission losses based on a real dataset
Eleftherios Couzoudis, Economics, University of Zurich, Chair for Quantitative Business Administration, Moussonstrasse 15, 8044, Zurich, Switzerland, eleftherios.couzoudis@business.uzh.ch, *Philipp Renner*

We present a model of the New Zealand electricity spot market with transmission losses, which is based on the Participation Code of the Electricity Authority. The goal is to avoid simplifications where possible. For this proof of concept we restrict the offers from energy producers to one price band and a static demand for the north island and for the south island. All functions are assumed to be polynomials. However we do not impose convexity on either the utility functions or the action sets. The Generalized Nash Equilibria is then computed by Polynomial Programming using a real data set.

2 - Accelerating the Convergence of MIP-based Unit-Commitment Problems by Simultaneously Tightening and Compacting the Formulation
German Morales-Espana, Institute for Research in Technology, Universidad Pontificia Comillas, C/ Santa Cruz de Marcenado 26, 28015, Madrid, Madrid, Spain, german.morales@iit.upcomillas.es, *Andres Ramos*

The Unit Commitment (UC) consists of optimal resource scheduling in electric power systems to minimize the total system operational costs. Creating tight or compact computationally efficient MIP formulations is a non trivial task because the obvious formulations are very weak or very large, and trying to improve the tightness (compactness) usually means harming the compactness (tightness). We propose an MIP-based UC that is simultaneously tight and compact. Consequently, the computational burden is significantly reduced in comparison with other UC formulations commonly found in the literature.

3 - Demand side participation for large consumers of electricity
Golbon Zakeri, Engineering Science, University of Auckland, Auckland, New Zealand, 1001, Auckland, New Zealand, g.zakeri@auckland.ac.nz

We will presents some models for dmand side participation for large consumers of electricity who can influence electricity prices. We will discuss these in the particular context of New Zealand, with NZ Steel as a large consumer of electricity in mind.

4 - Unit commitment and topology optimization for a smarter transmission grid in the non-programmable generation era
Fabrizio Lacalandra, QuanTek S.r.L, via teulada, 00195, Roma, Italy, fabrizio.lacalandra@quantek.it

The classical deterministic Unit Commitment (UC) problem do not include the grid constraints. One further flexibility element is given by the grid topology optimization (GTO) whose goal is to reduce congestions and enable better dispatch. The UC together with GTO leads to very difficult mixed integer optimization problems with weak disjunctive constraints and high symmetry. We will present a novel MILP formulation for the UCTO problem that includes a simple - yet effective - perturbation of the objective function aiming to reduce the symmetry of the problem.

■ MA-54

Monday, 8:30-10:00
B14-1

Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks (COST TD1207) I

Stream: Energy, Environment and Climate
Invited session

Chair: *Martin Mevissen*, IBM Research Dublin, IBM Technology Campus, Damastown Industrial Park, Mulhuddart, 15, Dublin, Ireland, martmevi@ie.ibm.com
Chair: *Andrea Lodi*, D.E.I.S., University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, andrea.lodi@unibo.it
Chair: *Claudia D'Ambrosio*, LIX, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, dambrosio@lix.polytechnique.fr

1 - A Stabilized Scenario Decomposition Algorithm for Stochastic Unit Commitment
Tim Schulze, The School of Mathematics, The University of Edinburgh, JCMB 5620, The King's Buildings, Mayfield Road, EH9 3JZ, Edinburgh, Scotland, United Kingdom, t.schulze-2@sms.ed.ac.uk, *Andreas Grothey*, *Ken McKinnon*

The expansion of energy supplies from volatile sources caused an increased interest in stochastic models for unit commitment. Solving large instances of this problem is computationally intractable. We apply a Dantzig-Wolfe scenario decomposition to multistage stochastic unit commitment problems and develop a dually stabilized column generation procedure which can handle convex quadratic generation costs and can guarantee optimality. We use a dual initialization procedure to hot start our method. Numerical results illustrate that convergence can be achieved within a few iterations.

2 - Balancing supply and demand in an electricity system: A mathematical programming approach
Jeanne Andersen, Department of Economics and Business, Aarhus University, Fuglsangsalle 4, 8210, Aarhus, Denmark, jeand@asb.dk, *Ditte Heide-Jørgensen*, *Trine Krogh Boomsma*, *Nina Detlefsen*

We propose a model for optimising electricity system operations within the hour. Taking a social welfare perspective, the model aims at reducing intra-hour costs by optimally activating so-called manual reserves based on forecasted imbalances between supply and demand. Since manual reserves are significantly less expensive than automatic reserves, we see a considerable reduction in total costs of balancing. In addition to providing guidelines for current electricity system operation, the model can be used for analysing the management of a future electricity system.

3 - Regulating Power Distribution in Energy Networks
Chistos Zaroliagis, Computer Engineering & Informatics, University of Patras, 26504, Patras, Greece, zaro@ceid.upatras.gr, *Spyros Kontogiannis*

We present a resource allocation mechanism for regulating a free energy market, in which the infrastructure is managed by a central authority while several competing energy providers distribute power to customers. Our mechanism enforces an incentive-compatible pricing scheme for the usage of the shared resources that is robust against the unknown incentives of the energy providers and assures convergence to a fair and socially optimal (utilitarian) solution. In case of disruptions, our mechanism can be used as an online recovery scheme causing the system to re-converge to its optimum very fast

4 - A New Formulation for the European Day-Ahead Electricity Market Problem
Mehdi Madani, Louvain School of Management, Université Catholique de Louvain, 1348, Louvain-la-Neuve, Belgium, mehdi.madani@uclouvain.be, *Mathieu Van Vyve*

The European electricity market model is usually described as an optimization problem with complementarity constraints expressing the existence of linear (ideally equilibrium) prices. We show how to reformulate this problem as a MILP or MIQCP, by the use of strong duality theory. This allows for example to use state-of-the-art solvers to find market equilibrium. In the MIQCP case, solvers fail because of the scale and structure of the problem. We provides with a (Benders-like) branch-and-cut algorithm derived from the new formulation by the use of the Farkas lemma.

■ MA-55

Monday, 8:30-10:00
B14-2

Analyzing political instruments for biomass-based supply chains

Stream: Biomass-based Supply Chains
Invited session

Chair: *Taraneh Sowlati*, Wood Science, University of British Columbia, 2931-2424 Main Mall, V6T1Z4, Vancouver, BC, Canada, taraneh.sowlati@ubc.ca
Chair: *Magnus Fröhling*, Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT), Hertzstraße 16, D-76187, Karlsruhe, Germany, magnus.froehling@kit.edu

1 - Decision support for legal regulation of production and market introduction of biofuels
Laura Elisabeth Hombach, School of Business and Economics, Chair of Operations Management, RWTH Aachen, 52056, Aachen, Germany, laura.hombach@om.rwth-aachen.de, *Grit Walther*

It is assumed that biofuels can reduce CO2 emissions of road transportation. However, regulation is necessary in order to promote (sustainable) production and usage of biofuels. In the EU, planning stability for investors and producers of biofuels is lacking, since regulation changed within the last years. A decision support framework is developed that facilitates the political decision maker in finding effective and efficient legal policies for (bio-)fuels. Therefore, eco-efficient political instruments are analyzed, which reduce emissions but guarantee reasonable solutions for investors.

2 - Potential competition of biomass for bioelectricity and biofuel under RFS2 and RPS
Lizhi Wang, Iowa State University, 50011, Ames, Iowa, United States, lzwang@iastate.edu, *Mohammad Rahdar*, *Guiping Hu*

Using publicly available data, we built a system model to study the renewable energy resources and investment potential in the 50 states of the U.S. Our model takes explicit consideration of policy influence of RFS2 and RPS on investment decisions for the next couple of decades. Modeling results provided insights on the interactions between RFS2 and RPS as well as potential competition of biomass for bioelectricity and biofuel under these policies.

3 - An Economic and Environmental Impact Analysis of Biofuel Policies in Brazil and USA
Hayri Önal, Agricultural and Consumer Economics, University of Illinois, 305 Mumford Hall, 1301 W. Gregory Dr., 61801, Urbana, Illinois, United States, h-onal@illinois.edu, *Hector M. Nunez*

The U.S. and Brazil implement complex biofuel policies and enforce blending mandates. The recent liberalization in U.S. trade policies and reduced economic incentives to blenders are likely to affect the land use in both countries, food/fuel prices, and GHG emissions. In this paper we present empirical results of a spatial equilibrium model simulating the agricultural and transportation fuel sectors of the two major biofuel economies.

4 - An Agent-Based Simulation of Land-Use Decisions for Biofuel Production in Germany
Sandra Venghaus, Innovation and Technology Management, University of Bielefeld, Germany, sandra.venghaus@uni-bielefeld.de

In an attempt to reduce CO2 emissions, the increasing cultivation of crops for biofuel production entails land-use decisions that are embedded in and depend on the surrounding socio-ecological system. Grounded in empirical data, a corresponding spatially explicit agent-based simulation is developed for the federal state of Brandenburg, Germany. It considers farmers who are heterogeneous in their production backgrounds (tradition) as well as their preferences, and it accounts for changes in production decisions as a result of communication in neighborhoods and/or through professional networks.

■ MA-56

Monday, 8:30-10:00
B15-3

Railway applications

Stream: OR Applications in Industry
Invited session

Chair: *Carlo Mannino*, Informatica e Sistemistica, Universita' La Sapienza, Via Buonarroti 12,, 00185, Rome, Italy, mannino@dis.uniroma1.it

1 - An iterative optimization framework for delay management and train scheduling
Francesco Corman, Transport Engineering and Logistics, Maritime and Transport Technology, Delft University of Technology, -, Delft, Netherlands, f.corman@tudelft.nl, *Twan Dollevoet*, *Andrea D'Ariano*, *Dennis Huisman*

Delay management decides whether a passenger connection between train services should be kept in case of delays. Recent approaches approximate the use of infrastructure capacity by incorporating headways between departures and arrivals. However, only microscopic scheduling models can correctly represent detailed movements of trains at busy stations areas. We propose an optimization approach to minimize the passenger travel time that iteratively solves macroscopic delay management and microscopic train scheduling models. We evaluate the approach on real-world instances from the Dutch railways.

2 - Optimization models for short-term rolling stock rostering and maintenance scheduling
Giovanni Luca Giacco, Ingegneria, Università Roma 3, via caltagirone 15, 00182, Rome, Italy, Italy, g.giacco@trenitalia.it, *Donato Carillo*, *Andrea D'Ariano*, *Dario Pacciarelli*

This work studies a railway rolling stock circulation problem with maintenance constraints faced by the managers of Trenitalia, the main Italian railway company. In the rostering problem, a set of service and maintenance tasks are to be covered with a minimum amount of rolling stock. The problem is formulated by a graph theoretical approach that combines the scheduling tasks related to train services, short-term maintenance and empty runs. MIP formulations are proposed for scheduling operations at maintenance site. Computational results compare favourably with the practical solutions.

3 - Efficient train formation and sorting using integer programming
Markus Bohlin, Swedish Institute of Computer Science, Box 1263, SE-16429, Kista, Sweden, markus.bohlin@sics.se, *Sara Gestrelius*, *Florian Dahms*

Efficient freight train marshalling is vital for high quality carload freight transportations. In the talk we outline recent advances in planning of marshalling using integer programming techniques. The problem involves the formation of departing freight trains from arriving trains subject to scheduling and capacity constraints. To increase yard capacity, we allow temporary storage of early freight cars as well as sorting according to train block. The approaches minimise the number of shunting operations and is evaluated on real-world data from the Hallsberg marshalling yard in Sweden.

4 - Finally optimal train dispatching in practice
Leonardo Lamorgese, SINTEF, Forskningsveien 1, 0314, OSlo, Norway, leonardo.lamorgese@gmail.com, *Carlo Mannino*, *Mauro Piacentini*

In a series of works we developed a decomposition approach for solving the real-time Train Dispatching problem, in a master-slave fashion. The master amounts to solving a problem on a simplified network, whereas the slave takes care of routings in stations. A heuristic version of the approach is in operation since 2010 on a number of lines in Italy. The exact version will be put in operation as of April 2013 for the test-campaign. The results will be available for the EURO conference. Laboratory tests on real-life instances already show impressive improvements over the current practice.

■ MA-57

Monday, 8:30-10:00
B15-4

Engineering Optimization

Stream: Engineering Optimization
Invited session

Chair: *Emre Çimen*, Industrial Engineering, Anadolu Universty, Anadolu Üniversitesi İki Eylül Kampüsü Endüstri Mühendisliği no:106, 26000, Eskişehir, Turkey, ecimen@anadolu.edu.tr

1 - Structural Topology Optimization Subject To Local Vanishing Constraints
Wolfgang Achtziger, Department of Mathematics, University of Erlangen-Nuremberg, Chair of Applied Mathematics 2, Cauerstrasse 11, 91058, Erlangen, Germany, achtziger@math.fau.de

We consider problem formulations of topology optimization of mechanical structures subject to local vanishing constraints. This means, constraints are neglected whenever a structural/finite element does not contain any material (e.g., local stress constraints). The numerical treatment of such problem formulations is difficult because certain mathematical regularity conditions are not satisfied. This difficulty is avoided by perturbation approaches for which convergence can be proved under standard assumptions. We present some new theoretical results and some numerical experiments.

2 - Decomposition in time of a medium-term hydrothermal unit commitment problem
Andreas Witzenhausen, Institute of Power Systems and Power Economics, RWTH Aachen University, Schinkelstraße 6, 52064, Aachen, Nordrhein-Westfalen, Germany, aw@iaew.rwth-aachen.de, *Ulf Kasper*, *Tim Bongers*, *Albert Moser*

As the share of renewables in power systems rises the requirements upon conventional generation in terms of flexibility are increasing. Therefore the hydrothermal unit commitment needs to be modeled in detail in order to appropriately consider power system flexibility. Since such optimization problems are too complex for a close-loop approach they have to be split into smaller sub problems in system or time domain. This paper compares a system decomposition approach to an approach that splits the optimization problem on the time domain. Coordination approaches of the sub problems are examined.

3 - Optimal Design and Time Deployment of of a new Hydrogen Transmission Pipe Networks for France
Daniel De Wolf, Economie Gestion, Université du Littoral, 189B avenue Maurice Schumann, B.P. 5526, 59379, Dunkerque Cedex 1, France, daniel.dewolf@univ-littoral.fr

We consider the problem of the optimal design of an hydrogen pipe transmission network. We define a local search method that simultaneously looks for the least cost topology of the network and for the optimal pipes diameters. The application to the case of development of future hydrogen pipeline networks in France has been conducted at the regional and national levels. We compare the proposed approach with another using Tabu search heuristic. Finally, we propose a heuristic approach for the deployment over time of the new network by considering alternate transportation modes.

4 - Hand-Arm Gesture Recognition with Mathematical Programming
Emre Çimen, Industrial Engineering, Anadolu Universty, Anadolu Üniversitesi İki Eylül Kampüsü Endüstri Mühendisliği no:106, 26000, Eskişehir, Turkey, ecimen@anadolu.edu.tr, *Gurkan Ozturk*, *Omer Nezih Gerek*

Remote controlling of a device has been a technical issue of interest by researchers since ages. Various control devices with different working principles have been developed so far. Today, researchers focus more on efficient and intuitive control of devices by innovative human — computer interface philosophies. In this this project, hand/arm gestures are recognized with mathematical programming based classifiers.

1 - Comparing relative skewness of multivariate distributions
Julio Mulero, Statistics and Operations Research, University of Alicante, Spain, julio.mulero@ua.es, *Felix Belzunce*, *José-María Ruiz*, *Alfonso Suarez Llorens*

The study of distributions usually involves the analysis of skewness. Measuring skewness via single quantities is to find a suitable stochastic order which captures the essence of what "F is less skewed than G' means. In this sense, Van Zwet (1964) proposed a convex transform order for comparing skewness of two univariate distribution. In the literature, different extensions for multivariate distributions have been introduced. In this talk, we propose and analyze a new multivariate convex tranform order based on the standard construction. Properties and applications are discussed too.

2 - Minimization of the Supply Chain Cost in a Pharmaceutical Factory
Gökçe Candan, Industrial Engineering, Sakarya University, Sakarya University Esentepe Campus, M5 Block, 54187, Sakarya, Turkey, gcandan@sakarya.edu.tr, *Harun Yazgan*, *Başar Candan*

Pharmaceutical products' supply chain requires a detail mathematical model to pursue successfully, because of their expiry conditions, regulation processes, human healthcare etc. Therefore, a successful management policy should be provided for demand, inventory, distribution requirements, production planning and scheduling in the pharmaceutical sector. In this study, a new mathematical approach based on a MILP is developed to minimize the pharmaceutical supply chain cost while satisfying customer demands. A real life example is applied and results are very encouraging.

3 - Customers' Perception of Service with Fuzzy Queuing Model Optimization
Chie-bein Chen, International Business, National Dong Hwa University, 1, Sec. 2, Da-hsueh Rd. Shou-feng, 974, Hualien, Taiwan, cbchen@mail.ndhu.edu.tw, *Hsing Paul Luh*, *Yi-Chih Chen*, *Chia-Hung Wang*

An optimization model whose queues prior to a service and costs depend on the perception of waiting will be proposed. This research is devoted to a new approach of fuzzy queue optimization model and the applications of Markov chains with fuzzy set theory in queue service management. The purpose of this study, therefore, is to present a possible approach to help service managers understand the complexity of waiting and choose an optimal decision under the rule of preference order. Finally, this research will take a real case to evaluate the compromise (or satisfying) solutions.

4 - A Novel Approach to Cutting Decision Trees
Fadime Uney-Yuksektepe, Industrial Engineering, Istanbul Kultur University, E5 Karayolu Londra Asfalti Uzeri, Atakoy Kampusu, 34156, Istanbul, Turkey, f.yuksektepe@iku.edu.tr

Cutting Decision Tree (CDT) induction is an efficient mathematical programming based method that tries to discretize the data set by using multiple separating hyperplanes. A new improvement to CDT model is proposed in this study by incorporating the second goal of maximizing the distance of the correctly classified instances to the misclassification region.Computational results show that developed model (CDT-New) achieves better classification accuracy for Wisconsin Breast Cancer database.

■ MA-58

Monday, 8:30-10:00
B15-6

Applications from Data Mining

Stream: Data Mining and Decision Making
Invited session

Chair: *Fadime Uney-Yuksektepe*, Industrial Engineering, Istanbul Kultur University, E5 Karayolu Londra Asfalti Uzeri, Atakoy Kampusu, 34156, Istanbul, Turkey, f.yuksektepe@iku.edu.tr

■ MA-59

Monday, 8:30-10:00
B15-5

Collective Learning Procedures I

Stream: Machine Learning and Its Applications
Invited session

Chair: *Michael Khachay*, Ural Branch of RAS, Institute of Mathematics and Mechanics, S.Kovalevskoy, 16, 620990, Ekaterinburg, Russian Federation, mkhachay@imm.uran.ru

1 - Learning Weights of Multiple Kernels by Genetic Algorithm: integrated with ECOC
Sureyya Ozogur-Akyuz, Department of Mathematics and Computer Science, Bahcesehir University, Bahcesehir University, Dept of Mathematics and Computer Science, Cıragan cad. Besiktas, 34353, Istanbul, Turkey, sureyya.akyuz@bahcesehir.edu.tr, *Terry Windeatt*

Multiple Kernel Learning (MKL) has become an emerging research area as data have multiple resources. Different fusion modelings exist in the literature. Error Correcting Output Code (ECOC) is one of the methods in Multiple Classifier Systems which combines binary classifier outputs to predict multiclass problems. In this study, MKL is integrated into ECOC by using Genetic Algorithm to find the kernel weights. Experiments are carried out for different tasks in UCI data sets.

2 - Engineering Graphs to Complexity Metric Vectors to Surrogate Model Predictors: Discovering Implicit Knowledge
Joshua Summers, Mechanical Engineering, Clemson University, 250 Fluor Daniel Building, Mail Stop: 0921, 29634-0921, Clemson, South Carolina, United States, jsummer@clemson.edu

An approach to mining implicit knowledge from engineering graphs is presented as a 3 step process: graph generating, complexity metric vector compiling, and surrogate model building. This has been demonstrated in different applications (CAD models to assembly time; function models to market cost; requirements models to change prediction; communication networks to project management). Here, we will explore this approach and applications and propose an inversion of the process to automatically create graphs from complexity metric vectors that are associated with desired outcomes.

3 - Constraint Handling in Surrogate-Based Expensive Black-Box Optimization
Rommel Regis, Mathematics, Saint Joseph's University, 5600 City Avenue, 19131, Philadelphia, PA, United States, rregis@sju.edu

Penalty methods are commonly used in constrained optimization. However, these methods might not be suitable for handling expensive black-box constraints. This talk presents optimization methods that use radial basis function (RBF) surrogates to model objective and constraint functions. These methods have been successfully applied to a 124-dimensional automotive problem with 68 black-box inequality constraints even when no feasible starting points are provided. This talk also discusses strategies for handling black-box equality constraints and present numerical results on test problems.

4 - Committee generalized solutions and boosting
Michael Khachay, Ural Branch of RAS, Institute of Mathematics and Mechanics, S.Kovalevskoy, 16, 620990, Ekaterinburg, Russian Federation, mkhachay@imm.uran.ru

The committee generalized solutions approach for solving infeasible systems of constraints, committee collective classifiers proposed by Prof. V.Mazurov in 70-th and R.Schapire's boosting approach in machine learning are closely related. Some examples of this relationship along with statements improving some known results will be presented. Particularly, the well known result on equivalence of weak and strong learning schemes can be improved in terms of technique similar to the known construction method for affine separating committee.

■ MA-62

Monday, 8:30-10:00
R18-1

MINLP: new developments and applications

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Sonia Cafieri*, Lab. MAIAA, Dept. de Mathematiques et Informatique, Ecole Nationale d'Aviation Civile, 7 Ave. Edouard Belin, 31055, Toulouse, France, sonia.cafieri@enac.fr

Chair: *Armin Fügenschuh*, Optimierung, Zuse Institut Berlin, Takustraße 7, 14195, Berlin, Germany, fuegenschuh@zib.de

1 - Mathematical programming-based approximation algorithms to solve models for water production and distribution in complex networks
Derek Verleye, Industrial Management, Ghent University, Technologiepark 903, 9052, Zwijnaarde, Belgium, derek.verleye@ugent.be, *El-Houssaine Aghezzaf*

We discuss the optimal planning of production and distribution in a real-world complex water supply network. The model is a nonconvex mixed-integer nonlinear program in which binary variables are used to model pump switches and the mechanism of inflow at water towers. These binary variables and the nonconvex pressure losses constraints make the problem very hard to solve. Although state-of-the art solvers such as Bonmin (using Branch&Bound and/or Feasibility Pump) have limited success, we propose some approximation algorithms and compare their performance with these solvers.

2 - A Rounding Property-based approach to Mixed-Integer Nonlinear Optimization Problems
Ruth Hübner, Institut für Numerische und Angewandte Mathematik, Georg-August-Universität Göttingen, Lotzestraße 16-18, 37083, Göttingen, Germany, r.huebner@math.uni-goettingen.de, *Anita Schöbel*

An integer NLP has the "Rounding Property (RP)" if an optimal solution can be found by rounding an optimal solution to its continuous relaxation. We carry this concept over to mixed-integer NLPs by rounding only the variables that need to be integer. In that way we get a lower dimensional continuous problem (as we fixed the integer variables) that is assumed to be easier to solve. We define that a MINLP has the RP if this leads to an optimal solution and identify special cases that guarantee that kind of property. One main question is how the RP depends on the number of continuous variables.

3 - Linear Relaxations: Combine and Compare Reformulation Methods, Gradient-based Method and Affine Arithmetic
Jordan Ninin, ENSTA-Bretagne, 2 rue François Verny, 29200, Brest, France, jordan.ninin@ensta-bretagne.fr

In a spatial Branch-and-Bound Algorithm, linear relaxations have proved their interest and efficiency. Three distinct approaches are used: the Reformulation-Linearization-Techniques, the first-order Taylor expansion, and the Affine Arithmetic. These methods are philosophically different and developed by distinct communities. Nevertheless, Contractor Programming is a methodology which allows to enclose each algorithm in a unified framework in order to interact with each other. Using this approach, we show that these three relaxation techniques can be combined and compared.

4 - Approximate solution strategies for multi-parametric mixed integer programming
Martina Wittmann-Hohlbein, Imperial College London, United Kingdom, m.wittmann-hohlbein09@imperial.ac.uk, *Efstratios Pistikopoulos*

We present a two-stage method and its extension towards a dynamic decomposition algorithm for the approximate solution of mp-MILP problems. Both approaches employ surrogate mp-MILP models that are derived from overestimating bilinear terms in the constraints by piecewise affine relaxations over an ab initio partition of the feasible set. The approximate models are tuned by the number of partitions. Problem sizes and computational requirements for the different alternatives are compared. The conservatism of the suboptimal solution of the mp-MILP problem for the proposed approaches is discussed.

■ MA-63

Monday, 8:30-10:00
R18-2

Control in Large-scale Systems

Stream: Operational Research and Control Problems
Invited session

Chair: *Mikhail Goubko*, Institute of Control Sciences RAS, Russian Federation, mgoubko@mail.ru

Chair: *Dmitry Novikov*, Institute of Control Sciences, Russian Academy of Science, Profsojuznaya st., 65, 117997, Moscow, Russian Federation, novikov@ipu.ru

1 - Mathematical modeling of staff and structure control problems in social and economic seasonal production systems
Artem Miroshnikov, The Faculty of Automation and Information Science, Lipetsk State Technical University, Russian Federation, Lipetsk city, Moskovskaya st., 30, 398600, Lipetsk, Lipetsk region, Russian Federation, a.i.miroshnikov@yandex.ru

One of the methods of mathematical description of business is its formal representation in terms of the theory of social and economic systems. The use of graphs and network structures is often not effective in distributed systems modeling where seasonality influences the operation of the business. In this case the use of more efficient graph structures such as hypergraphs and metagraphs together with operational research, which computes optimal values of utility functions of a principal and an agent, can simplify solving problems related to staff and structure control in the system.

2 - An Operational Research Approach to Active Control for Mechanical Structures
James Trollope, Control Theory and Applications Centre, Coventry University, 10 Coventry Innovation Village, Cheetah Road, CV1 2TL, Coventry, United Kingdom, james.trollope@coventry.ac.uk, *Keith Burnham*

Prompted by the need for self-preserving mechanical structures to be able to actively control and reconfigure their structural properties, this paper describes the concepts of a novel approach. A definition of the optimisation problem for active control of mechanical structures is described and formulated in an operational research context. A family of candidate systems is initially proposed and a guided random search algorithm iteratively applied to select the 'best' solution. Multiple objectives may be included, resulting in flexibility of design depending on the intended application.

3 - Optimization of special traffic delay function for regulated traffic intersection
Anton Sysoev, The faculty of Automation and Computer Science, Lipetsk State Technical University, Moscovskaya, 30, 398600, Lipetsk, Russian Federation, anton_syssoyev@mail.ru

We model a transport intersection using non-classical approaches and study the optimization problem of traffic light cycle time on a regulated intersection. We construct the original traffic delay function based on new approaches to calculation of quality level of intersection operation and propose the algorithm to minimize this function.

4 - Online social networks analysis: a conceptual approach
Dmitry Gubanov, Laboratory 32, ICS RAS, Profsoyuznaya 65, Moscow, Russian Federation, dmitry.a.g@gmail.com

Intensive penetration of online social networks in our life have significant effects on economics, politics and culture. These effects are currently difficult to measure, analyze, and predict. We propose a conceptual approach to social network monitoring, analysis, forecasting and control. The approach has four stages. (1) State the meaningful domain-specific questions. (2) Define quantitative problem-specific measures. (3) Develop the technologies of monitoring and analysis. (4) Develop technologies of decision support and report generation.

■ MA-64

Monday, 8:30-10:00
R18-3

Defence and Security

Stream: Defence and Security
Invited session

Chair: *Ana Isabel Barros*, Military Operations, TNO, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - Time Delay Impact of Acoustic Sonars on Intercepting Underwater Targets in Harbour Defence System
Suruz Miah, Defecne Research and Development Canada, Department of National Defence, Canada, 101 Colonel By Drive, 6CBS, K1A 0K2, Ottawa, Ontario, Canada, Suruz.Miah@drdc-rddc.gc.ca, *Bao Nguyen*, *Davide Spinello*, *Alex Bourque*

This paper proposes a target interception technique in the presence of sonar (mounted on an interceptor) time delay. We assume that the interceptor's bearing is always towards the target. The interceptor sends a sonar ping to the target and receives it with some delay. We present the interceptor's motion model with the time delay impact of sonars. The interception strategy is thoroughly investigated with sensitivity analysis. An analytical solution is provided to find the trajectory and the intercept time of an interceptor. This analysis is presented with and without time delay of a sonar.

2 - Optimal Search Algorithms for Autonomous Underwater Vehicles Equipped with Synthetic Aperture Sonars
Michel Couillard, Research Department, CMRE, Viale San Bartolomeo 400, 19126, La Spezia, Italy, couillard@cmre.nato.int

This paper presents novel optimal search algorithms designed for autonomous underwater vehicles equipped with synthetic aperture sonars. First, an adaptive track spacing algorithm using in situ sonar performance estimates adjusts the vehicle's path as the mission progresses to avoid coverage gaps. The sonar imagery collected is processed in real time to detect objects on the seabed. If detections are made, a dynamic revisit algorithm is used to optimally acquire additional sonar images of the detected objects. These algorithms were successfully tested at sea during the ARISE 2012 trial.

3 - Performance metrics for maritime air defence
Bao Nguyen, Centre for OR & Analysis, Defence R&D Canada, 101 Colonel By Drive, K1A0K2, Ottawa, Ontario, Canada, bunguyen@usa.net

At Defence Research Development Canada (DRDC), we examine concepts for maritime air defence. To assess the effectiveness of these concepts, we have developed a number of metrics that include the Probability of Integrated System Effectiveness (PISE) which accounts for the reliability and the availability of the sensors and the weapon systems as well as the firing tactics. Other metrics will also involve inventory savings in terms of number of interceptors and over hits. We consider these metrics from the view point of a multiple objective problem.

4 - Selecting the beyond visual range air-to-air tactic most likely to be the best
Helcio Vieira Junior, COMAER, Brazil, junior_hv@yahoo.com.br, *Mischel Carmen N. Belderrain*, *Karl Kienitz*

We propose a new procedure for the multinomial selection problem to solve a real problem of any modern Air Force: the elaboration of better air-to-air tactics for Beyond Visual Range air-to-air combat that maximize its aircraft survival probability H(theta,omega), as well as enemy aircraft downing probability G(theta,omega). In this study, using a low resolution simulator with generic parameters for the aircraft and missiles, we could increase an average success rate of 16.69% and 16.23% for H(theta,omega) and G(theta,omega), respectively, to an average success rate of 76.85% and 79.30%.

■ MA-65

Monday, 8:30-10:00
R18-5

Bargaining models and mechanism design

Stream: Emerging Applications in Game Theory and Management
Invited session

Chair: *Vladimir Mazalov*, Karelia Research Center of Russian Academy of Sciences, Institute of Appied Mathematical

Research,Karelia Research Center, Pushkinskaya st. 11, 185910, Petrozavodsk, Karelia, Russian Federation, vmazalov@krc.karelia.ru

1 - Stochastic cake-division procedure
Julia Tokareva, Mathematical Department, Transbaikal State University, Aleksandro-Zavodskaya, 30, 672039, Chita, Russian Federation, jtokareva2@mail.ru, *Vladimir Mazalov*

Stochastic procedure of fair n-person cake division problem is proposed. We consider a multistage model which characterized by finite horizon and non-cooperative behavior of players. We use an arbitration procedure which applies random offers. The optimal behavior of the players is derived. Nash equilibrium is found in the class of threshold strategies for identical and weighted players. The value of the game is derived in analytical form.

2 - Bargaining in Dynamic Games.
Leon Petrosyan, Applied Mathematics, St.Petersburg State University, Jelesnovodskaya 27 app.20, 199155, St.Petersburg, Russian Federation, spbuoasis7@peterlink.ru

Suppose at the beginning the bargaining mechanism suggests some "optimal" control of development of the dynamic system under consideration. It may happen and really happens in many cases that after some time the same set of decision makers may try to check the "optimality" of the chosen control. The checking will give in most of the cases the control different from one selected at the beginning. This means time-inconsistency of bargaining solution. The regularization approach is proposed to overcome this difficulty. The similar situation can arise in mechanism design problems.

3 - Equilibrium in the appointment time bargaining model
Vladimir Mazalov, Karelia Research Center of Russian Academy of Sciences, Institute of Appied Mathematical Research,Karelia Research Center, Pushkinskaya st. 11, 185910, Petrozavodsk, Karelia, Russian Federation, vmazalov@krc.karelia.ru

We consider n-person bargaining model related with the convenient appointment time game. Players have preferences represented by piece wise linear and single-peaked utility functions. We follow to the approach developed by C. Ponsati and derive the asymptotic optimal strategies of players in explicit form for the model with a discount factor closed to unit.

4 - Nash bargaining solutions in bioresource management problems
Anna Rettieva, Institute of Applied Mathematical Research Karelian Research Centre of RAS, Pushkinskaya str., 11, 185910, Petrozavodsk, Russian Federation, annaret@krc.karelia.ru

Discrete-time game-theoretic models related to a bioresource management problem (fish catching) are investigated. The players (countries or fishing firms) differ in their time preferences and use different discount factors. We present two different approaches of bargaining procedure to construct the value function for cooperative solution in this case. In the first one the cooperative strategies are determined as the Nash bargaining solution for the whole planning horizon. In the second, we use recursive Nash bargaining procedure determining the cooperative strategies on each time step.

■ MA-66

Monday, 8:30-10:00
R18-4

OR: Visualization and Arts

Stream: OR: Visualization and Arts
Invited session

Chair: *Vitaly Podobedov*, Computational Mathematics and Cybernetics, Moscow State University, Vorobievy Gory, MSU, 119992, Moscow, Russian Federation, vetix@or-art.org

1 - Abstract Determinism — Harmony through Chaos
Vitaly Podobedov, Computational Mathematics and Cybernetics, Moscow State University, Vorobievy Gory, MSU, 119992, Moscow, Russian Federation, vetix@or-art.org

For appearance of beauty, complexity is not a need; simplicity can bear perfection. Such words are well confirmed by a fact that even simple mathematical models can produce good visual art. Namely, local optimization algorithms, regions of attraction of local minima of the multiextremal functions, and deterministic chaos give us an inexhaustible variety of complex beautiful images - in a style called as abstract determinism. Its background, history and place among the other styles of mathematical art are presented. A prospect of being a bridge between human- and robot art worlds is also shown.

2 - Effects of background music on browsing and purchasing process in shopping website
Chien-Jung Lai, Department of Distribution Management, National Chin-Yi University of Technology, No. 57, Sec. 2, Zhongshan Rd., Taipei District, Taichung City, Taiwan (ROC), 41170, Taichung, Taiwan, laicj@ncut.edu.tw, *Kang-Ming Chang*

This study is to design the background music placement modes and examine browser's emotional and EEG response in the on-line shopping process (browsing and purchasing). 0-2 min fading-in, place point at 2 min, full music, and none music were proposed and undertaken. Results showed that playing background music with placement point at 2 min and 0-2 fading-in had higher level of pleasure. Receiver operating characteristics (ROC) analysis indicated that EEG power had significant difference for shopping process in none music condition, however, the difference diminished in full music condition.

3 - Diagram method for mechanical systems of solid bodies with friction
Lina Otradnova, Department of Mechanics and Mathematics, Lomonosov MSU, GSP-1, Leninskie Gory, 119991, Moscow, Russian Federation, otradnova.lina@gmail.com

We consider a new model of impact of rigid body with friction. At the moment of contact a tangential velocity of contact point is equal to zero. The model can be described as special case of Kozlov's tough friction model. In real life such kinds of friction occure in Sports like pole vaulting, table tennis; in roulette games; in conveyors. A new diagram method is illustrated with diagrams for examples of disk motion between two parallel lines (lines are considered without motion and with motion). On such diagrams we see visually that the ball motion comes to stable mode.

4 - A Method to Improve Rich Picture Interpretation
Tessa Berg, Computer Science, HeriotWatt University, United Kingdom, tb79@hw.ac.uk, *Robert Pooley*

The rich picture (RP) is a diagrammatic means of identifying differing world views with the aim of creating shared understanding of a problem situation. The RP has predominantly been used as a freeform, unstructured tool with no commonly agreed syntax. We demonstrate how the simple RP icon can be rapidly communicated, processed and transmitted. Our research highlights the value of adding small levels of structure, in certain cases, to the RP. We show that there are considerable benefits for both the interpreter and the creator by providing a method for interpretation.

■ MA-69

Monday, 8:30-10:00
R19-3

Risk and Sustainable Development

Stream: OR for Development and Developing Countries
Invited session

Chair: *Alexander Makarenko*, Institute for Applied System Analysis, National Technical University of Ukraine "KPI", Prospect Pobedy 37, 03056, Kiev, Ukraine, makalex@i.com.ua

1 - Towards understanding of risks and sustainability on global, regional and local levels
Alexander Makarenko, Institute for Applied System Analysis, National Technical University of Ukraine "KPI", Prospect Pobedy 37, 03056, Kiev, Ukraine, makalex@i.com.ua

The general questions of risks and sustainability are considered. Formalization of complex social systems are discussed. Risks definitions and evaluation of risks in such system are considered. Proposed concepts for modeling of social systems allow filling the gap between the evaluation of risks in pure technical systems and attitude for risks by population. Anticipatory aspects and presumable paths of the system had been considered in risks and sustainability evaluation. Sustainable development is considered for different levels which need risks evaluation.

2 - Enterprise Risk Management (ERM): A New Way of Looking at Risk Management at an Organisational Level
Shahzeb Ali Malik, International Institute of Risk and Safety Management (IIRSM), Suite 7a,, 77 Fulham Palace Road, W6 8JA, London, United Kingdom, shahzeb.malik@iirsm.org, *James Freeman*, *Barry Holt*

Risk Management is rapidly evolving; its practitioners are increasingly shifting focus from pure operational or financial risks to a broader Enterprise Risk Management. ERM involves a set of processes and methods used to manage not just risks associated with accidental losses but also financial, strategic and other business risks. This paper highlights the benefits and barriers associated with adopting ERM. The Protivi and COSO models are introduced in the context of an on-going project to develop a practical tool for providing better analysis of risk data and improved knowledge management.

3 - The Impact of Housing Development on City Sustainability
Sam Kirshner, School of Business, Queen's University, Canada, skirshner@business.queensu.ca, *Yuri Levin*, *Mikhail Nediak*

Urban intensification is considered to be one of the most important means of maintaining the sustainability of large metropolitan areas. However, intensification policies are often driven by profit maximizing developers and short-term housing demand, rather than the long-term need of the working population. To investigate the potential impact of intensification, we model a heterogeneous housing market where demographic changes cause people to move houses. We demonstrate that a housing stock based on short-term need can have adverse consequences on sustainability measures.

4 - Forecasting mexican inflation using neural networks
Jose Luis Chavez - Hurtado, Metodos Cuantitativos, CUCEA, Universidad de Guadalajara, Mexico, Zapopan, Jalisco, Mexico, martedead@gmail.com, *Gemma Cithlalli Lopez - Lopez*, *Laura Plazola Zamora*

In this work we use a neural network model to forecast Mexican inflation. For the model design we vary the number of hidden layers from 1 to 2 and the number of hidden neurons from 1 to 50. Database contains annual Mexican inflation from 1970 to 2010. Period from 1970 to 1993 was used for training, while the period from 1994 to 2010 was used to measure the forecasting model performance. Compared with Bank of Mexico's predictions, Neural Networks model estimations are clearly more accurate to the real inflation behavior; a critical point to prevent or to avoid inflationary crisis effects.

■ MA-72

Monday, 8:30-10:00
R16-2

Methodology of societal complexity and healthcare

Stream: Methodology of Social Complexity
Invited session

Chair: *Dorien DeTombe*, Methodology of Societal Complexity, Chair Euro Working Group, P.O.Box 3286, 1001 AB, Amsterdam, Netherlands, detombe@nosmo.nl

1 - The Roman Catholic Church as a Complex Societal Problem
Dorien DeTombe, Methodology of Societal Complexity, Chair Euro Working Group, P.O.Box 3286, 1001 AB, Amsterdam, Netherlands, detombe@nosmo.nl

Religious institutes, as Roman Catholic Church, prescribe their followers highly esteemed values for behavior. Do leaders of the Roman Catholic Church follow these rules themselves? Media news showed differently. Regarding the Roman Catholic Church as a firm, it is easier to see what is happening behind the facade of holiness. Awareness of the Roman Catholic church as a complex societal problem, analyzed with the methodology Compram (DeTombe,1994-2013) might lead to a more realistic view on the actions of the members of the Roman Catholic firm.

2 - Inter-Religious Conflict Resolution
Cathal Brugha, Management Information Systems, University College Dublin, Quinn School of Business, Belfield, 4, Dublin 4, Ireland, Cathal.Brugha@ucd.ie

This paper contextualizes religious-political interaction as a mutual adapting process starting with separation of church and state to prevent Conflict, then moving to Confrontation firstly in terms of the freedom to act productively, and then to promote the common interests of society without being abused. It uses a conflict-resolution meta-framework to propose that the discussion should next move into Co-operation, where people with different views openly discuss what they have in common, such as belief in God, the good of society, peaceful coexistence, and build on what they have in common

3 - Governance and Dissent in the Complex Society
Stephen Taylor, Champlain Regional College, Retired, 5320 Avenue MacDonald, Apt 207, H3X 2W2, Cote Saint-Luc, Quebec, Canada, steveta@alumni.concordia.ca

Societies are challenged to manage dissent while providing good governance. Immigration and shifting demography introduce complexity into societies by increasing variety in the philosophy and values of the citizens. Electronic communications facilitate broadcasting of opinion and mobilization of support for varied positions. Patterns of governance rooted in slow to change agricultural and industrial societies are not adapting to people expecting rapid change, while the diversity fosters the need for more intervention and regulation. This presentation should elicit a discussion of these issues.

4 - Random Stub Matching Models of Multigraphs
Termeh Shafie, Statistics, Stockholm University, Sweden, termeh.shafie@stat.su.se

The local and global structure of multigraphs under random stub matching (RSM) are analyzed. The distributions under RSM as well as some modified distributions with modeled degrees are used for calculations of moments and entropies, and for comparisons by information divergences. The main results include a new formula for the probability of an arbitrary number of loops at a vertex, and for an arbitrary number of edges at any site. Further, simplicity and complexity of RSM-multigraphs are studied and a new method of approximating the probability that an RSM-multigraph is simple is proposed.

■ MA-73

Monday, 8:30-10:00
R16-3

OR in Agriculture I

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *Marcela Gonzalez-Araya*, Departamento de Modelación y Gestión Industrial, Universidad de Talca, Merced 437, s/n, Curicó, Región del Maule, Chile, mgonzalez@utalca.cl

1 - A multicriteria mathematical programming model for the assessment of rural development plans
Basil Manos, AGRICULTURAL ECONOMICS, Aristotle University of Thessaloniki, University Campus, Thessaloniki, Greece, manosb@agro.auth.gr, *Thomas Bournaris*, *Christina Moulogianni*

Rural communities face the problems of ageing of population, high share of elder farmers and imbalanced distribution of farmers across age classes. Rural Development Plans (RDP) is one of the policy instruments that affect agriculture and people living in rural areas. The RDP measure "Setting up Young Farmers' aims to fight the demographic problems of these areas. This study highlights the role and impact of RDPs and the "Setting up Young Farmers' in Greece. A multicriteria mathematical programming model was implemented with a final goal to support future policies and design.

2 - MILP models for optimal crop selection
Carlo Filippi, Quantitative Methods, University of Brescia, Contrada S. Chiara 50, 25122, Brescia, BS, Italy, filippi@eco.unibs.it, *Renata Mansini*, *Elisa Stevanato*

When deciding the best way to cultivate a piece of land, a farmer has to select crops and assign their operations over time, considering: market price and yield variability of harvested products; resource requests for each crop; machinery and manpower availability; timing of the operations required by each crop. We discuss and test on real data two MILP models: a deterministic one, which maximizes the difference between the expected revenues and the production costs; a stochastic one, which allows to maximize the average expected return under a predefined quintile of worst realizations.

3 - MCDA and GIS to develop land suitability for agriculture.
Mendas Abdelkader, Geomatic, CTS, POB 13, 31200, Arzew, Algeria, mendask@yahoo.fr

In this paper, a spatial decision support system was developed for establishing the land suitability map for agriculture. It incorporates a multicriteria analysis method, which can facilitate decision making in situations where several solutions are available and various criteria have to be taken into account, into a GIS, powerful tool for analyzing spatial data. A land suitability map for durum wheat has been produced in an area of Algeria. Through the obtained results, it appears that ELECTRE Tri integrated into a GIS is better suited to the problem of land suitability for agriculture.

4 - Optimization models for planning raw materials purchase and storage in agribussiness companies
Marcela Gonzalez-Araya, Departamento de Modelación y Gestión Industrial, Universidad de Talca, Merced 437, s/n, Curicó, Región del Maule, Chile, mgonzalez@utalca.cl, *Marcos Oliva*, *Luis Acosta*

Two optimization models have been developed to support planning decisions about purchase and storage of raw materials (fruits or vegetables) for agribusiness process. One model aims to minimize purchase costs and transportation costs from fields to packing houses of raw materials and to select raw materials with high quality. The second model seek to minimize storage costs and transportation costs from packing houses to cold storages and to assigns different storage locations to raw materials according to their quality classification.

■ MA-74

Monday, 8:30-10:00
R16-4

Teaching OR/MS I

Stream: Teaching OR/MS
Invited session

Chair: *Peter Bell*, Richard Ivey School of Business, University of Western Ontario, N6A 3K7, London, Ontario, Canada, pbell@ivey.ca

1 - Introducing OR to Undergraduate Students at the OR/CS Interface
David Rader, Rose-Hulman Institute of Technology, 5500 Wabash Ave, Terre Haute IN 47803, United States, IN 47803, Terre Haute, United States, rader@rose-hulman.edu

When teaching OR to math, computer science, and engineering students, it is important to convey not only the fundamental problems and theory of the discipline but also what makes it such an exciting field of study; this is especially true when this introduction is at the interface of OR and CS. We discuss some approaches that have been successful in motivating students, which highlight modeling approaches, algorithm (solution) development, and how theoretical insights from the problem affect solution approaches and improvements. Examples from various courses are given.

2 - Data analysis and systems modelling in OR education in Engineering courses
Marta Castilho Gomes, CESUR, Instituto Superior Técnico, Universidade Técnica de Lisboa, Av. Rovisco Pais, 1049-001, Lisboa, Portugal, marta.gomes@ist.utl.pt, *Rui Oliveira*

Data collection, validation and analysis should have a role in OR education as important as the study of standard problem types, frameworks and methods. We discuss the experience of strengthening these skills in MSc Civil Engineering students by means of a Data Analysis and Systems Evaluation course. In this, multivariate statistical techniques are taught and applied by students in a group project that spans through one semester. This work is quite a challenge for the students and the supervisors. We present some illustrative projects and reflect on the teaching and learning process.

3 - An interactive Maple Tool for Parametric Linear Programming Problems
Gyongyi Bankuti, Department of Mathematics and Physics, Kaposvár University, Guba Sandor Street 40., H-7478, KAPOSVÁR, HUNGARY, Hungary, bankuti.gyongyi@ke.hu, *György Kövér*

Although most of the Quantitative Methods or Operation Research courses contain the Simplex Method based solution methodology of classical parametric linear programming problems (parametric in objective function), Maple does not have a tool for this problem. In our presentation we wish to introduce this recently developed interactive tool, which not only avoids the tiring manual calculation, but also shows the students the solution process simply, quickly, even on diagrams. The tool is mostly for education, demonstration purposes, not for modeling real life problems.

4 - What should we be teaching and how might we deliver a highly ranked OR course?
Peter Bell, Richard Ivey School of Business, University of Western Ontario, N6A 3K7, London, Ontario, Canada, pbell@ivey.ca

MBA students are (mostly) not going to make a career in analytics and often lack strong quantitative backgrounds but most MBA schools include a core "business analytics' course. Big data and advanced analytics are grabbing press headlines almost daily, consequently choice of topic coverage and pedagogy can be a constant challenge for the core course instructor. This presentation will discuss some of the topic coverage options and suggest some pedagogical changes that may allow for a better fit between program and student expectations/needs and the skill set of the OR instructor.

Monday, 10:30-12h00

■ MB-01

Monday, 10:30-12h00
O1-1

Opening Session

Stream: Opening and Closing Sessions
Plenary session

Monday, 12:30-14:00

■ MC-02

Monday, 12:30-14:00
O1-2

Optimal Stopping and Markov Decision Processes 1

Stream: Discrete Optimal Control
Invited session

Chair: *Katsunori Ano*, Mathematical Sciences, Shibaura Institute of Technology, 307 Fukasaku, Minuma-ku, 337-8570, Saitama-shi, Saitama-ken, Japan, k-ano@shibaura-it.ac.jp

1 - Threshold Strategies in Optimal Stopping Problem with Applications to Mathematical Finance
Vadim Arkin, Central Economics and Mathematics Institute, Nakhimovskii prospekt, 47, 117418, Moscow, Russian Federation, arkin@cemi.rssi.ru, *Alexandr Slastnikov*

We study optimal stopping problems for one-dimensional diffusion processes over a class of stopping times, which are specified as first exit times when process exceeds some level (threshold strategies). The necessary and sufficient conditions for optimality of stopping time over the threshold strategies are obtained. It is proposed sufficient conditions under which stopping time generated by optimal threshold strategy remains optimal over all stopping times. The results are applied to both financial options (of American style) and real options.

2 - Lower Bounds for Bruss' Odds Problem with Multiple Stoppings
Tomomi Matsui, Department of Information and System Engineering, Chuo University, Kasuga, Bunkyo-ku, 112-8551, Tokyo, Japan, matsui@ise.chuo-u.ac.jp, *Katsunori Ano*

This paper deals with Bruss' odds problem with multiple stopping chances. A decision maker observes sequentially a sequence of independent 0/1 (failure/success) random variables with the objective to predict the last success. We give a lower bound of the probability of win (obtaining the last success) for the problem with m-stoppings. We also show that the asymptotic value for each secretary problem with m-stoppings attains our lower bound. Finally, we prove a conjecture on secretary problem, which gives a connection between the probability of win and the threshold values of optimal strategy.

3 - Free Double Boundaries Problem for the American Put Option
Kyohei Tomita, Mathematical Sciences, Shibaura Institute of Technology, 307 Fukasaku, Minuma-ku, 337-8570, Saitama-shi, Saitama-ken, Japan, v09043@shibaura-it.ac.jp, *Katsunori Ano*

We studies the optimal double stopping and its free double boundaries problem for the American put option. Smoot fit and continuous fit conditions and the verification theorem of the free double boundaries problem are proved. We give the integral equations to characterize the optimal early-exercise stopping boundaries and some properties for the price and stopping boundaries.

4 - A Typical Lower Bound for Odds Problem in Markov-dependent Trials
Katsunori Ano, Mathematical Sciences, Shibaura Institute of Technology, 307 Fukasaku, Minuma-ku, 337-8570, Saitama-shi, Saitama-ken, Japan, k-ano@shibaura-it.ac.jp

The optimal stopping problem known as odds problem is studied. We show that even thought for Markov-dependent trials, the optimal stopping rule can be expressed as of sum-the-odds form. It is shown that the asymptotic lower bound of the probability of win (that is, the event to obtain the last success) is again 1/e for any transition probability of Markov chain, so that, for any sequence of success probabilities under some reasonable condition. Our results successfully cover the original elegant Bruss' sum-the-odds theorem of the optimal stopping rule for Bernoulli trials.

■ MC-03

Monday, 12:30-14:00
O1-3

Service competition and strategic queueing behavior

Stream: Service Management
Invited session

Chair: *Moshe Haviv*, Department of Statistics, Hebrew University of Jerusalem, Mount Scopus Campus, Har Hatsofim, 91905, Jerusalem, Israel, haviv@mscc.huji.ac.il
Chair: *Pengfei Guo*, Faculty of Business, Hong Kong Polytechnic University, Hong Kong, pengfei.guo@polyu.edu.hk

1 - Equilibrium customer behavior in a queueing system with batch services
Antonis Economou, Department of Mathematics, Section of Statistics and Operations Research, University of Athens, Panepistemioupolis, Athens 15784, Greece, 15784, Athens, Greece, aeconom@math.uoa.gr, *Olga Boudali*

Once arriving at a queueing system with batch services, a customer may have information on the number of waiting complete batches and/or the number of present customers in his own batch. Based on this information the customer may choose to join the system or to balk. We will present some results on the equilibrium customer behavior in such a system under various levels of information, providing analytic and numerical findings. The value of information, the associated social optimization problem and the price of anarchy will be also discussed.

2 - Optimal Pricing for a Service Facility with Trial Service and Retrial Customers
Zhaotong Lian, Faculty of Business Administration, University of Macau, Taipa, Macao SAR, China, lianzt@umac.mo

We study the pricing strategy of a service facility which is modeled as a retrial queueing system with trial service. There are two classes of customers in the system: VIP customers and ordinary customers. When the server is busy, the arrival VIP customers are queued in the priority queue with infinite capacity whereas ordinary customers enter the retrial group till the server is available. After a trial service, some of ordinary customers will purchase a standard service. We obtain the optimal pricing policy and the proper service rates. Some interesting managerial insights are obtained.

3 - Time-based Competition with Benchmark Effects
Liu Yang, Tsinghua University, China, yangliu@sem.tsinghua.edu.cn, *Francis De Vericourt*, *Peng Sun*

We consider a duopoly where firms compete on waiting times in the presence of an industry benchmark. The formation of the benchmark is endogenous and depends on both firms' choices. When the benchmark is equal to the shorter of the two offered delays, we characterize the unique Pareto Optimal Nash equilibrium. Our analysis reveals a stickiness effect by which firms equate their delays at the equilibrium. When the benchmark corresponds to the average of the two offered delays, we show the existence of a pure Nash equilibrium. In this case, we reveal a reversal effect.

4 - Service Time Competition with Bounded Rational Customers
Pengfei Guo, Faculty of Business, Hong Kong Polytechnic University, Hong Kong, pengfei.guo@polyu.edu.hk, *Robin Li*, *Zhaotong Lian*

We study a service competition game in which multiple servers decide their mean service times. Customers' utility is a function of expected delay and service quality which is an increasing function of service time. Customers choose the service providers according to a multinomial logit choice model. We demonstrate that the equilibrium is unique and stable.

■ MC-04

Monday, 12:30-14:00
O4-4

Complementarity Problems and Variational Inequalities 2

Stream: Mathematical Programming
Invited session

Chair: *Sandor Zoltan Nemeth*, School of Mathematics, The University of Birmingham, The Watson Building, Edgbaston, B15 2TT, Birmingham, United Kingdom, nemeths@for.mat.bham.ac.uk

1 - On the irreducibility, self-duality, and non-homogeneity of completely positive cones
Roman Sznajder, Mathematics, Bowie State University, 14000 Jericho Park Road, 20715-9465, Bowie, Maryland, United States, rsznajder@bowiestate.edu

For a given closed cone in a Euclidean space, its completely positive cone is the convex cone generated by rank-one matrices formed using the elements of the underlying closed cone. Completely positive cones arise in the conic LP reformulation of a nonconvex quadratic minimization problem over a set with linear and binary constraints. Motivated by the properties of the nonnegative orthant and the positive semidefinite cone (and more generally of symmetric cones in Euclidean Jordan algebras), we indicate when (or whether) a completely positive cone can be irreducible, self-dual, or homogeneous.

2 - Extended lattice operations and isotone projection sets
Sandor Zoltan Nemeth, School of Mathematics, The University of Birmingham, The Watson Building, Edgbaston, B15 2TT, Birmingham, United Kingdom, nemeths@for.mat.bham.ac.uk

The generalized lattice operations of Gowda, Sznajder and Tao for self-dual cones are extended to more general cones. Motivated by iterative methods for variational inequalities, it is shown that the projection onto a closed convex set is isotone with respect to the order defined by the cone if and only if the closed convex set is invariant with respect to the extended lattice operations. Geometric characterizations of the invariant sets are given. For the nonnegative orthant and the Lorentz cone the invariant sets are determined. Invariance conditions for simplicial cones are given.

3 - Pareto Efficiency in Robust Optimization
Nikos Trichakis, Harvard Business School, United States, nikos@hbs.edu, *Dan Iancu*

We argue that the classical robust optimization (RO) paradigm need not produce solutions that possess the (suitably adapted) property of Pareto optimality. We illustrate how this could lead to inefficiencies and suboptimal performance in practice. We introduce and provide a basic theoretical characterization of Pareto robustly optimal solutions. Numerical studies demonstrate that such solutions have significant upside compared with ones obtained via classical RO, at no extra cost or downside.

■ MC-05

Monday, 12:30-14:00
O4-1

Dynamic Programming II

Stream: Dynamic Programming
Invited session

Chair: *Lidija Zadnik Stirn*, Biotechnical Faculty, University of Ljubljana, Vecna pot 83, 1000, Ljubljana, Slovenia, lidija.zadnik@bf.uni-lj.si

1 - Optimal quality positioning and pricing of Urban Logistics Services — a spatial competition approach
Stefan Spinler, Kuehne Foundation Endowed Chair in Logistics Management, WHU - Otto Beisheim School of Management, 56179, Vallendar, Germany, stefan.spinler@whu.edu, *Matthias Winkenbach*

We present a spatial competition model with non-uniformly distributed customers, sequential entry and simultaneous post-entry price competition among multiple providers of an urban freight consolidation and transportation service. Competitors have heterogeneous, multivariate quadratic cost functions depending on the chosen service quality (i.e. location) and obtained market share. The model allows for both anticipated and unanticipated entry of players. In conjunction with dynamic programming, it serves to analyze optimal strategic positioning and pricing policies for urban logistics services.

2 - Production control policies in flexible manufacturing systems via Approximate Dynamic Programming
Christopher Kirkbride, The Management School, Lancaster University, Dept. of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, c.kirkbride@lancaster.ac.uk, *Mustafa Cimen*

We consider the development of production control policies in a single-stage manufacturing system with multiple factories and products. Manufacturing flexibility in such systems (factories can produce subset of products) means that the state and decision space of these problems is beyond the scope of Dynamic Programming. We apply Approximate Dynamic Programming to this high-dimensional problem to develop strongly performing control policies. We utilise a linear parametric model to approximate the value functions and exploit the approximation and problem structure to infer production decisions.

3 - Stochastic optimization of a gas plant with storage taking into account take-or-pay restrictions
David Wozabal, Vienna University of Economics and Business, Austria, david.wozabal@univie.ac.at, *Nils Löhndorf*

We present a stochastic dynamic model for the joint operation of a gas turbine and a gas storage as well as the optimal use of a long term gas supply contract with a take-or-pay clause. The planning horizon is one year and the model formulation takes into account a stochastic price development on the gas market and uncertain prices for electricity. Decisions about the dispatch of the resources are taken in a hourly resolution. The resulting problem is numerically solved using approximate dual dynamic programming, resulting in a provably near optimal policy.

4 - The development of electricity generation in an oil & gas producing country under uncertainty: application to the power sector in Egypt
Frederic Lantz, IFP-School, 228, avenue Napoleon Bonaparte, 92852, Rueil-Malmaison, France, frederic.lantz@ifpen.fr

The economic analysis of power generation in an oil and gas producing country under uncertainty through optimization modelling approaches is presented and applied to Egypt. To determine the optimal exploitation path of the power generation considering both thermal power plants and renewable sources, a dynamic programming model has been developed considering a set of gas prices and several levels of electricity generation from renewable. The results show that dynamic programming is an appropriated technique here.

■ MC-06

Monday, 12:30-14:00
O4-2

Recent Advances in Global Optimization 2

Stream: Global Optimization
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id

Chair: *Adil Bagirov*, School of Science, Information Technology & Engineering, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

1 - Capacity optimization model of nursing staff management problem under uncertainty
Suryati Sitepu, Mathematics, University Sisingamangaraja/Grad School of Math. USU, Fmipa usu, 20155, Medan, Indonesia, suryati.sitepu@yahoo.com

Capacity management systems create insight into required resources like staff and equipment. For inpatient hospital care, capacity management requires information on beds and nursing staff capacity. This paper presents a capacity model under uncertainty that gives insight into required nursing staff capacity and opportunities to improve capacity utilization on a ward level. A capacity model is developed to calculate required nursing staff capacity. The uncertainty turns up on the availability schedule of staff and the number of patient. The model is applied to hospitals in Medan

2 - Integer Programming Model for a Distribution System based on Location-Routing with Distance and forbidden route constraints
Madyunus Salayan, Mathematics, University Muslim Nusantara/Grad.School of Math. USU, Fmipa usu, 20155, Medan, Indonesia, madyunus_s@yahoo.com, *Herman Mawengkang*

In a distribution network it is important to decide the locations of facilities that impacts not only the profitability of an organization but the ability to serve customers.Generally the location-routing problem is to minimize the overall cost by simultaneously selecting a subset of candidate facilities and constructing a set of delivery routes that satisfy some restrictions. In this paper we impose forbidden route in the constraint. We use integer programming model to describe the problem. A direct search is proposed to solve the result model.

3 - Chance constrained programming for capacitated open vehicle routing problems
Hotman Simbolon, Univ.HKBP Nommensen/Grad School of Math. USU, Fmipa usu, 20155, Medan, Indonesia, simbolon_hotman@yahoo.com

In open vehicle routing problems, the vehicles are not required to return to the depot. In this paper, we extend the problem by including the reliability of customer demands. Each customer has a demand and each customer must be serviced by a single vehicle and no vehicle may serve a set of customers whose total demand exceeds its capacity. Each vehicle route must start at the depot and end at the last customer it serves. The objective is to define the set of vehicle routes that minimizes the total costs. We solve the stochastic model using sample average approximation approach.

4 - A stochastic optimization model for positioning a new product in a multiattribute space with risk
Nerli Khairani, Mathematics, University Negeri Medan/Grad. School of Math. USU, Fmipa usu, 20155, Medan, Indonesia, knerli@yahoo.com, *Herman Mawengkang*

This is a marketing problem faced by a firm which wishes to position a new brand product in an existing product class. Individuals usually differ in their choice of an object out of an existing set, and they would also differ if asked to specify an ideal object. The aim of the problem considered is to optimally design a new product in order to attract the largest number of consumers. This paper addresses a mixed integer nonlinear stochastic programming model to formulate the positioning problem. A direct search approach is proposed to solve the model. A computational experience is presented.

■ MC-07

Monday, 12:30-14:00
O4-3

Vector and Set-Valued Optimization II

Stream: Vector and Set-Valued Optimization
Invited session

Chair: *Beatriz Hernández-Jiménez*, Economics, University Pablo

de Olavide, Edificio Nº 3, José Moñino - 2ª planta-despacho26, Ctra. de Utrera, Km. 1- 41013 Sevilla, 41013, SEVILLA, Spain, mbherjim@upo.es

1 - Projectors in reflexive Banach Spaces and applications to variational inequalities

Annamaria Barbagallo, Department of Mathematics and Applications "R. Caccioppoli", Universitá di Naples "Federico II", 80126, Napoli, Italy, annamaria.barbagallo@unina.it, *Stéphane Pia*

In 1977, E. Zarantonello introduced the important notion of projector in reflexive Banach space, but his work on this subject is still almost unknown. Instead, the notion of generalized projection of Y. Alber in strictly convex and smooth Banach spaces is well known. The aim of the talk is to explore Zarantonello's paper under the light of recent results on projected dynamical system theory. We apply his notion of projectors to projected dynamical inclusions and show that critical points of their solutions, if there exist, coincide with equilibria of variational inequalities.

2 - Core Solutions for set-valued fuzzy linear production games

Miguel A. Hinojosa, Universidad Pablo de Olavide, Cta. Utrera s/n, 41013, Seville, Spain, mahinram@upo.es, *Amparo Mármol*, *Luisa Monroy*, *Francisco Ramon Fernandez*

In a real-world production problem, some of the parameters involved, namely the avail- ability of the resources, technological coe?cients and the incomes associated to each product, may not be perfectly determined thus re?ecting some ambiguity or fuzzy un- derstanding of their nature. Therefore these parameters may admit a representation as fuzzy numbers. In this paper we show how multi-criteria decision theory can be used to deal with a fuzzy linear production problem and with the associated fuzzy linear production game. Different core solutions are discussed.

3 - Optimality conditions and generalized convexity for nonlinear multiobjective programming problems. Scalarization theorems and duality

Beatriz Hernández-Jiménez, Economics, University Pablo de Olavide, Edificio Nº 3, José Moñino - 2ª planta-despacho26, Ctra. de Utrera, Km. 1- 41013 Sevilla, 41013, SEVILLA, Spain, mbherjim@upo.es, *Rafaela Osuna-Gómez*, *Lucelina Batista dos Santos*, *Marko A. Rojas-Medar*

Generalized convexity play a central role for duality results and in order to characterize the solutions set. Taking in mind Craven's notion of K-invexity function and Martin's notion of Karush-Kuhn-Tucker invexity, we define new notions of generalized convexity for a multiobjective problem with conic constraints. These new notions are both necessary and sufficient to ensure every Karush-Kuhn-Tucker point is a solution. The study of the solutions is also done through the solutions of a scalar problem associated. A dual problem is formulated and weak and strong duality results are provided.

■ MC-08

Monday, 12:30-14:00
O3-2

Tutorial - S. Dauzere-Peres

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Christian Prins*, ROSAS, University of Technology of Troyes, BP 2060 - 12 rue Marie Curie, 10010, Troyes, France, christian.prins@utt.fr

1 - Tutorial on Dynamic Lot Sizing

Stéphane Dauzere-peres, Manufacturing Sciences and Logistics, Ecole des Mines de Saint-Etienne, 880 avenue de Minet, 13541, GARDANNE, France, dauzere-peres@emse.fr

This tutorial aims at presenting well-known results and perspectives in dynamic lot-sizing to beginners in the field or to researchers interested in refreshing their knowledge. The general problems will first be modeled, with their key parameters and decisions variables. Basic trade-offs and classifications will be introduced. The talk will then focus on big time bucket models. Disaggregate and shortest path formulations will be given and discussed. The principles behind the Wagner-Whitin algorithm for the single-item case and a well-known Lagrangian heuristic for the capacitated multi-item case will be presented. Some extensions of lot-sizing problems will be reviewed. In particular, the modeling and resolution of complex multi-level lot-sizing problems will be covered. The last part of the talk will open to various problems where lot-sizing decisions are integrated with other decisions such as cutting-stock decisions, scheduling decisions and routing decisions.

■ MC-09

Monday, 12:30-14:00
O3-3

Sponsor - JMP

Stream: Sponsors
Sponsor session

Chair: *Renato De Leone*, School of Science and Technologies, Università di Camerino, via Madonna delle Carceri 9, 62032, Camerino, MC, Italy, renato.deleone@unicam.it

1 - Tolerance Design in JMP: An Introduction To Profiling and Stochastic Optimisation

Volker Kraft, JMP Devision, SAS Institute, In der Neckarhelle 162, 69118, Heidelberg, Germany, volker.kraft@jmp.com, *Ian Cox*

OOvercoming the struggle to design and build or deliver products or services that can delight customers allows any business the opportunity to survive. Tolerance design, which rationally aligns the voice of the process with the voice of the customer, offers the best chance to do this economically and repeatedly, allowing companies not just to survive, but also to prosper in a competitive world. Through a series of examples, this presentation shows how JMP handles tolerance design in a uniquely visual and engaging way. No matter what statistical or engineering approach has been used to build a useful model relating outputs to inputs, JMP provides a unified and consistent environment to profile and optimize responses in the presence of real-world variation. This allows you to tackle such problems quickly and easily, and to effectively communicate your findings to other stakeholders.

■ MC-10

Monday, 12:30-14:00
G5-1

Social Networks and Media

Stream: Telecommunication, Networks and Social Networks
Invited session

Chair: *Pedro Ferreira*, CMU, United States, pedrof@cmu.edu

1 - Consumer Heterogeneity and Long Tails: How Consumption Patterns Change as Consumers Move Online

Gonca Soysal, JSOM, UT Dallas, 800 W Campbell Rd, SM 32, 75080, Richardson, TX, United States, gonca.soysal@utdallas.edu, *Alejandro Zentner*

In this paper we analyze to what extent consumer heterogeneity can account for long tail effects using an individual level panel database from a large specialty apparel retailer selling through both online and physical store channels. Heterogeneity across channels is likely to be large in our setting compared to the setting examined in Zentner et

al.(2012), who document long tail effects for the video rental market even after accounting for selection effects. Understanding the reason behind the differences between online and offline purchase patterns is important for researchers and retailers.

2 - Is Social Influence Always Positive? Evidence from a Large Mobile Network
Rodrigo Belo, CMU, United States, rbelo@cmu.edu

We analyze a subset of products deployed by a large European mobile carrier and look at their characteristics in terms of viral features and network externalities. We develop a model to identify incentives in the adoption of these products and use randomization to identify social influence. We find that network externalities contribute to a decrease in the adoption rate of some products. These results have important management and policy implications. Social influence is not always positive and it is important to design products that exhibit characteristics for adoption to occur as expected.

3 - The Impact of Like Information on the Sales of Movies in Video-on-Demand: a Randomized Experiment
Miguel Godinho de Matos, Engineering & Public Policy, Carnegie Mellon University, 5000 Forbes AVE/Baker Hall 129, 15213, PITTSBURGH, PA, United States, Miguel.GodinhoMatos@gmail.com, *Pedro Ferreira*

We design and implement a randomized experiment within the VoD system of a large telecom provider to determine the role that likes play on the sales of movies over VoD. The experiment consisted in random manipulations of movie popularity information at random times. Our results show that self-fulfilling prophecies are hard to sustain in markets with costly goods that are sufficiently well-known. Movies for which popularity information is artificially increased (decreased) sell more (less) than they would otherwise. The provider enjoys increased profits, but subscribers lose welfare.

4 - Determinants of Subscriber Churn in Wireless Networks: The Role of Peer Influence
Qiwei Han, Engineering and Public Policy, Carnegie Mellon University, 5629 Hempstead Rd, Apt 5, 15217, Pittsburgh, Pennsylvania, United States, qiweih@cmu.edu, *Pedro Ferreira*

Subscriber churn is a top challenge for mobile operators. In this paper, we apply generalized propensity score matching to separate peer influence from other confounding factors that might affect churn. Our empirical analysis, developed over a large scale mobile network, confirms that peer influence plays a role in churn. The estimated marginal influence of having a first friend churn is roughly 3%. While the marginal effect of friends' churn decreases significantly as more friends do so, contagious churn is still a significant part of the story beyond high churn rate in the mobile industry.

■ MC-11

Monday, 12:30-14:00
G5-3

Telecommunications, Networks and Social Networks 1

Stream: Telecommunications, Networks and Social Networks (contributed)
Contributed session

Chair: *José-Fernando Camacho-Vallejo*, Facultad de Ciencias Físico-Matemáticas, Universidad Autónoma de Nuevo León, Av. Universidad s/n, 66450, San Nicolas, Nuevo León, Mexico, jose.camachovl@uanl.edu.mx

1 - A Column Generation Algorithm for Communication Systems with High Error Correction Capability
Banu Kabakulak, Industrial Engineering Department, Bogazici University, Turkey, banu.kabakulak@boun.edu.tr, *Z.Caner Taskin*, *Ali Emre Pusane*

Channel coding aims to minimize errors which occur during the transmission of digital information from one place to another. Besides the original data, the low-density parity-check (LDPC) codes include additional data to increase error correction capability. Being sparse, they allow heuristic iterative decoding algorithms with low complexity and low decoding latency. However, receiver can obtain erroneous information since decoders are not optimal. In this study, to overcome these errors, a linear programming based decoding algorithm is considered and a column generation method is proposed.

2 - A new algorithm for blind separation of discrete signals used in digital communications
Abdenour Labed, Computer Science, Ecole Militaire Polytechnique, BP 17, B. E. B, 16111, Algiers, Algeria, a-labed@mailcity.com

Blind source separation consists in extracting transmitted signals from their unknown mixture, without the use of training sequences. In this context, the Constant Modulus Algorithm (CMA) is one of the most studied ones. But, for non constant modulus signals like quadrature amplitude modulated (QAM) signals suitable for high data-rate communications, the CMA has shown its limits. We augment the CMA cost function by a term that summarizes a priori information about the modulation characteristics and obtain enhanced performance.

3 - The joint power control and spectrum allocation problem in cognitive networks
Abdelkader Tounsi, computer science, university badji mokhtar, Laboratory of networks and system, BP 12 23000, 23000, annaba, annaba, Algeria, tounsi.abdelkader@lrs-annaba.net, *Malika Babes*

The growing popularity for cognitive network increases the need for efficient use of the limited frequency spectrum. On the other hand, transmission from cognitive networks can cause harmful interference to primary users of the spectrum. Therefore, important design criteria for cognitive radio include maximizing the spectrum utilization and minimizing the interference caused to primary users using the power control techniques. In our work, we consider the joint power control and spectrum allocation using the model of CSGS with the aim to maximize the system utilities.

4 - A Scatter Search Algorithm for a Bi-level Topological Design of LANs
José-Fernando Camacho-Vallejo, Facultad de Ciencias Físico-Matemáticas, Universidad Autónoma de Nuevo León, Av. Universidad s/n, 66450, San Nicolas, Nuevo León, Mexico, jose.camachovl@uanl.edu.mx, *Julio Mar-Ortiz*

The topological local access networks (LAN) design problem consist on assigning users to clusters and the union of clusters by bridges in order to obtain a minimum response time network with minimum connection cost. We propose a solution method for a bilevel topological design of a LAN based on Scatter Search. Our solution method considers the Stackelberg equilibrium to solve the bilevel problem. This procedure incorporates memory structures for combination purposes. The computational results show that our proposed method outperforms the previous Nash Genetic approaches.

■ MC-12

Monday, 12:30-14:00
G5-4

Shared Mobility Systems 2

Stream: Transportation and Logistics
Invited session

Chair: *Tal Raviv*, Department of Industrial Engineering, Tel Aviv University, 69978, Tel Aviv, Israel, talraviv@eng.tau.ac.il

1 - Parking Reservations in Shared Mobility Systems
Mor Kaspi, Industrial Engineering, Tel-Aviv University, Ramat Aviv, 69978, Tel-Aviv, Israel, morkaspi@post.tau.ac.il, *Tal Raviv*, *Michal Tzur*

We propose improving the performance of bike and car sharing systems by the incorporation of reservation policies. In particular, we study a parking space reservation policy in which the users are required to state their destination upon rental of the vehicle and the system reserves a parking space for them. A Markovian model of the system is formulated. Using this model, we prove that under reasonable demand rates, this policy will improve the performance of the system. This result is confirmed via extensive simulation study of large realistic systems.

2 - Adaptive Pricing for Rebalancing of Shared Mobility Systems

Alexander Nikolaev, Department of Industrial and Systems Engineering, University at Buffalo (SUNY), 409 Bell Hall, 14260-2050, Buffalo, NY, United States, anikolae@buffalo.edu, *Michael Stearns*, *Changhyun Kwon*

We explore a creative approach to managing vehicle redistribution in shared-mobility systems. In bike repositioning, the problem of delivery truck scheduling/routing is often addressed independently from bike sharing operations planning. We present a model for regulating bike flow by designing adaptive pricing policies, i.e., strategically offering incentives to travelers. The idea is to designate certain bike stations as accumulation hubs and dynamically match them, pairwise, thus allowing trucks to be used more efficiently. Challenges and opportunities of the proposed approach are discussed.

3 - On the relation of the use of information and communication technologies (ICT) in the efficiency of Brazilian logistics service industry

Carlos Ernani Fries, Department of Production and Systems Engineering, Federal University of Santa Catarina, Caixa Postal 5185, 88040-970, Florianopolis, Santa Catarina, Brazil, ernani@deps.ufsc.br, *Mônica M. M. Luna*

Information and communication technologies (ICT) are recognized as a competitive factor for companies to provide better services at lower costs. However, its positive impact on productivity and efficiency has been questioned by several studies since the 80s. This work aims to clarify the relationship of the use of ICT with efficiency measures evaluated by DEA for the logistics service industry in Brazil. Results show a close relation between technical and scale efficiency and the use of ICT packages suggesting that these effectively exert influence on efficiency and therefore on productivity.

4 - Metaheuristics for the Static Balancing of Bicycle Sharing Systems

Günther Raidl, Institute for Computer Graphics and Algorithms, Vienna University of Technology, Favoritenstr. 9-11/1861, 1040, Vienna, Austria, raidl@ads.tuwien.ac.at, *Petrina Papazek*, *Marian Rainer-Harbach*, *Bin Hu*

We consider the static problem of balancing a public bike sharing system via a vehicle fleet. A greedy heuristic is used to create initial solutions. It is extended to a PILOT method that evaluates candidate stations considered for addition in a refined, recursive way. For local improvement, a Variable Neighborhood Descent involving several specifically designed neighborhoods is used. Last but not least, we investigate GRASP and General Variable Neighborhood Search for further diversification. Results are reported on instances derived from the real-world scenario in Vienna.

■ MC-13

Monday, 12:30-14:00
G5-5

Optimizing operations in distribution centers

Stream: Facility Logistics
Invited session

Chair: *Yun Fong Lim*, Lee Kong Chian School of Business, Singapore Management University, 50 Stamford Rd, #04-01, 178899, Singapore, Singapore, yflim@smu.edu.sg

1 - Dynamic worker task assignment strategies for crossdocking operations

Jiana-Fu Wang, Marketing, National Chung Hsing University, 250 Kuo Kuang Rd., 40227, Taichung, Taiwan, jfwang@dragon.nchu.edu.tw

This study focuses on issuing dynamic worker task assignment, especially on worker's return trip to an inbound door, to perform efficient crossdocking operations. Three task assignment strategies including shortest inbound door scenario, time-limited shortest inbound door scenario, and joint assignment scenario are compared with zero solution scenario. These strategies integrate detailed crossdocking processes via computer simulation. Simulation results show that the average truck waiting time can be reduced up to 48%, and the average package transferring cycle time can be saved up to 26%.

2 - A Fuzzy Logic Based Real Time Warehouse Management System for Steel Industry

Ozlem Uzun Araz, Industrial Engineering Dept., Celal Bayar University, Turkey, ozlem.araz@cbu.edu.tr, *Ozgur Eski*, *Ceyhun Araz*

Warehouse management system (WMS) is an important part of a production management system. The efficient warehouse operations require effective storage location assignment policies. The aim of this paper is to propose an integrated real time WMS based on RFID technology and fuzzy inference system. We also present a fuzzy based heuristic for storage location assignment problem of steel coils which aims to minimize material handling cost and the number of defective parts and to maximize utilization of storage area. Simulation is used for testing proposed approach for a realistic case study.

3 - Robust Storage Assignment in Unit-Load Warehouses

Yun Fong Lim, Lee Kong Chian School of Business, Singapore Management University, 50 Stamford Rd, #04-01, 178899, Singapore, Singapore, yflim@smu.edu.sg, *Marcus Ang*, *Melvyn Sim*

Assigning products to and retrieving them from proper storage locations are crucial in minimizing the operating cost of a unit-load warehouse. The problem becomes intractable when the warehouse faces variable supply and uncertain demand in a multi-period setting. We introduce a robust optimization model and obtain a storage-retrieval policy to minimize the worst-case expected total travel. Despite imprecise specification of demand distributions, the policy achieves close to the expected value given perfect information, and significantly outperforms existing heuristics in the literature.

■ MC-14

Monday, 12:30-14:00
G5-6

Variable neighbourhood search

Stream: Metaheuristics
Invited session

Chair: *Nenad Mladenovic*, School of Mathematics, Brunel University, Kingston Lane, UB8 3PH, Uxbridge, Middlesex, United Kingdom, Nenad.Mladenovic@brunel.ac.uk

1 - Variable neighborhood search for two multimedia problems

Polina Kononova, Operation Research, Sobolev Institute of Mathematics of SBRAS, pr. Koptuga 4, 630090, Novosibirsk, Russian Federation, polinusik@gorodok.net

We present variable neighborhood search algorithms for the following media problem. The player takes objects from the remote database and prefetchs them into the buffer. The size of the buffer is limited. The presentation of an object cannot be started earlier than the finish of its loading. An object leaves the buffer after the completion of its presentation. We consider two objective functions: minimization of the total time of the whole presentation for the given size of the buffer and minimization of the buffer size for the give length of schedule.

2 - A Global Variable Neighborhood Search for the Permutation Flowshop Scheduling Problem with the Total Tardiness Criterion
M. Fatih Tasgetiren, Industrial Engineering, Yasar University, Selcuk Yasar Campus, Izmir, Turkey, fatih.tasgetiren@yasar.edu.tr, *Ruben Ruiz*, *Quan-Ke Pan*

This paper presents presents a global variable neighborhood search algorithm for the permutation flowshop scheduling problem with the total tardiness criterion. The performance of the algorithm is tested on the benchmark set in http://soa.iti.es. It includes 540 problems ranging from 50 to 350 jobs and from 10 to 50 machines. The computational results show its highly competitive performance against the best performing algorithms from the literature and some new best known solutions are obtained.

3 - A Global Variable Neighborhood Search Algorithm for the No-Idle Permutation Flowshop Scheduling Problem with Total Tardiness Criterion
Ozge Buyukdagli, Industrial Engineering, Yasar University, Selcuk Yasar Kampusu Agacli Yol Bornova, Izmir, Turkey, ozge.buyukdagli@yasar.edu.tr, *M. Fatih Tasgetiren*, *Quan-Ke Pan*, *P. N Suganthan*

A global variable neighborhood search (gVNS) algorithm is presented for the no-idle permutation flowshop scheduling problem with the total tardiness criterion. The iterated greedy (IG) and iterated local search (ILS) algorithms are embedded in the VNS algorithm by using the idea of its neighborhood change. The performance of the algorithm is tested on the benchmark set in http://soa.iti.es. It includes 540 problems ranging from 50 to 350 jobs and from 10 to 50 machines. The computational results will be presented in detail with comparisons to some algorithms from the literature.

4 - Fast Matheuristics for the Discrete (r|p)-centroid problem
Nenad Mladenovic, School of Mathematics, Brunel University, Kingston Lane, UB8 3PH, Uxbridge, Middlesex, United Kingdom, Nenad.Mladenovic@brunel.ac.uk, *Ivan Davydov*, *Yury Kochetov*, *Dragan Urosevic*

This paper addresses the Stackelberg facility location game. Two decision makers, a leader and a follower, compete to attract customers. The leader opens p facilities, anticipating that the follower will react to the decision by opening own r facilities. Each customer patronizes the closest facility. The goal is to find p facilities for the leader to maximize his market share. We present this game as a mixed integer linear bi-level program. We design local search heuristics and apply classical mathematical programming tools for the follower problem.

■ MC-15

Monday, 12:30-14:00
G5-2

Metaheuristics for line balancing problems and workflow scheduling problems

Stream: Metaheuristics (contributed)
Contributed session

Chair: *Sonia Yassa*, Val d'oise, EISTI, Avenue du Parc, 95000, Cergy, France, sonia.yassa@eisti.eu

1 - A GRASP Based Heuristic for Assembly Line Worker Assignment and Balancing Problem
Sebnem Demirkol Akyol, Industrial Engineering, Dokuz Eylul University, Dokuz Eylul University Department of Industrial Engineering, Tinaztepe Campus Buca, 35160 , Izmir, Turkey, sebnem.demirkol@deu.edu.tr, *Adil Baykasoğlu*, *Lale Özbakır*

Assembly Line Worker Assignment and Balancing Problem (ALWABP) arises when the operation time for every task differs according to the worker who executes the task. The problem is especially important for manually operated assembly lines with high labor turnover. In this work, a GRASP based heuristic is developed to find an initial solution in an effective manner. Then, a path re-linking approach is applied as a local search procedure in order to improve results. The present study is supported by Dokuz Eylul University Scientific Research Projects, Project Number: 2012.KB.FEN.058.

2 - Using Simulated Annealing for the Accessibility Windows Assembly Line Balancing Problem (AWALBP)
Gema Calleja, IOC-DOE, UPC, Av. Diagonal 647, 11th floor, 08028, Barcelona, Spain, gema.calleja@upc.edu, *Albert Corominas*, *Alberto García-Villoria*, *Rafael Pastor*

The AWALBP is an assembly line balancing problem where the length of the workpieces is larger than the width of the workstations. A procedure using a matheuristic and a mixed integer linear programming (MILP) model was previously tested to solve the AWALBP and it succeeded in finding optimal solutions to instances up to a certain size. We propose simulated annealing (SA) and a hybrid procedure using SA and MILP in order to find good quality solutions for larger instances. Results show that a better solution is obtained in most of the cases that could not be previously solved optimally.

3 - Ant Colony Optimization Algorithm for Stochastic U-Line Re-balancing
Erkan Celik, Industrial Engineering, Yildiz Technical University, 34349, Istanbul, Turkey, erkcelik@yildiz.edu.tr, *Yakup Kara*

An ant colony optimization algorithm has been proposed for re-balancing of stochastic U-lines with the objective of minimizing total cost of re-balancing. Total cost of re-balancing is consisted of opening or closing cost of a workstation, re-location of tasks on the line and utilization costs of workstations. The proposed algorithm was developed by considering two cases. The first case assumes that current locations of tasks are fixed while tasks can be re-located on the U-line in the second case. A comprehensive experimental study was conducted to compare the rebalancing costs of both cases.

4 - A Genetic Algorithm Approach to a Cloud Workflow Scheduling Problem With Multi-QoS Requirements
Sonia Yassa, Val d'oise, EISTI, Avenue du Parc, 95000, Cergy, France, sonia.yassa@eisti.eu, *Rachid Chelouah*, *Hubert Kadima*, *Bertrand Granado*

The advent of Cloud Computing allows researchers to investigate its benefits in executing scientific applications by providing on-demand computing, storage and network services. In this paper, we address the cloud workflow scheduling problem and present a new scheduling approach based on genetic algorithm able to handle multi-QoS requirements such as time, cost and reliability. The proposed algorithm is evaluated on a set of real world scientific applications using Amazon EC2 services.The computational results shows the efficiency the proposed metaheuristic.

■ MC-16

Monday, 12:30-14:00
G5-7

Network Flows II

Stream: Routing Problems
Invited session

Chair: *Paola Festa*, Dept. of Mathematics and Applications, University of Napoli Federico II, Compl. MSA - Via Cintia, 80126, Napoli, Italy, paola.festa@unina.it
Chair: *Francesca Guerriero*, D.E.I.S.: Department of Electronics, Computer Science and Systems, University of Calabria, Via P. Bucci, 87036, Rende, Italy, guerriero@deis.unical.it

1 - An innovative approach for the Resource Constrained Elementary Shortest Path Problem
Luigi Di Puglia Pugliese, D.E.I.S.: Department of Electronics, Computer Science and Systems, University of Calabria, Via ponte P. Bucci, 87036, Rende, Italy, Italy, ldipuglia@deis.unical.it, *Francesca Guerriero*, *Roberto Musmanno*

Column-generation methods have been successfully applied for solving the Vehicle Routing Problem. Generating a column means to solve an instance of the Resource Constrained Elementary Shortest Path Problem. In this talk, we present an innovative solution strategy to optimally solve the problem based on the reference point concept. The defined approach is tested on benchmark instances and compared with the best algorithms known so far from the scientific literature. The computational results underline that the defined strategy is very efficient and outperforms the state-of-the-art algorithms.

2 - Sigma-robustness for the Robust Shortest Path Problem in Multimodal Networks
Yakoub Bouchenine, University of science and technology Houari Boumediene, Algeria, yakoub.bouchenine@gmail.com, *Zineb Habbas*, *Djamel Khadraoui*, *Habiba Drias*, *Hedi Ayed*

Sigma-robustness is a process of maintaining a shortest path under network's uncertainties; it ensures a well distributed degree centrality (DC) over the shortest path's nodes, by making use of some statistical distribution measures. That is, skewness illustrates the symmetry around the central value for a homogeneous distribution of DC, kurtosis shows how acute the central peak is, therefore, sharp peaks maximizes the number of nodes with the highest values of DC. The presented concept is applied on multimodal networks; it aims to support the transfer between several transportation modes.

3 - Dynamic programming algorithms for the (Elementary) Resource Constrained Shortest Path Problem
André Linhares, LIAFA, Université Paris Diderot - Paris 7, Paris, France, linhares@liafa.univ-paris-diderot.fr, *Ruslan Sadykov*, *François Vanderbeck*, *Luigi Di Puglia Pugliese*, *Francesca Guerriero*

The Resource Constrained Shortest Path Problem (RCSPP) often arises as a subproblem when decomposition techniques are applied to solve combinatorial optimization problems, most notably those of routing and scheduling. In this talk, we propose variants of the state-of-the-art dynamic programming algorithms for solving the RCSPP, and we assess their efficiency through computational experiments.

4 - Adaptive Situation-Aware Approach to Network Load Balancing
Janusz Granat, National Institute of Telecommunications, 02-796, Warsaw, Poland, J.Granat@itl.waw.pl, *Przemyslaw Lyszczarz*

One of the trends in network management is self-adaptation. We will present a new self-adaptation algorithm for network load balancing. The optimization problem for each node and gossip-based communication protocol between neighborhood nodes has been proposed. The optimization criterion is defined as network bandwidth efficiency. The presented approach has been tested in simulation environment OMNeT++. Several configurations of MPLS Virtual Private Network have been considered. The results of comparison of centralized and self-adaptation algorithms will be presented.

■ MC-17

Monday, 12:30-14:00
G5-8

Sustainable Distribution Planning

Stream: Sustainable Transport Planning
Invited session

Chair: *Dan Black*, Business School, University of Edinburgh, Edinburgh, United Kingdom, Dan.Black@ed.ac.uk

1 - Green distribution planning considering alternative routes: a mathematical model
Gajanand M S, Department of Management Studies, Indian Institute of Technology, Madras, Research Scholar, Department of Management Studies,, IIT Madras, 600036, Chennai, Tamil Nadu, India, msgajanand@gmail.com, *Narendran T T*

Logistics firms aim to reduce vehicular emissions as a part of their environmental initiatives. A useful surrogate measure of emissions is fuel consumption which depends on factors such as road angle, nature of road, traffic conditions, vehicle parameters, velocity, distance and load. We formulate a Multiple-Route-Vehicle-Routing Problem (MRVRP) that evaluates alternative routes between each pair of nodes for minimizing fuel consumption. The model also shows the trade-offs involved in the choice of a route-plan.

2 - Developing a sustainable land-use and transportation optimization model
Narges Shahraki, industrial engineering, koc university, koc university, istanbul, Turkey, nshahraki@ku.edu.tr, *Metin Turkay*

In this study, we present a land use and transportation optimization model. We consider environmental, social and economic aspects of triple bottom line of sustainability in the objective functions of the model. The resulting model has two objective functions. The formulated model is a stochastic model hence the demand is a random variable. We implement ?-constraint method to solve the multi-objective model, and we verify our presented model through several examples. In this paper for the first time in literature, a sustainable land-use and transportation optimization model is formulated.

3 - Optimal delivery service strategy with carbon emissions and demand-supply interactions
Hui-Chieh Li, Ta Hwa University of Science Technology, Taiwan, winnie.tem88g@nctu.edu.tw, *Jhen-jia Hu*

The study explores how to determine a delivery strategy for distributors in terms of service cycle frequency and duration and vehicle type for all cycles. We explore relationships of time-dependent demand, delivery cost and their influences on optimal delivery service strategy with carbon emissions and demand-supply interaction. The role of carbon emissions is considered as emission costs, depending on distance traveled and load in weights. The model applies mathematical programming methods and attempts to maximize the total profit of the distributor during the study period.

4 - Punctuality and Environmental Impact in Regional Grocery Distribution
Dan Black, Business School, University of Edinburgh, Edinburgh, United Kingdom, Dan.Black@ed.ac.uk, *Richard Eglese*

An increasing body of research looks at the evaluating the environmental impact of vehicle routing and scheduling decisions. Such decisions can be improved by including congestion data into the VRP model. Deliveries often have time windows which can either be fixed (hard time windows) or can be altered (soft time windows). In the latter case it is usually assumed that the decision maker has full control over time windows. This case study investigates the delivery of goods to supermarkets from a regional distribution centre where this assumption is not always true.

■ MC-18

Monday, 12:30-14:00
G5-9

Stochastic Modeling and Simulation I

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Frank Herrmann*, Innovation and Competence Centre for Production Logistics and Factory Planning, University of Applied Sciences Regensburg, PO box 120327, 93025, Regensburg, Germany, Frank.Herrmann@HS-Regensburg.de

1 - Simulation of a stochastic model for master production scheduling in a hierarchical production planning system used in industrial practise to cope with demand uncertainty
Frank Herrmann, Innovation and Competence Centre for Production Logistics and Factory Planning, University of Applied Sciences Regensburg, PO box 120327, 93025, Regensburg, Germany, Frank.Herrmann@HS-Regensburg.de

Demand uncertainty for master production scheduling is addressed over the last years by approaches of stochastic or robust optimisation. In this contribution a more detailed model is regarded. Instead of analysing the planning results by a cost function, and so implicitly assume that the plans are realizable, here the effects of robust master production scheduling are evaluated using a planning hierarchy that is common in industrial applications. The primary objective is to minimise tardiness of customer order deliveries, and the secondary objective is to minimise inventory of end products.

2 - Combining Car Sequencing with stochastic modeling and Multi-Criteria Decision for production stabilization
Thomas Husslein, OptWare GmbH, Pruefeninger Str. 20, 93049, Regensburg, Germany, husslein@optware.de

The objective of the car sequencing problem is to find an optimal permutation for building cars on an assembly line. Instable processes in the preceding production stages especially the paint shop often prevent the realization of optimally planned sequences. The stabilization task derives from a given target assembly sequence a different paint shop sequence. A decision support system that incorporates a stochastic model of the production process and solves the stabilization task considering different goals has been developed and successfully tested.

3 - An approach to combine simulation and optimization of business processes
Christian Mueller, Dep. of Management and Business computing, TH Wildau, Bahnhofstrasse, D-15745, Wildau, Germany, christian.mueller@th-wildau.de, *Mike Steglich*

This paper describes an approach to combine simulation and optimization of business processes. This approach is illustrated with a simulation model of a traffic network, where the vehicles are controlled by local navigation systems. For this, a simulation model is generated from an Event-driven Process Chain Diagram by EPC-Simulator. For solving the navigation subtasks the simulation model is combined with the CMPL modelling and optimization system to solve the navigation subtasks.

4 - A simulation optimization approach for forecasting and inventory management of intermittent demand items
Katrien Ramaekers, Research group Logistics, Hasselt University, Agoralaan - building D, 3590, Diepenbeek, Belgium, katrien.ramaekers@uhasselt.be, *Gerrit K. Janssens*

Intermittent demand appears at random, with some time periods having no demand at all. When demand occurs, it is not necessarily for a constant demand size. Intermittent demand is not only difficult to predict; selecting the right periodic inventory system is also a problem. The majority of literature on intermittent demand focuses on either one of these topics. Only a few studies investigate the combined performance of the system. In this research, simulation optimization is used to study the combined performance based on data of a Belgian company.

■ MC-19

Monday, 12:30-14:00
G5-10

Advances in Sustainable Transport

Stream: Business Excellence in Logistics
Invited session

Chair: *Ulrich Breunig*, Business Administration, University of Vienna, Chair for Production and Operations Management, Brünner Straße 72, A-1210, Vienna, Austria, ulrich.breunig@univie.ac.at
Chair: *Verena Schmid*, Departamento de Ingenería Industrial, Universidad de los Andes, Bogotá, Colombia, v.schmid@uniandes.edu.co

1 - Estimating the Number of Electric Vehicles to Battery Charging Stations Allowing for Multiple Charging
Yudai Honma, Waseda Institute for Advanced Study, Waseda University, 60-02-05A, Okubo 3-4-1, 169-8555, Shinjuku-ku, Tokyo, Japan, yudai@aoni.waseda.jp, *Shigeki Toriumi*

Electric vehicles (EV) have attracted an increasing amount of attention. However, the continuous cruising distance of an EV is limited to around 160 km, which is insufficient for everyday use. Battery capacity is the limiting factor in long-distance EV travel. In planning the EV infrastructure, an appropriate number of chargers must be installed at each station. In this study, on the basis of the supporting infrastructure for widespread EV use, we propose a mathematical model for estimating the number of vehicles arriving at each charge station.

2 - Design of Reverse Logistics Network for Waste Batteries
Irem Donmez, Department of Industrial Engineering, Koc Universıty, Rumeli Feneri Yolu, Sarıyer, 34450, Istanbul, Turkey, idonmez@ku.edu.tr, *Metin Turkay*

As the demand for portable electronic devices grows, the disposal of batteries power them pose important environmental problems. How to manage this large amount of waste batteries? In this study, we present a mixed-integer linear programming (MILP) model to design reverse logistics network of waste batteries. The model involves collection, transportation, sorting and disposal of waste batteries. Furthermore, we conduct a sensitivity analysis of the network design in terms of the change of collection amount and the composition of collected batteries, which is critical to offer useful outputs.

3 - A Route-First Cluster-Second Heuristic for an Electric-Vehicle Routing Problem
Mesut Yavuz, Byrd School of Business, Shenandoah University, 210 Halpin-Harrison Hall, 22601, Winchester, VA, United States, myavuz@su.edu

Utilization of electric vehicles (EVs) is a key concern for fleet operators due to their limited driving range before a recharge is needed, long charging times and limited availability of public charging infrastructure. We consider a vehicle routing setting with a heterogeneous fleet consisting of an internal combustion engine vehicle (ICEV) and an EV, and present a mathematical model for the emerging vehicle routing problem as well as a route-first cluster-second heuristic for its solution. Our preliminary computational experiments show that the heuristic is fast and finds good solutions.

4 - A Large Neighbourhood Search for the Two-Echelon Capacitated Vehicle Routing Problem
Ulrich Breunig, Business Administration, University of Vienna, Chair for Production and Operations Management, Brünner Straße 72, A-1210, Vienna, Austria, ulrich.breunig@univie.ac.at, *Verena Schmid*, *Richard Hartl*

A local-search metaheuristic based on a Large Neighbourhood Search is developed and implemented to find good solutions within limited computing time for the Two-Echelon Capacitated Vehicle Routing Problem. Large trucks deliver goods from a depot to intermediate facilities, where freight is transferred to smaller vehicles, which then deliver it to customers. The goal is to satisfy all customer demands with the lowest possible costs and driven distance. We will give a work-in-progress comparison with other exact and heuristical solution approaches.

■ MC-20

Monday, 12:30-14:00
G5-11

Rolling Stock and Crew (Re-)Scheduling

Stream: Optimization in Public Transport
Invited session

Chair: *Leo Kroon*, Rotterdam School of Management, Erasmus

University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, lkroon@rsm.nl

1 - Robust approach to solving optimization problems in public transportation

G. N. Srinivasa Prasanna, International Institute of Information Technology, Bangalore, 560100, Bangalore, India, gnsprasanna@iiitb.ac.in, *Abhilasha Aswal*, *Anushka Chandrababu*, *Chethan Danivas*, *Rijutha Natarajan*

We present a robust optimization based approach, with a polyhedral specification of uncertainty, for solving the fleet scheduling problem in railways and road transportation networks. In addition to the heuristics for solving the robust problem, we have a complete decision support framework that can compare alternative input specs using an extended relational algebra of polytopes and also analyze the optimization outputs. We present our work with Indian railways, one of the largest railways networks in the world and KSRTC, a state owned road transportation company in India.

2 - Robust and cost-efficient vehicle and crew scheduling in public transport

Bastian Amberg, Information Systems, Freie Universitaet Berlin, Garystr. 21, 14195, Berlin, Germany, bastian.amberg@fu-berlin.de, *Boris Amberg*, *Natalia Kliewer*

As disruptions and -in consequence- delays are unavoidable during execution of vehicle and crew schedules in public transport, possible delays should already be considered in the planning phase. We present integrated scheduling approaches to create vehicle and crew schedules that are both cost-efficient and robust to (minor) disruptions. In addition to minimizing vehicle and crew costs the approaches aim at minimizing the expected overall propagation of delays through the transport network. Expected delay propagation within and between vehicle blocks and crew duties is taken into account.

3 - Re-optimization of Rolling Stock Rotations

Markus Reuther, Optimization, Zuse-Institut Berlin, Takustrasse 7, 14195, Berlin, Germany, reuther@zib.de

The Rolling Stock Rotation Planning Problem is to schedule rail vehicles in order to cover timetabled trips by a cost optimal set of vehicle rotations. The problem integrates several facets of railway optimization, i.e., vehicle composition, maintenance constraints, and regularity aspects. In industrial applications existing schedules often have to be re-optimized to integrate timetable changes or construction sites. We present an integrated modeling and algorithmic approach for this task as well as computational results for industrial problem instances of DB Fernverkehr AG.

4 - Railway Rolling Stock Planning: Robustness Against Large Disruptions

Leo Kroon, Rotterdam School of Management, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, lkroon@rsm.nl, *Valentina Cacchiani*, *Alberto Caprara*, *Laura Galli*, *Gabor Maroti*, *Paolo Toth*

We describe a two-stage optimization model for determining robust rolling stock circulations for passenger trains. Here robustness means that the rolling stock circulations can better deal with large disruptions of the railway system. The model is solved with Benders decomposition.

We evaluate our approach on real-life instances of Netherlands Railways. The computational results show that the rolling stock circulation obtained on a limited number of disruption scenarios is indeed more robust in case one of these disruption scenarios or a scenario from a much larger set occurs.

■ MC-21

Monday, 12:30-14:00
G6-1

New Scheduling Algorithms

Stream: Scheduling
Invited session

Chair: *Alena Otto*, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de

Chair: *Liliana Grigoriu*, Operations Research, University Siegen, Germany, liliana.grigoriu@gmail.com

1 - A Branch and Price and Cut approach for single machine scheduling with sequence-dependent setup times minimizing total weighted completion time

Paul Göpfert, WINFOR (Business Computing and Operations Research) Schumpeter School of Business and Economics, University of Wuppertal, Gaußstraße 20, 42119, Wuppertal, Germany, goepfert@wiwi.uni-wuppertal.de, *Stefan Bock*

In this talk we consider a real-world production process that can be modeled as a single machine scheduling problem with sequence-dependent setup times, job due dates and inventory constraints. By minimizing total weighted completion time the objective aims at attaining high production efficiency. We propose a new branch and price and cut approach for the construction of optimal schedules that is heavily exploiting the fact that jobs are grouped in families. By the application of cuts and different branching strategies tight lower bounds are found. First computational results are presented.

2 - An FPTAS for earliness-tardiness with constant number of due dates and polynomially related weights

George Karakostas, Computing & Software, McMaster University, 1280 Main St. W., L8S4K1, Hamilton, Ontario, Canada, karakos@mcmaster.ca

Given a schedule of jobs on a single machine, each one with a weight, processing time, and a due date, the tardiness of a job is the time needed for its completion beyond its due date, and its earliness is the time remaining until its due date after its completion.The weighted version is notoriously hard: unless P=NP, it cannot be approximated within an exponential factor in polytime. We present an FPTAS for the basic scheduling problem of minimizing the total weighted earliness and tardiness tardiness when the number of distinct due dates is fixed and the job weights are polynomially related.

3 - Multiprocessor scheduling with fixed jobs or downtimes

Liliana Grigoriu, Operations Research, University Siegen, Germany, liliana.grigoriu@gmail.com

We consider scheduling a set of independent tasks on multiple same-speed processors with periods of unavailability in order to minimize the maximum completion time. We give a simple polynomial Multifit-based algorithm the schedules of which end within 1.5, 1.6 and respectively 1.625 times the end of an optimal schedule or times the latest end of a downtime when there are at most two downtimes, at most three downtimes, and respectively any number of downtimes on each machine. No approximation bound that is less than 1.5 can be insured by a polynomial algorithm for this problem unless P=NP.

4 - Effective Solution Space Limitation at the Example of Multiprocessor Scheduling

Rico Walter, FSU Jena - Chair of Management Science, Germany, rico.walter@uni-jena.de

We are concerned with the fundamental makespan minimization problem on identical parallel machines for which we provide a thorough investigation of the underlying solution space. Based on a sophisticated representation of schedules as sets of one-dimensional paths we derive universally valid properties of optimal solutions from which we deduce efficient dominance rules. Implemented in a powerful branch-and-bound algorithm, the results of our computational study attest to the effectiveness of the new approach. Interestingly, the new structural insights also apply to further assignment problems.

■ MC-22

Monday, 12:30-14:00
G6-2

Scheduling in Production and Assembly

Stream: Scheduling, Time Tabling & Project Management (contributed)
Contributed session

Chair: *Vid Ogris*, Algit d.o.o., Podhom 64a, 4247, Zgornje Gorje, -Select-, Slovenia, vid.ogris@algit.si

1 - Scheduling the assembly lines of a plastic products manufacturer
Emine Akyol, Industrial Engineering, Anadolu University, Turkey, emineakyol@anadolu.edu.tr, *Tugba Saraç*

In this study, one-stage and multi-stage assembly line scheduling problems of a plastic products manufacturer are considered. A mathematical model is developed for each line types. Process oriented constraints like release dates and shift availabilities of lines are taken into consideration. Proposed models are solved by GAMS software and obtained schedules are compared with the schedules used by the factory.

2 - Heuristics for the robotic cell problem with controllable processing times
Mohamed Kharbeche, Mechanical and Industrial Engineering, Qatar University, College of Engineering, P.O. Box 2713, Doha, Qatar, Qatar, mkharbec@qu.edu.qa, *Mohamed Haouari*, *Ameer Al-Salem*

We investigate the Robotic Cell Problem with Controllable Processing Times. This problem requires simultaneously scheduling jobs, machines, and the transportation device. We propose a nonlinear mixed integer programming formulation that is used to derive an LP-based heuristic and a lower bound. Also, we describe a genetic algorithm that includes several innovative features including an original solution encoding as well as a mutation operator. Extensive computational results are reported for both exact and heuristic methods.

3 - Mathematical modeling approach to sub-assembly detection and assembly line balancing problems
Onur Ozcelik, Istanbul Kultur University, Hürriyet Mh. 34191 Bahçelievler/İstanbul Istanbul Kultur University, 34191, Istanbul, Turkey, onurozcelik@windowslive.com, *Rifat Gürcan Özdemir*, *Ugur Cinar*, *Eren Kalem*

This paper presents mathematical modeling approach to solve sub-assembly detection and assembly line balancing problems jointly. The sub-assembly detection problem involves formation of sub-assemblies by grouping component which provides reduction in the total work content of the line. In assembly line balancing problem, total work content is partitioned to the workstations for minimizing number of workers. Each sub-assembly formed requires a fixed setup cost. Thus, main issue is to balance the tradeoff between sub-assembly setup cost and saving obtained by reducing work content in the line.

4 - Solving Job Shop Scheduling Problem with Evolutionary Algorithm
Vid Ogris, Algit d.o.o., Podhom 64a, 4247, Zgornje Gorje, -Select-, Slovenia, vid.ogris@algit.si, *Tomaz Kristan*, *Davorin Kofjač*

As a part of a larger planning and scheduling process, production scheduling is essential for the proper functioning of a manufacturing enterprise. On the basis of an evolution algorithm (EA), we have developed a system for optimizing the job shop scheduling problem. The evolution algorithm uses negative ponders that help us in determining the least bad solution with regard to multi-objective criteria minimization function, including minimal makespan, tardiness, etc. The algorithm has been validated against real-world data and well known job shop scheduling benchmark instances.

■ MC-23

Monday, 12:30-14:00
G6-3

Realistic parallel machines scheduling

Stream: Realistic Production Scheduling
Invited session

Chair: *Norbert Trautmann*, Department of Business Administration, University of Bern, Ordinariat für Quantitative Methoden der BWL, Schützenmattstrasse 14, 3012, Bern, BE, Switzerland, norbert.trautmann@pqm.unibe.ch

1 - A Heuristic Solution Approach for Identical Parallel Machine Scheduling Problem
Gulcan Gocuklu, Industrial Engineering, Eskisehir Osmangazi University, Meselik, M3 Building, 26480, Eskisehir, Turkey, ggocuklu@gmail.com, *Mujgan Sagir*

A heuristic solution approach is developed to address the identical parallel machine scheduling problem with minimal total tardiness. Motivated by the current mathematical models, a revised new model is developed. On the other hand, due to the NP-hard characteristics of the problem, the need for a heuristic approach for large sized problems is inevitable. A heuristic algorithm is coded by C# programming language. The current scheduling approach is also coded as an algorithm. Proposed and current schedules are compared. Total tardiness value is obtained as smaller in all cases considered.

2 - Model-oriented heuristics for a new parallel scheduling problem
Edson Senne, Mathematics, UNESP/FEG, Caixa Postal 205, 12516-410, Guaratingueta, SP, Brazil, elfsenne@feg.unesp.br, *Luis Alberto Osés Rodriguez*

A new scheduling problem with sequence dependent set-up times, machine eligibility constraints and task execution synchronization, aiming to minimize the makespan, is presented. In this problem, found in manufacturing processes of cast rolling mill rolls, pairs of tasks must be completed at the same time. A MIP formulation for the problem is proposed. Solution methods that combine the heuristics relax-and-fix and iterated local search are developed. Computational results from real instances show that the obtained solutions outperform those returned by a standard MIP solver after 1,5 hours.

3 - Planning of a batch production process in the printing industry
Norbert Trautmann, Department of Business Administration, University of Bern, Ordinariat für Quantitative Methoden der BWL, Schützenmattstrasse 14, 3012, Bern, BE, Switzerland, norbert.trautmann@pqm.unibe.ch, *Philipp Baumann*

We consider an offset-printing process for the production of napkin pouches with customer-specific designs. The planning problem is to determine a minimum-cost allocation of the printing-plate slots to these designs subject to various technological constraints. We present an MILP formulation, and we develop a multi-pass matching-based savings heuristic. Our computational analysis for real-world instances shows that small-sized instances can be solved to optimality using the MILP formulation, and good feasible solutions to medium- and large-sized instances can be devised using the heuristic.

4 - Short-term scheduling of make-and-pack production processes: a hybrid method for large-scale instances
Philipp Baumann, Department of Business Administration, University of Bern, IFM, AP Quantitative Methoden, Schützenmattstrasse 14, 3012, Bern, Switzerland, philipp.baumann@pqm.unibe.ch, *Norbert Trautmann*

We investigate short-term scheduling of industrial make-and-pack production processes. The planning problem is to minimize the makespan while a given demand is fulfilled and complex technological constraints are met. A schedule typically comprises 500-1500 operations. We propose a hybrid method that uses an MILP model to schedule subsets of operations iteratively. Moreover, we develop strategies to efficiently integrate the MILP model into the heuristic framework. Computational results for data of the Procter & Gamble Company indicate that the hybrid method outperforms the best-known method.

■ MC-24

Monday, 12:30-14:00
G6-4

Project Scheduling and Control

Stream: Project Management and Scheduling
Invited session

Chair: *Mario Vanhoucke*, Faculty of Economics and Business Administration, Ghent University, Vlerick Business School, University College London, Tweekerkenstraat 2, 9000, Ghent, Belgium, mario.vanhoucke@ugent.be

1 - A Scatter Search for the Resource Renting Problem
Len Vandenheede, EB08, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, len.vandenheede@ugent.be, *Mario Vanhoucke*, *Broos Maenhout*

The existence of time-dependent costs is often neglected in the resource-constrained project scheduling problem (RCPSP). However, in real-life the use of renewable resource is usually subject to those so-called renting costs. A good example are the wages of employees. Renting costs are studied in the Resource Renting Problem (RRP). In this presentation, we will propose a scatter search to efficiently solve the RRP. In a computational experiment, the most important project characteristics that determine the solution quality will be discussed.

2 - Comparison of payment models for the RCPSPDC using a genetic algorithm
Pieter Leyman, Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000, Ghent, Belgium, pieter.leyman@ugent.be, *Mario Vanhoucke*

In this presentation, we discuss the resource-constrained project scheduling problem with discounted cash flows (RCPSPDC) from the point of view of the contractor. We compare several payment models and design an appropriate local search method for each one. Furthermore, several different genetic operators are tested and compared, and a bi-directional schedule generation scheme is applied. We finish by comparing the proposed genetic algorithm with others from the literature.

3 - On multivariate regression models for project duration forecasting
Jeroen Colin, Faculty of Economics and Business Administration, University of Ghent, Bernard Spaelaan, 93, 9000, Gent, Belgium, jeroen.colin@ugent.be, *Mario Vanhoucke*

One of the main interests in project control research has been to forecast a project's final duration. Earlier studies have shown that earned schedule performance metrics outperform earned value metrics when forecasting the project duration. We compare these best practice standards with two multivariate regression models, based on a projection on latent structures. It is conjectured that these models outperform the earned schedule forecasting formulas in terms of convergence and absolute deviation. Project-specific Monte-Carlo simulations provide the necessary data for model-building.

4 - Performing risk analysis and project control on real-life projects: An evaluation of established and novel metrics and techniques
Jordy Batselier, Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000, Ghent, Belgium, jordy.batselier@ugent.be, *Louis-Philippe Kerkhove*, *Mario Vanhoucke*

We evaluate the relevance and accuracy of known Schedule Risk Analysis (SRA) and Earned Value Management (EVM) metrics and techniques for a collection of real-life projects in Belgium. The projects are carefully selected from relevant case studies gathered by our research department in recent years. Both established as well as novel risk analysis and project control methods will be evaluated and benchmarked, and general conclusions will be drawn.

■ MC-25

Monday, 12:30-14:00
G9-1

Auctions and Sourcing: Experiments and Data

Stream: INFORMS MSOM Stream
Invited session

Chair: *Aadhaar Chaturvedi*, Business Administration, Université de Namur, Rempart de la Vierge 8, 5000, Namur, Belgium, aadhaar.chaturvedi@fundp.ac.be
Chair: *Damian Beil*, Technology and Operations, University of Michigan, 701 Tappan St, 48109, Ann Arbor, MI, United States, dbeil@umich.edu

1 - Trust in Procurement Interactions
Nicolas Fugger, University of Cologne, Germany, fugger@wiso.uni-koeln.de, *Elena Katok*, *Achim Wambach*

We examine the implications of other regarding preferences on different procurement mechanisms in presence of incomplete contracts. We find that non-binding mechanisms like buyer-determined auctions and negotiations result in higher prices but enable cooperation. On the other hand binding auctions put more competitive pressure on prices but thereby rule out cooperation. We provide experimental evidence for these predictions and analyze the influence of those mechanisms on buyers' trust and suppliers' willingness to cooperate given that the provision of high quality is not enforceable.

2 - Group-buying platforms : leveraging the crowd effect in the virtual world
Philippe Chevalier, Louvain School of Management - CORE, Université catholique de Louvain, Place des Doyens, 1, 1348, Louvain-la-Neuve, Belgium, philippe.chevalier@uclouvain.be, *Constantin Blome*, *Liang Lu*

With the advent of the Internet, a new dimension in social interaction has emerged. Many companies have tried to take advantage of this new type of social interaction; one of the most notorious examples is Groupon. We performed a survey of the customers of a Groupon deal for a spa, based on the results we build a model of customer behavior and study how group-buying platforms enable service suppliers to benefit from the crowd signaling effect.

3 - Split-award Auctions: Insights from Theory and Experiments
Aadhaar Chaturvedi, Business Administration, Université de Namur, Rempart de la Vierge 8, 5000, Namur, Belgium, aadhaar.chaturvedi@fundp.ac.be, *Damian Beil*, *Elena Katok*, *Bernardo Quiroga*

We look at a buyer's use of split-award auctions when it faces constraints on the maximum proportion of business that it can procure from a single supplier. These business constraints arise when diversifying supply or keeping suppliers engaged is of a concern to the buyer. For an exogenously defined split we characterize the bidding strategies and test them in a controlled laboratory experiment. For the buyer's decision on the optimal-splits, we find that a greedy approach to allocating maximum permissible splits starting from the lowest ranked bidder might not always be optimal.

4 - Multiple Attribute Reverse Auctions
Hannele Wallenius, Industrial Engineering and Management, Aalto University, Otaniementie 17, 00076Aalto, Espoo, Uusimaa, Finland, hannele.wallenius@aalto.fi, *Jyrki Wallenius*, *Jeffrey Teich*, *Long Pham*

Online procurement auctions play an important role in e-Commerce. The objective of this paper is to gain a deeper understanding of Multiple Attribute Reverse Auctions and how to implement them. This is achieved through an extensive state-of-the-art literature review of articles published in academic journals. Specific issues related to such auctions are discussed: rules, choice of attributes, reservation prices, the role of bid decrement, scoring functions, winner determination, and information architecture.

■ MC-26

Monday, 12:30-14:00
G9-7

Integer Programming and Applications

Stream: Combinatorial Optimization I
Invited session

Chair: *Monique Guignard-Spielberg*, OPIM, University of Pennsylvania, 5th floor, JMHH, 3730 Walnut Street, 191046340, Philadelphia, PA, United States, guignard_monique@yahoo.fr

1 - Reoptimization and Column Generation for Bin Packing Related Problems
Lucas Létocart, LIPN UMR CNRS 7030, Institut Galilée - Université Paris 13, 99 avenue J-B. Clément, 93430, Villetaneuse, France, lucas.letocart@lipn.univ-paris13.fr, *Fabio Furini*, *Roberto Wolfler-Calvo*

In the context of reoptimization, we have, for the bin packing problem, a symmetric matrix Q defining a price for assigning items to the same bin of a reference solution S. Thus now the goal becomes to minimize the total cost of the bins minus the prices collected by reproducing parts of solution S. Our contribution is to mathematically describe the concept of Local Reoptimization delivering a computational framework which is capable of computing optimal solutions. To this end we developed and compared different formulations both from a theoretical and computational point of view.

2 - A polynomial time algorithm for the minimax regret uncapacitated lot sizing model
Dong Li, Said Business School, University of Oxford, Park End Street, OX1 1HP, Oxford, United Kingdom, Dong.Li@sbs.ox.ac.uk, *Dolores Romero Morales*

We study the Minimax Regret Uncapacitated Lot Sizing (MRULS), where the uncertainty is modeled by intervals. Minimax Regret Mixed Integer Programs with interval uncertainty sets are known to be NP-Hard. By decomposing the MRULS into sequences of subproblems, we show that, in each subproblem, the uncertainty can be represented by at most O(n) scenarios, where n is the planning horizon. Using this, we develop an O(n6) time algorithm for the MRULS, an O(n4) time when only the production cost function is uncertain, and an O(n5) time when only the demands are uncertain.

3 - A Branch-and-Price Algorithm for Sustainable Crop Rotation Planning
Agnès Plateau, Centre d'Étude et de Recherche en Informatique du Cnam, 292, rue Saint-Martin, 75141, Paris cedex 03, France, aplateau@cnam.fr, *Laurent Alfandari*, *Xavier Schepler*

We deal with the agricultural problem of planning crops over a given time horizon and given land plots to meet the farmer's needs over time. The MSCRP (Minimum-Space Crop Rotation Planning) focuses on building rotations that minimize the total area needed to meet demand. We show that the MSCRP problem is NP-hard and give a 0-1 linear formulation. We use Dantzig-Wolfe decomposition and column generation. Finally, we study a branching scheme for solving the master problem by branch-and-price. Computational experiments show the efficiency of our approach on randomly generated instances.

4 - Practical Optimization of Crossdocking Operations
Monique Guignard-Spielberg, OPIM, University of Pennsylvania, 5th floor, JMHH, 3730 Walnut Street, 191046340, Philadelphia, PA, United States, guignard_monique@yahoo.fr, *Peter Hahn*

Crossdocking aims at minimizing transportation costs by unloading freight from incoming trailers and loading it into outbound trailers with little or no storage in between. Our optimization concentrates on the crossdock itself and combines assigning trucks to doors so as to avoid congestion on the floor, and improving the use and cost of the workforce. We describe a prototype implementation that assigns trucks dynamically through a workday by repeatedly solving a quadratic 0-1 model via the convex hull heuristic, and updates the loading/unloading operations as often as needed.

■ MC-27

Monday, 12:30-14:00
G9-8

Aspects of Satisfiability

Stream: Boolean and Pseudo-Boolean Optimization
Invited session

Chair: *Stefan Porschen*, Fachgruppe Mathematik, Fachbereich 4, HTW Berlin, Fachbereich 4, Treskowallee 8, 10318, Berlin, Berlin, Germany, porschen@htw-berlin.de

Chair: *Ewald Speckenmeyer*, Institut für Informatik, Universität zu Köln, Pohligstr. 1, 50969, Köln, Germany, esp@informatik.uni-koeln.de

1 - Enumeration and Parameterized Complexity
Arne Meier, Institut für Theoretische Informatik, Fakultät für Elektrotechnik und Informatik, Universität Hannover, Appelstrasse 4, 30167, Hannover, Germany, meier@thi.uni-hannover.de

In this talk we introduce different kinds of notions of enumeration algorithms in the parameterized complexity world. At first, we will focus on the Vertex Cover problem and motivate thereby the application of the new framework and explain techniques how to obtain efficient enumeration algorithms. The second part of the talk will deal with the enumeration of backdoor sets of CNF-formulas.

2 - An exact satisfiability-based method for the maximum k-club problem
Andreas Wotzlaw, Institut für Informatik, Universität zu Köln, Köln, Germany, wotzlaw@informatik.uni-koeln.de

Given an undirected graph G, the maximum k-club problem is to find a maximum-cardinality subset of nodes inducing a subgraph in G of diameter at most k. This NP-hard generalization of clique, originally introduced to model cohesive subgroups in social networks analysis, is of interest in network-based data mining and clustering applications. We present a propositional logic based partial MAX-SAT formulation of the problem and show that the resulting exact approach outperforms considerably the state-of-the-art methods while evaluated both on sparse and dense graph instances from the literature.

3 - A Characterization of Tree-Like Resolution Size
Olaf Beyersdorff, School of Computing, University of Leeds, LS2 9JT, Leeds, United Kingdom, o.beyersdorff@leeds.ac.uk

Information about the size of proofs in tree-like Resolution allows to derive bounds on the running time of DPLL algorithms which form the basis for modern SAT solvers. We explain an asymmetric Prover-Delayer game which precisely characterizes proof size in tree-like Resolution, i.e. in principle our proof method allows to always achieve the optimal lower bounds. This is in contrast with previous techniques from the literature. We provide a very intuitive information-theoretic interpretation of the game and illustrate it by proving optimal lower bounds for the pigeonhole principle.

4 - Compact representation of all solutions of Boolean optimization problems
Carla Michini, ETH Zurich, 8902, Zürich, Switzerland, carla.michini@ifor.math.ethz.ch, *Utz-Uwe Haus*

It is well known that binary decision diagrams can sometimes be compact representations of the full solution set of Boolean optimization problems. Recently they have been suggested to be useful as discrete relaxations in integer and constraint programming. We characterize the mimimal and maximal width of binary decision diagrams (BDDs) representing the set of all solutions to a stable set problem for various basic classes of graphs. In particular, for graphs whose bandwidth is bounded by a constant, the maximum width of the BDD is also bounded by a constant.

■ MC-28

Monday, 12:30-14:00
G9-2

Geometric Clustering 2

Stream: Geometric Clustering
Invited session

Chair: *Noriyoshi Sukegawa*, Graduate School of Decision Science and Technology, Tokyo Institute of Technology, Ookayama, 152-8552, Meguro-ku, Tokyo, Japan, yy.n.s.goo@gmail.com

1 - Predictive analytics by means of geometric clustering
Andreas Brieden, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85579, Neubiberg, Germany, andreas.brieden@unibw.de

Precisely predicting a target value based on a large amount of historical data is a crucial task in many different applications. One natural approach is to determine homogenous subsets of data and, given some cardinality constraints, to make the prediction by using the law of large numbers for each of the subsets.

This talk reports on several applications where geometric clustering has been proved to be superior to various benchmark algorithms. (Joint work with Peter Gritzmann & Michael Öllinger)

2 - Geometry of Generalized Quadratic Assignment Problems
Frauke Liers, Department Mathematik, FAU Erlangen-Nuremberg, Cauerstrasse 1, 91058, Erlangen, Germany, frauke.liers@math.uni-erlangen.de, *Bernhard Stöcker*

The quadratic matching problem (QMP) asks for a matching in a graph that optimizes a quadratic objective in the edge variables. The QMP generalizes the quadratic assignment problem as the latter can be modelled as a perfect QMP on a bipartite graph. The QMP has several relevant applications and can be interpreted as a constrained clustering problem. In this talk, we present polyhedral results for the QMP on different graph classes together with separation algorithms. We furthermore report computational results.

3 - Exploiting Facets of the Cut Polytope for Sparse Betweenness Problems
Andreas Schmutzer, Department Mathematik, FAU Erlangen-Nuremberg, Germany, schmutzer@informatik.uni-koeln.de, *Frauke Liers*

Given a sequence of objects and costs for triples of objects i,k and j that apply iff k occurs between i and j in the sequence, the betweenness problem asks for a minimum cost permutation of all objects. For many applications sparse models of betweenness problems are preferable. We generalize for sparse formulations the result that betweenness polytopes are faces of the cut polytope. Further we derive a combinatorial characterization of cuts in an associated graph that correspond to betweenness solutions. Finally we give computational results that exploit facets of sparse cut polytopes.

4 - Redundant constraints in the standard formulation for the clique partitioning problem
Noriyoshi Sukegawa, Graduate School of Decision Science and Technology, Tokyo Institute of Technology, Ookayama, 152-8552, Meguro-ku, Tokyo, Japan, yy.n.s.goo@gmail.com, *Atsushi Miyauchi*

The clique partitioning problem is an NP-hard combinatorial optimization problem with a large number of applications, including qualitative data analysis, community detection and group technology. In this talk, we deal with the standard ILP formulation for this problem and theoretically reveal a certain class of redundant constraints. This class is a subset of the so-called transitivity constraint which is known to be useful when solving several real-world instances. By this result, the number of the constraints that should be considered can be reduced.

■ MC-29

Monday, 12:30-14:00
G9-3

Stochastic Dynamic Programming Applications

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Fikri Karaesmen*, Dept. of Industrial Engineering, Koc University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, fkaraesmen@ku.edu.tr

1 - Effect of system parameters on the optimal cost and the optimal policy in a class of queuing control problem
Samuel Vercraene, GCSP, G-Scop Grenoble-INP, 46 avenue Felix Viallet, 38000, Grenoble, France, vercraene@gmail.com, *Jean-Philippe Gayon*, *Fikri Karaesmen*

We focus on the class of queuing system control problem involving a cost minimization or a reward maximization. It is well established that in many of these problems the optimal policy is a threshold policy. When several system parameters values are changed, we show that it is sometimes possible to predict the evolution of the optimal cost and the optimal policy. Our approach is based on the propagation of certain properties of the Dynamic Programming (DP) value function. We show that, the prediction possibility depends mainly of the complexities of the DP formulation and the DP state space.

2 - Optimal control of a multi-class queueing system with abandonments
Jean-Philippe Gayon, Grenoble INP - GSCOP, France, jean-philippe.gayon@grenoble-inp.fr, *Pierre Lemaire*, *Alexandre Salch*

We address the problem of dynamically scheduling several classes of jobs with abandonments. Processing times and release dates are arbitrarily distributed while patience times are exponentially distributed. The objective is to minimize the long run expected holding costs and abandonment costs in the class of dynamic policies with preemption. When processing times are exponentially distributed, we provide conditions under which a strict priority rule is optimal. We also investigate situations where strict priority policies are not optimal.

3 - Optimal Replacement of Markovian Mission-Based Systems
Bora Cekyay, Industrial Engineering, Dogus University, Istanbul, Turkey, bcekyay@dogus.edu.tr

We consider the maintenance of a mission-based system that is designed to perform missions consisting of a random sequence of phases or stages with random durations. A finite state Markov process describes the mission process. The age or deterioration process of the system is described by another finite state monotone Markov process whose generator depends on the phases of the mission. We discuss an optimal replacement problem, and characterize the optimal policy assuming that the replacement durations are exponentially distributed with phase-dependent parameters.

4 - Markov Population Decision Chains with Constant Risk Posture
Pelin Canbolat, Industrial Engineering, Koç University, Turkey, pcanbolat@ku.edu.tr

We analyze the problem of maximizing expected system utility in Markov population decision chains, which concern the control of a population of individuals in different states by assigning an action to each individual in the system in each period. Under constant risk posture, we show that if progeny of distinct individuals are independent, and progeny of individuals in a state who take the same action are identically distributed, then it is possible to solve the problem with the original set of state-action pairs without augmenting it to include information about the population in each state.

■ MC-30

Monday, 12:30-14:00
G9-10

Global Combinatorial Optimization & Applications

Stream: Discrete and Global Optimization
Invited session

Chair: *José Paixão*, Dept. Statistics and Operations Research, Faculty of Sciences - University of Lisbon, Bloco C6 - Campo Grande, 1749-016, LISBOA, Portugal, jpaixao@fc.ul.pt
Chair: *Sergei Chubanov*, University of Siegen, Hoelderlinstr. 3, Siegen, Deutschland, 57076, Siegen, Germany, sergei.chubanov@uni-siegen.de

1 - A Modified Test-Problem Generator for Global Optimization
Chi-Kong Ng, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Shatin, N.T, Hong Kong, ckng@se.cuhk.edu.hk, *Duan Li*

Sophisticated software for benchmarking unconstrained GO algorithms is developed. By combining univariate problems and applying linear transformation of variables, a general class of inseparable, analytic and highly multimodal test-problems with 2**n a priori known minima is obtained. The generator, and a standard set of 300 test problems (10 sizes, 3 difficulty levels) for MATLAB & GAMS are produced, and are available for download. Computational experiments have demonstrated the stability of the generating process & the controllability of assigning the difficulty level to the test problems.

2 - Quadratic Combinatorial Optimization with One Product Term
Laura Klein, Mathematics, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, laura.klein@tu-dortmund.de, *Christoph Buchheim*

The standard linearization of a binary quadratic program (BQP) yields an exact IP-formulation but the resulting LP-bound is very weak in general. We consider BQPs with a tractable underlying linear problem and examine the case of only one product term, which is still tractable but yields stronger cutting planes also for the problem containing all products. As an example, we apply this idea to the quadratic minimum spanning tree problem and present two new classes of facets with efficient separation algorithms. Computational results show significant improvement over the standard linearization.

3 - Optimal decision policy and budget allocation for a R&D portfolio
Anabela Costa, Quantitative Methods for Management and Economics, ISCTE - Instituto Universitário de Lisboa/ CIO, Av. das Forças Armadas, 1649-026, Lisboa, Portugal, anabela.costa@iscte.pt, *José Paixão*

R&D portfolio management deals with the finding of the optimal decision policy for each project, that is, the determination of a sequence of actions (improvement, continuation or abandonment) made at each stage of the R&D phase that respects the allocated budget and maximizes the overall value of the portfolio. In this talk, we propose a 0-1 integer linear program for solving this problem and present computational experience allowing conclusions to be drawn on the adoption of this model. Further, we discuss the chance of incorporate additional managerial choices in the presented formulation.

4 - A decomposition algorithm using tight linear programming relaxations of subproblems
Sergei Chubanov, University of Siegen, Hoelderlinstr. 3, Siegen, Deutschland, 57076, Siegen, Germany, sergei.chubanov@uni-siegen.de

In many cases the feasible set of a hard optimization problem with a linear objective function (e.g., the TSP) is an intersection of sets for each of which there is a polynomial algorithm for optimizing linear functions (an LP oracle). A usual way to obtain a relaxation is to replace each set by its convex hull. Our algorithm can solve such relaxations with a given precision. The number of calls to the LP oracles is polynomial in the dimension of the space and in the reciprocal of the approximation error.

■ MC-31

Monday, 12:30-14:00
G9-11

Retail Shelf Planning and Replenishment

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Alexander Hübner*, Operations Management, Catholic University Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, Germany, alexander.huebner@ku-eichstaett.de

1 - An approach to determine packaging sizes in retail environments
Michael Sternbeck, Supply Chain Management and Operations, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt/Donau, Germany, Michael.Sternbeck@ku-eichstaett.de, *Rob Broekmeulen*, *Karel van Donselaar*, *Heinrich Kuhn*

The size of a case pack is considered an efficiency driver in internal retail supply chains. Retailers can largely influence packaging sizes used for store delivery by manipulating processes and for the private label assortment. It impacts order picking in distribution centres and in-store efficiency as the pack size affects the extent to which products delivered do not fit onto the shelf due to capacity restrictions. We introduce a shelf-back-model to derive pack sizes that incorporate relevant processes along the internal retail supply chain and explicitly integrate in-store operations.

2 - Hierarchical MIP-based heuristics to solve the Shelf Space Allocation Problem at a Portuguese Retail Chain
Teresa Bianchi-Aguiar, INESC TEC, Faculty of Engineering, University of Porto, Portugal, mtbaguiar@fe.up.pt, *Maria Antónia Carravilla*, *José Fernando Oliveira*

A good product arrangement in shelves can boost product demand and ultimately, the retail stores financial performance. Accordingly, we developed an optimization method for managing shelf space at a Portuguese retail chain. The method hierarchically applies MIP models, combined with heuristics, to derive the right allocation of products in shelves. Benefits from its implementation in the company include: trade-off analysis between solutions biased towards profit maximization or towards company's rules, image standardization and time reductions.

3 - Layout-based Shelf Space Allocation to Maximize Impulse Buying
Ahmed Ghoniem, Operations & Information Management, University of Massachusetts Amherst, College of Engineering Qatar University P.O. Box 2713, 121 Presidents Dr., Amherst, MA 01003, USA, MA 01003, USA, USA, United States, aghoniem@isenberg.umass.edu, *Tulay Varol*, *Bacel Maddah*

We investigate the problem of allocating shelf space to product categories in order to enhance product visibility and stimulate impulse buying store-wide. Nonlinear mixed-integer programming formulations are proposed and linearized to afford exact solutions to this problem. Computational results are discussed based on a case study involving a store in New England as well as simulated instances.

4 - Single Period Inventory Model for Stochastic and Shelf Space Dependent Demand
Neha Advani, Quantitative Methods and Information Systems, Indian Institute of Management, Bangalore, B-201, Royal legend Appartments, Kodichikenhalli Road, Bomanhalli, 560068, Bangalore, Karnataka, India, neha.advani09@iimb.ernet.in

Past research has shown the demand stimulating effect of inventory on shelves in retail context. However, it does not consider the stochasticity while modeling shelf space dependent demand. We address this gap and develop managerial insights by modeling a single period inventory system with stochastic and shelf space dependent demand. We present structural and numerical results for the nature of optimal policy for this model along with impact of stochasticity/shelf space dependence on ordering decisions and on expected profit of the system.

■ MC-32

Monday, 12:30-14:00
G8-1

Logistics and Inventory Management

Stream: Supply Chain Optimization
Invited session

Chair: *Lotte Verdonck*, Research Group Logistics, Hasselt University, Research Foundation Flanders (FWO), Belgium, lotte.verdonck@uhasselt.be

1 - A new enhancement of the heuristic for the vehicle routing problem
Andrey Zyatchin, Operations Management, Graduate School of Management, Volkhovsky Per, 3, 199004, St. Petersburg,, Russian Federation, zyatchin@gsom.pu.ru

Clarke and Wright proposed algorithm for VRP, where routes are designed by arranged savings, counted for every pair of customers. Some enhancements of the algorithm are based on adding new parameters in the savings, which includes geometric nature of VRP and customers' demands. In this study an additional parameter for the saving is proposed. The parameter is the weight for a customer's value. Such value could be determined by many reasons, e.g. it corresponds to ABC classification from CRM system. The approach was applied to solve test instances for the VRP.

2 - Coordination of Supply Chain with Stochastic Demand by Delay-in-Payment Contract
Xiaobo Zhao, Industrial Engineering, Tsinghua University, 100084, Beijing, China, xbzhao@tsinghua.edu.cn, *Deng Gao*

We propose a delay-in-payment contract to coordinate a supply chain that consists of a single supplier and a single retailer facing stochastic customer demand. With the contract, the supplier allows the retailer to pay partial order cost at the ordering epoch, and to pay the rest part after permissible periods. The system is formulated as a stochastic dynamic programming problem and is shown that there exists a base-stock policy to be optimal. Comparing with traditional wholesale-price contract, the system with the delay-in-payment contract can achieve a Pareto improvement.

3 - RFID applications for distribution management on retail trade
Joachim R. Daduna, Hochschule für Wirtschaft und Recht Berlin Berlin, Badensche Str. 52, 10825, Berlin, Germany, daduna@hwr-berlin.de

Globalization in retail trade in connection with a growing complexity in supply chain management requires an efficient and reliable information management. Therefore, it is essential to apply RFID to attain real-time data for planning, monitoring, and control. Moreover, media break-free information flows are necessary as a basis for sustainable cooperation. Applications in distribution management are shown and the different aspects of RFID technology are analyzed and evaluated. Based on this an outlook is given and possible developments in the coming years will be provided.

4 - Analysing the effects of cost allocation methods for the cooperative facility location problem
Lotte Verdonck, Research Group Logistics, Hasselt University, Research Foundation Flanders (FWO), Belgium, lotte.verdonck@uhasselt.be, *Patrick Beullens*, *An Caris*, *Katrien Ramaekers*, *Gerrit K. Janssens*

Transportation companies operating at the same level of the supply chain may cooperate horizontally to increase their efficiency levels. One approach to horizontal carrier collaboration is the sharing of warehouses or distribution centres with partnering organizations. This problem may be classified as the cooperative facility location problem and can be formulated as a MILP. To demonstrate the benefits of collaborative optimisation, the cooperation potential of a U.K. case study is examined. In addition, the effects of three cost allocation techniques are analysed and compared.

■ MC-33

Monday, 12:30-14:00
G8-3

Scheduling problem

Stream: Production and the Link with Supply Chains
Invited session

Chair: *Farouk Yalaoui*, Institut Charles Delaunay, ICD LOSI, University of Technology of Troyes, 12, Rue Marie Curie BP 2060, 10000, Troyes, France, farouk.yalaoui@utt.fr
Chair: *Gonzalo Enrique Mejia Delgadillo*, Industrial Engineering, Universidad de Los Andes, Edificio Mario Laserna, Carrera 1E No 19A40, 11001, Bogota, Colombia, gmejia@uniandes.edu.co

1 - Long term capacity planning with products' renewal
Gorkem Yilmaz, Management Department (DOE), Institute of Industrial and Control Engineering (IOC), Av. Diagonal 647 (edif. ETSEIB), p.11, 08028, Barcelona, Spain, gorkemyilmaz11@yahoo.com, *Amaia Lusa*, *Ernest Benedito*

We describe a variant of the Long Term Capacity Planning Problem and we propose a Mixed Integer Linear Program for solving it. The variant described corresponds to a system with the following main characteristics: short-life cycle products and renewal; different capacity options (acquisition, renewal, updating, outsourcing and reducing); and key tactical decisions (integration between strategic and tactical decisions).

2 - A framework for the vehicle routing and scheduling problem
Gonzalo Enrique Mejia Delgadillo, Industrial Engineering, Universidad de Los Andes, Edificio Mario Laserna, Carrera 1E No 19A40, 11001, Bogota, Colombia, gmejia@uniandes.edu.co

This paper presents a framework for truck and warehouse scheduling. This problem is modeled as a Flexible Open Shop Scheduling Problem (FOSSP). the goal of the framework is to facilitate the development of metaheuristic algorithms with different constraints and objective functions. In this paper we evaluate three algorithms: Simulated Annealing, Tabu Search and GRASP. The results are compared against other approaches from the literature and those of two mathematical programming formulations.

3 - Production scheduling in the food industry
Wolfgang Garn, Surrey Business School, University of Surrey, GU2 7XH, Guildford, Surrey, United Kingdom, w.garn@surrey.ac.uk

In this paper we study the optimality of production schedules in the food industry. Specifically we are interested whether stochastic economic lot scheduling based on aggregated forecasts outperforms other lot sizing approaches. Empirical data on the operation's customer side such as product variety, demand and inventory is used. Hybrid demand profiles are split into make-to-order (MTO) and make-to-stock (MTS) time series. We find that the MTS demand aggregation stabilizes, minimizes change-overs, and optimizes manufacturing.

4 - Production Planning and Scheduling in Cogeneration systems Considering Electricity Price Fluctuations
Ertürk Açar, Industrial Engineering, Koç University, Rumeli Feneri Yolu / Sarıyer, 34450, Istanbul, Turkey, eracar@ku.edu.tr, *Metin Turkay*

Cogeneration facilities produce steam and electricity. Since both steam and electricity cannot be inventoried for later use, production planning to satisfy steam and electricity demand is one of the primary concerns. Meantime, price of electricity shows variations within a day. In order to have rational decisions on the operations, a decision support system in industrial scale is developed that includes sensitivity analysis and 'What-if' scenario studies considering electricity price variations. We present our MILP modeling approach and summarize the findings on an industrial case study.

■ MC-34

Monday, 12:30-14:00
G8-4

Supply Chain Contracts and Information Sharing

Stream: Supply Chain Risk Management
Invited session

Chair: *Avi Giloni*, Sy Syms School of Business, Yeshiva University, 500 West 185th Street, BH 428, 10033, New York, New York, United States, agiloni@yu.edu

1 - Stability contract in the pulp and paper industry: a study case in Quebec forest companies
Bertrand Hellion, INPG, G-SCOP, 4 Boulevard Joseph Vallier, 38000, Grenoble, Rhône Alpes, France, bertrand.hellion@gmail.com

The main actors of the forest in the North Cost region are 3 sawmills and a papermill. The sawmills saw harvested wood to produce chips and lumber, at different quality. They sell the lumber on a market, whilst the chips are sold at low cost at the single papermill. We made a contract design to ensure a long-term partnership between these actors. Then both the centralized and decentralized model for this supply chain are presented. We highlight some theorical properties, some experiments as well, leading to insight for decision maker.

2 - Evaluating Supply Chain Conditions under Information Security Breach
Olatunde Durowoju, Norwich Business School, University of East Anglia, University of East Anglia, Norwich Research Park, Norwich, Norfolk, United Kingdom, o.durowoju@uea.ac.uk

This study employed discrete event simulation to understand, in quantitative terms, how supply chain conditions or configurations absorb or desorb the impact of information security breach. We considered a supply chain with three tiers; the retailer, wholesaler and manufacturer. Supply chain conditions was conceptualised in this study as a combination of ordering policies and supply structure. The result of an analysis of variance ($p<0.05$) revealed that ordering option and supply chain structure have a mitigating effect on security breach impact.

3 - Spanning Revenue Sharing Contract Model for Multi Echelon Supply Chain under Asymmetric Cost Information
Ahmad Rusdiansyah, Department of Industrial Engineering, Institut Teknologi Sepuluh November (ITS) Surabaya, Kampus ITS, Sukolilo, 60111, Surabaya, Jawa Timur, Indonesia, arusdianz@gmail.com, *Rescha Dwi Astuti Putri*

SC contracts are tools adopted to coordinate channels in a decentralized decision making supply chain. In this research, we develop spanning revenue sharing contract model for multi-stage supply chains in condition the cost information is asymmetric. We assume the manufacturer only knows some estimation about the retailer's cost structure. We compared two SC contract models: pairwise contract between two players in each echelon, and spanning contract covering all echelons. We conduct numerical experiments to compare the behavior and performance of both models.

4 - The Impact of Seasonality on the Value of Information Sharing in Supply Chains
Avi Giloni, Sy Syms School of Business, Yeshiva University, 500 West 185th Street, BH 428, 10033, New York, New York, United States, agiloni@yu.edu

We consider a two player chain and explore the role that seasonality of demand plays in determining the value of information sharing where the retailer faces ARMA demand. We model the value of information sharing as the reduction in the mean-square forecast error of the supplier's best linear forecast that results from the retailer sharing its observed demand. We demonstrate that seasonality plays a vital role in determining the value of information sharing. We show that a stronger seasonal component of the process generating demand makes it more likely that information sharing is valuable.

■ MC-36

Monday, 12:30-14:00
G7-1

Preference Learning II

Stream: Preference Learning
Invited session

Chair: *Krzysztof Dembczynski*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, kdembczynski@cs.put.poznan.pl

1 - A ranking rule and its relation to the feedback edge set problem in a stochastic monotonicity setting
Michael Rademaker, Departement of Mathematical Modelling, Statistics and Bioinformatics, Ghent University, Coupure links 653, 9000, Gent, Belgium, michael.rademaker@ugent.be, *Bernard De Baets*

The current work translates a ranking problem into an optimization problem. As such it belongs to both operations research and the decision sciences. We present our ranking problem as working on a directed graph, with vertexes being the objects to be ranked, and the edges weighted by the degree to which one object is preferred to another. The goal is to compute a ranking for which the edge weights come closest to fulfilling stochastic monotonicity. We examine theoretical properties of this ranking problem and our methodology, in part by relating it to the well-known feedback edge set problem.

2 - Optimal weight constraint elicitation techniques for additive multi-attribute utility models
Gert van Valkenhoef, Department of Epidemiology, University Medical Center Groningen, Universty of Groningen, PO Box 30.001, 9700 RB, Groningen, Netherlands, g.h.m.van.valkenhoef@rug.nl, *Tommi Tervonen*

We consider the elicitation of incomplete weight information for the additive utility model. In this setting, the feasible weight space is bounded by linear constraints obtained from a decision maker. These can be elicited either indirectly as pair-wise comparisons of reference alternatives or directly as intervals for criteria trade-off ratios. We show how to choose the next elicitation question that maximizes the information gain on the ranking of the decision alternatives, and propose a stopping criterion for the elicitation process.

3 - Inferring parsimonious preference models in robust ordinal regression
Roman Slowinski, Institute of Computing Science, Poznan University of Technology, Laboratory of Intelligent Decision Support Systems, Street Piotrowo 2, 60-965, Poznan, Poland, roman.slowinski@cs.put.poznan.pl, *Salvatore Greco*, *Vincent Mousseau*

Ordinal regression is used to infer parameters of a supposed preference model, which make this model compatible with preference information provided by the decision maker. As values of these parameters are usually not unique, robust ordinal regression handles a complete set of parameters of the compatible preference model of a given type. Here we care not only about compatibility of the model with the preference information, but also about keeping the model as parsimonious as possible. Our base model is a general additive value function with interaction components for pairs of criteria.

■ MC-37

Monday, 12:30-14:00
G7-4

Multiobjective Optimization for Engineering Design Modeling

Stream: Multicriteria Decision Making
Invited session

Chair: *Paolo Guarneri*, Mechanical Engineering, Clemson University, United States, pguarne@clemson.edu
Chair: *Georges Fadel*, Mechanical Engineering, Clemson University, 29634, Clemson, SC, United States, fgeorge@clemson.edu

1 - Analytical derivation of the Pareto-optimal set in Multi-Objective Optimization problems
Massimiliano Gobbi, Dept. of Mechanical Engineering, Politecnico di Milano, via La Masa, 1, 20156, Milan, Italy, massimiliano.gobbi@polimi.it, *Giampiero Mastinu*, *Giorgio Previati*

A method for the analytical derivation of the Pareto-optimal set for multi-objective optimization problems is described and applied in the paper. The Fritz John necessary condition for Pareto-optimality has been used for the analytical derivation. The method has been applied to solve actual engineering problems. The optimization of mass and compliance of a cantilever beam, in presence of design constraints, has been performed analytically. The relationship between road vehicles suspension system parameters to optimize the most relevant vehicle performance indices has been derived.

2 - Bilevel multiobjective packaging optimization
Paolo Guarneri, Mechanical Engineering, Clemson University, United States, pguarne@clemson.edu, *Brian Dandurand*, *Georges Fadel*, *Margaret Wiecek*

The vehicle layout design is modeled as a multiobjective optimization problem in which the components are morphing since their shape is determined by their functionality and available space. The problem is formulated as a bilevel multiobjective problem to account for the different specializations required by the vehicle and component designs. A numerical algorithm is proposed and applied to the design of the vehicle underhood while concurrently optimizing the battery shape. The computed optimal solutions reflect the bilevel tradeoff between the vehicle and battery levels.

3 - Underhood layout design optimization with thermal aspects
Georges Fadel, Mechanical Engineering, Clemson University, 29634, Clemson, SC, United States, fgeorge@clemson.edu, *Sreekanth Reddy Gondipalle*, *Paolo Guarneri*, *Ravi Teja Katragadda*

The vehicle layout design problem involves multiple criteria such as compactness, accessibility and safety subject to geometric constraints. A relevant criterion to be considered is the thermal interaction between the components. Due to the large number of function evaluations, a computationally demanding physical model is not suitable. A neural network approximation derived from a CFD model is integrated in the optimization to reduce the cost. The proposed strategy allows the designer to include thermal considerations in the tradeoffs of the vehicle layout design.

4 - A MCDM Software Tool for the Automated Design Environments
Amirhosein Mosavi, University of Debrecen, Debrecen, Hajdu Bihar, Hungary, a.mosavi@citromail.hu

Decision-making processes in the automated design environments are largely multiobjective in nature and characterized by various forms of uncertainty. The proposed MCDM software tool works on the basis of reactive search optimization methodology where the learning techniques are integrated into the search heuristics for solving complex optimization problems. The preferences, multiple software components, and strategy adaptation are integrated through an online learning scheme, and visualization as well as trade-offs are used in the context of rapid virtual prototyping.

■ MC-39

Monday, 12:30-14:00
G7-3

Analytic Hierarchy Process 2

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Josef Jablonsky*, Dept. of Econometrics, University of Economics Prague, W.Churchill sq. 4, 13067, Prague 3, Czech Republic, jablon@vse.cz

1 - A Hybrid Approach for Multicriteria Decision Meking Methods in Assesment of Logistics Service
Vedat KoÇdaĞ, Industrial Engineering, Kocaeli University, Turkey, vedatkocdag@gmail.com, *Kasim Baynal*, *Zerrin AladaĞ*

In this paper, select most appropriate logistic service provider problem are analyzed using the Analytic Hierarchy Process (AHP) and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) methods together. The process of AHP and PROMETHEE logical solution may be affected by subjective judgments therefore, quality of information that can be loss and the final decision may be negatively affects. The proposed solution the main role of AHP process of providing quality data for PROMETHEE method.

2 - Best practice for major acquisitions using MCDA/AHP methodology
Eldar Aarholt, Teleplan Consulting AS, Fornebuveien 31, P.O.Box 69, 1324, Lysaker, Norway, aar@teleplan.no

For more than 15 years, MCDA/AHP methodology has been used for some major acquisitions in Norway; such as new frigates, helicopters, combat aircraft, and communications systems. This paper sums up a best practice implementation of decision processes relating to evaluation and mission model development, requirements evaluation, scoring system calibration, and weighting considerations. Electronic evaluation tools used are also covered. Challenges relating to acquisition planning, evaluation coordination and complexity are highlighted as well as recommendations based on project experience.

3 - Inconsistency indices in the Analytic Hierarchy Process: a numerical study
Matteo Brunelli, Aalto University, Finland, matteo.brunelli@aalto.fi, *Luisa Canal*, *Michele Fedrizzi*

Consistency of preferences has been a widely studied topic within the theory of the Analytic Hierarchy Process. Often, reliability of preferences is supposed to go arm-in-arm with their consistency. Many indices have been proposed in literature to estimate how far a matrix is from being fully consistent. However, it has not been studied how similar these indices are. Are they similar and can be used interchangeably or are they different and leading to different conclusions? We shall present the results of some numerical simulations and clarify the relations between inconsistency indices.

4 - Is the AHP a suitable tool for re-calculation of human composite indices?
Josef Jablonsky, Dept. of Econometrics, University of Economics Prague, W.Churchill sq. 4, 13067, Prague 3, Czech Republic, jablon@vse.cz

Human composite indices (human development/poverty index, happy planet index, etc.) measure the level of human being in world countries from specific points of view. They are published every year by UNDP or other institutions. Their calculation is a standard multiple criteria decision making (MCDM) problem that can be solved using MCDM methods and data envelopment analysis models. The paper discusses the possibility to re-calculate the indices by using the AHP model with absolute measurement and compares the given results with original definition and other modeling approaches.

■ MC-40

Monday, 12:30-14:00
Y12-1

Decision Analysis, Decision Support Systems II

Stream: Decision Analysis, Decision Support Systems, DEA and Performance Measurement (contributed)
Contributed session

Chair: *Fabio Tardella*, Department of Methods and Models for Economics, Territory and Finance, Sapienza University of Rome, Via del Castro Laurenziano, 9, 00161, Roma, Italy, fabio.tardella@uniroma1.it

1 - A Multi-attribute Procurement Auction based on Yardstick Competition
Kurt Nielsen, Institute of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25 building C, 1958, Frederiksberg C., Denmark, kun@foi.ku.dk, *Jens Leth Hougaard*, *Athanasios Papakonstantinou*

We analyze a multi-attribute procurement auction that uses yardstick competition to settle prices. Upon receiving the submitted bids the auctioneer computes the yardstick bids by a linear weighting of the other bids. The winner is compensated with the yardstick price. Any bidder with a yardstick bid higher than its submitted bid may weakly improve the chance of winning the auction by raising the price-bid. This however increases the chance of being excluded by bidders who lower their bid. Hence there is no equilibrium. By simulations we show that deviating from truth-telling is limited.

2 - A model of consumer behavior and utility formation with a behavior menu formed by society

Vladimir Matveenko, Center for market studies and spatial economics, National Research University Higher School of Economics, 3 The 10th Liniya Vasilievsky Island, 199034, St. Petersburg, Russian Federation, vmatveenko@hse.ru

It is shown that for each linear-homogeneous utility function on characteristics of goods there exists a unique set of weights of characteristics such that the function is represented as a solution of a problem of a choice of weights from the set. The latter is explained as a behavior menu of the individual. The behavior menu is formed by the society. In such way, a theory of consumer behavior is constructed in which the consumer makes a choice, first of all, of her attitude to life and only then of the consumed bundle of goods.

3 - An Hybrid model of multicriteria analysis for the OLAP systems: Application to the implantation of large areas of distribution

Omar Boutkhoum, Computer Science, Faculty of the Sciences Semlalia, Cadi Ayyad University, Bd. Prince My Abdellah, 2390 , Marrakech, Morocco, o.boutkhoum@uca.ma, *Mohamed Hanine*, *Abdessadek Tkniouine*

OLAP (On Line Analytical Processing) tools are among the technology decision offering the possibility of archiving, management, analysis and multidimensional modeling. However, they are limited in the consideration of the multicriteria and quality aspect of the decision problem. To overcome these limitations, we proposed in this research, a methodological approach for integrating multicriteria analysis in OLAP systems. This approach aims to create an hybrid model of data (OLAP / MCA) for the implementation of our case study dealing with the implantation of large areas of distribution.

4 - Comparing social choice properties of some positional voting systems

Teresa Peña, Economía Aplicada, Universidad de Valladolid, Valle esgueva, 6, 47011, Valladolid, Spain, maitepe@eco.uva.es, *Bonifacio Llamazares*

Scoring rules are a class of positional voting systems (PVS's) used in different decisional contexts. It is known that, in these PVS's, the winner may change depending on the scoring vector used. To avoid this shortcoming, some authors have proposed evaluating each candidate with the most favourable scoring vector for him/her. In this work we compare scoring rules with PVS's that allow to use different scoring vector for each candidate. To do this we consider several criteria relevant from social choice point of view such as monotonicity, Pareto-optimality, Condorcet consistency, etc..

■ MC-41

Monday, 12:30-14:00
Y12-5

DEA Applications VIII

Stream: DEA and Performance Measurement II
Invited session

Chair: *Andres Polo*, Facultad de Ingeniería, Universidad Agraria de Colombia, Calle 170 54 A 10, Bogotá, Colombia, polo.andres@uniagraria.edu.co

1 - Efficiency Analysis of Japanese Private Broadcasting Using Data Envelopment Analysis

Masatsugu Tsuji, Graduate School of Aplied Informatics, University of Hyogo, 1-3-3, Higashi-Kawasaki-cho, Chuou-ku, 650-0044, Kobe, Hyogo, Japan, tsuji@ai.u-hyogo.ac.jp

The objective of the paper is to analyze efficiency of Japanese TV stations. DMUs were local TV stations in regions and 24 stations were selected all over Japan, The period of analysis is 2002-2007, and there are 144 DMUs. Operating costs, wages and depreciation are utilized as input, while revenues and the number of households viewing TV programs are as output. DEA used is: SBM; VRS; and output-oriented model. The result shows 20% of DMUs obtained 1 and the average was 0.858. Next, we identified factors which influenced significantly efficiency of DMU by regression such as Tobit model.

2 - Monitoring performance of hydroelectric power plants

Clara Vaz, School of Technology and Management, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 134, 5301 - 857, Bragança, Portugal, clvaz@ipb.pt, *Ângela Ferreira*

This study develops a methodology to provide insights regarding the efficiency and productivity of the hydroelectric power plants of an European player in the energy sector throughout the operation stage. DEA is used to measure the efficiency of utilities in generating electrical energy from the resources available and exogenous variables. This analysis enables the identification of the best practices of power plants which lead to improved performance. The Malmquist index, complemented with bootstrapping, is used to measure the changes in plants productivity between in the last years.

3 - Incorporating the Concept of DEA-DA into the Case-Based Distance Methods for Screening

Li-Ching Ma, Department of Information Management, National United University, No.1, Lienda, 36003, Miaoli, Taiwan, Taiwan, lcma@nuu.edu.tw, *Pei-Pei Hsu*

The case-based distance methods (CBDMs) for screening are useful methods to assist decision makers in eliminating alternatives which are unlikely to be chosen. However, most of these methods, based on selected cases and distance measurements, can only treat screening problems with positive weights of criterion. This study incorporates the concept of DEA-DA (Data Envelopment Analysis-Discriminant Analysis) into the CBDMs to solve screening problems involving negative weights. The results show that the proposed approach can increase hit rates because of relaxing restriction for positive weights.

4 - Measuring productivity in supply chains: Malmquist Index approach

Andres Polo, Facultad de Ingeniería, Universidad Agraria de Colombia, Calle 170 54 A 10, Bogotá, Colombia, polo.andres@uniagraria.edu.co

This paper develops a productivity index applicable when supply chains desire to improve cost and compensations. The index is inspired by the Malmquist index which is decomposed into technical and efficiency change. These decompositions provide a clearer picture of the root sources of productivity change to decision making in supply chains. The measurements were performed under the computational results of a supply chain mathematical model configured as non-integrated and integrated; to perform the results are computed using non-parametric mathematical programming.

■ MC-42

Monday, 12:30-14:00
Y12-3

Building a Decision Aiding Theory-of-practice: Empirical Research Concepts and Examples

Stream: Decision Processes
Invited session

Chair: *Gilberto Montibeller*, Dept. of Management, London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.montibeller@lse.ac.uk

1 - Practices and the praxis of organizational decision making - a systematic account
Kai Helge Becker, Mathematical Sciences, Faculty of Science & Technology, Queensland University of Technology, 2 George Street, GPO Box 2434, QLD 4001, Brisbane, Australia, kai.becker@qut.edu.au

Practice-based analyses play a significant and innovative role in current research on management and organizations. Despite some relevant recent contributions, this stream of research has not yet systematically addressed the consequences of a practice-based approach to organizational decision making. This paper fills this gap. It provides a conceptual framework to analyze processes of organizational decision making from a practice perspective, thereby integrating major insights from previous research. The new perspective suggested here also sheds new light on practices of Decision Analysis.

2 - Using archival data to study how organizations use decision analysis
Jeffrey Keisler, Management Science & Information Systems, University of Massachusetts Boston, 100 Morrissey Blvd, M/5-249, 02125, Boston, MA, United States, jeff.keisler@umb.edu, *Jeffrey Stonebraker*

Starting with general questions about decisions and supporting models at a large pharmaceutical company, we examined an archival database of decision analytic models for project portfolio management. Using this company as a case study, we formulated hypotheses and drew conclusions about the role of decision analysis there. We discuss lessons, challenges and opportunities for using such data to develop theory. What data exist, in what form, with what gaps? Which questions might be posed and which results obtained?

3 - Unpacking the dynamics of group decision aid use with video-based analysis
L. Alberto Franco, Hull University Business School, University of Hull, Management Systems, Cottingham Road, HU6 7RX, Hull, United Kingdom, alberto.franco@hull.ac.uk

Decision-aid researchers are increasingly concerned with examining the process of building and using decision models within interventions. In this presentation I adopt this focus and propose systematic and rigorous video-based analysis to unpack the dynamics of decision-aid use in a group context. Experience with this approach has so far produced important insights regarding how groups use decision aids in practice, and with what effects. Implications of this work for the conduct of group decision aid interventions will be discussed.

4 - Inquiring decision-aiding methodologies in the wild: the Action-Research strategy
Gilberto Montibeller, Dept. of Management, London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.montibeller@lse.ac.uk

Researchers interested in understanding the impact of decision-aiding methodologies are confronted with three conflicting research objectives, which they want to maximise: the generalizability of their results, the controllability of their experiments, and the realism of decision contexts. Action-Research is a powerful strategy if we want to maximise the latter objective, as long as it is rigorously conducted and properly employed. In this paper I will review this research strategy, illustrate its use in practice, and discuss its advantages, misuses, and limitations.

■ MC-43

Monday, 12:30-14:00
Y12-2

Experimental Economics and Game Theory 2

Stream: Experimental Economics and Game Theory
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Alexander Vasin*, Operations Research, Lomonosov Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su

1 - A computationally efficient alternative to the Money Pump Index
Bart Smeulders, Faculty of Economics and Business, KU Leuven, Naamsestraat 69, 3000, Leuven, Belgium, bart.smeulders@kuleuven.be, *Frits Spieksma*

We study the rationality of consumer behaviour. The recently proposed Mean Money Pump Index (MPI) quantifies the level of rationality violations by consumers. We show that computing the MPI is computationally intractable, which makes the measure impractical for use with large datasets. To overcome this problem, we propose a new measure: the Maximum Money Pump Index. It is closely linked to the MPI, it preserves its intuitive interpretation, and it allows for computation in polynomial time.

2 - Subgame perfect equilibria in wage bargaining with discount rates varying in time
Ahmet Ozkardas, Economics, Turgut Ozal University, Université de Paris I Pantheon Sorbonne, Ayvalı Mh. Gazze Cd., No:7 Etlik Keçiören, 06010, Ankara, Turkey, ahmetozkardas@hotmail.com, *Agnieszka Rusinowska*

We present a non-cooperative union-firm wage bargaining model in which the strike decision of the union is determined either exogenously or endogenously. The innovative element that our model brings to the existing literature concerns the parties' preferences which are expressed by sequences of discount factors varying in time. We determine subgame perfect equilibria if the strike decision of the union is exogenous. We also analyze the minimum and maximum wage contract equilibria for the model with endogenous strategies. We adapt our model to a pharmaceutical product price determination.

3 - A separable HRQoL-model
Mathias Barra, Health Services Research Unit, Akershus University Hospital, Sykehusveien 25, 1478, Lørenskog, Norway, Norway, mathias.barra@ahus.no, *Liv Ariane Augestad*

We investigate a large dataset of reported health related quality of life (HRQL) for patients. HRQL-loss is often claimed to be a convex function of the number of diagnoses (NoD), e.g., by assuming that each disease reduces the remaining HRQL by a factor. We, however, find a linear relationship between NoD and HRQL-loss, which appears to violate the principle of decreasing marginal (dis)utility. Our proposal is that HRQoL is linearly separable over diagnoses, representing independent dimensions of health. The result has important implications for medical decision analysis and optimization.

4 - Sustainable Development and Simulation Game Modeling
Zhana Tolordava, Head of the University Educational and Research Center for Simulation and Interactive Learning Methods, Tbilisi Ivane Javakhishvili State Univesity, Chavchavadze Avenue n1, 0128, Tbilisi, Georgia, 0186, avenue Vaja Pshavela YI quarter n. 18, Tbilisi, Georgia,, 380000, Tbilisi, Georgia, tolordava@hotmail.com

Study of the existing concepts of sustainable development and corresponding simulation game models are needed for conclusions on the problem of simultaneous sustainable economic and environmental development. Sustainable development means not only non-existence of the human impact on the environment but also adequate economic development ensuring satisfaction of the people's material wishes determined by the concrete social and cultural conditions of the public life. At simulation modeling of the sustainable development both the economic and environmental criteria should be considered equally.

■ MC-45

Monday, 12:30-14:00
Y10-3

Mathematical Models in Macro- and Microeconomics 2

Stream: Mathematical Models in Macro- and Microe-

conomics
Invited session

Chair: *Ludmilla Koshlai*, Systems analysis and OR, Institute of Cybernetics, Gonchar str.,65-a,apt.20, 01054, Kiev, Ukraine, koshlai@ukr.net
Chair: *Albert Corominas*, IOC-DOE, UPC, Av. Diagonal, 647, 08028, Barcelona, Spain, albert.corominas@upc.edu
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Optimising the extraction rate of a non-renewable non-durable resource: a mathematical programming approach
Albert Corominas, IOC-DOE, UPC, Av. Diagonal, 647, 08028, Barcelona, Spain, albert.corominas@upc.edu, *Enric Fossas*

We assume a monopolistic market of a resource such as crude oil or fossil water. Stating the problem of obtaining the optimal policies concerning the extraction and the pricing of the resource as a non-linear program allows achieving general conclusions under diverse assumptions about the demand curve, the discount rate and the length of the planning horizon. We compare the results with the most common beliefs about the pace of exhaustion of these resources.

2 - Input-Output Modeling to investigate Ukrainian cargo transport system
Elena Pervukhina, Dept. of Information Systems, Sevastopol National Technical University, Universitetskaya Str., 33, 99053, Sevastopol, Crimea, Ukraine, elena@pervuh.sebastopol.ua, *Jean-Francois Emmenegger*

The paper addresses an investigation of the role of the Ukrainian cargo transport system in the national economy as a whole through input-output analysis. The aim is to identify and trace peculiarities of transitional economy, tendency of its development, and to reveal a degree to correspondence of the Ukrainian transport industry to the European standards. Based on a known input-output approach, we take the cargo volumes transported by cargo system as exogenous and study further an economic effect on other industries.

3 - Information technologies for structural and technological changes in the economy of Ukraine
Ludmilla Koshlai, Systems analysis and OR, Institute of Cybernetics, Gonchar str.,65-a,apt.20, 01054, Kiev, Ukraine, koshlai@ukr.net

This presentation introduces the information technologies for structural and technological changes in the economy of Ukraine with special emphasizes to energy saving. We consider mathematical models of four types of energy saving measures, which have a common information base and, together with the necessary software, algorithms and developed user interface, are the kernel of a specialized decision support system (DSS). Model calculations with real data will be presented and policy-making recommendations will be suggested.

4 - Software development in planning structural reforms in a transition economy
Oleksandr Pylypovskyi, Radiophysical, Taras Shevchenko National Univesity Of Kyiv, 252187, Kyiv, Ukraine, o.pylypovskyi@gmail.com, *Ludmilla Koshlai*, *Petro Stetsyuk*

Problems of software creation for decision support in planning structural reforms during transition are considered. Main attention is paid to the choice of models, methods and databases for developed software MiSTC, which is designed as specialized decision-support system available for Windows. This tool uses Lapack++ and Qt libraries and requires no special user's computer training. Such features as modularity and extensibility provide quick adaptation to special user's requirements.

■ MC-46

Monday, 12:30-14:00
Y10-1

New approaches in Game Theory

Stream: Game Theory, Solutions and Structures
Invited session

Chair: *Agnieszka Rusinowska*, CNRS, Paris School of Economics, 75647, Paris, France, agnieszka.rusinowska@univ-paris1.fr

1 - A Smooth Path-Following Approach to the Determination of Perfect Equilibria of Finite n-Person Games in Normal Form
Chuangyin Dang, Systems Engineering & Engineering Management, City University of Hong Kong, 83 Tat Chee Avenue, HK SAR, Kowloon, Hong Kong, mecdang@cityu.edu.hk

This paper develops a smooth path-following method to compute perfect equilibria for strategic-form games. The idea is to closely approximate Nash equilibria of a perturbed game by incorporating a barrier term into each player's payoff function with an appropriate convex combination. An application of multilinear form of the payoff function leads to the existence of a smooth path that starts from a totally mixed strategy profile and ends at a perfect equilibrium. To follow the path, we adapt a predictor-corrector method. Numerical results show that the method is effective and efficient.

2 - Openshop sequencing games
Pedro Calleja, Economical, Financial and Actuarial Mathematics, University of Barcelona, Facultat de CC. Economiques i Empresarials, Av. Diagonal 690, 08034, Barcelona, Spain, calleja@ub.edu

This paper takes a game theoretical approach to openshop scheduling problems with unit execution times to minimize sum of completion times. By supposing an initial schedule, and associating each job (consisting in a number of operations) to a different player, we can construct a cooperative TU game associated to any openshop scheduling problem. We assign to each coalition the maximal cost savings it can obtain by means of admissible rearrangements of operations of jobs of members of the coalition. We show that the associated games are balanced, by providing a core allocation.

3 - Information Sharing Networks in Linear Quadratic Games
Sergio Currarini, Scienze Economiche, Università di Venezia, S. Giobbe 873, 30121, venezia, Italy, s.currarini@unive.it

We study the bilateral exchange of information in the context of linear quadratic games. An information structure is here represented by a non directed network, whose nodes are agents and whose links represent sharing agreements. We first study the equilibrium use of information in any given sharing network, finding that how "public" a piece of information is affects the equilibrium use of it, in line with previous results in the literature. We then study the incentives to share information and the resulting pairwise stable networks , or the cases of correlated and uncorrelated signals.

4 - Computing Tournament Solutions using Relation Algebra and RelView
Agnieszka Rusinowska, CNRS, Paris School of Economics, 75647, Paris, France, agnieszka.rusinowska@univ-paris1.fr, *Rudolf Berghammer*, *Harrie De Swart*

We apply relational algebra and RelView system to the tournament choice problem. The Copeland set can immediately be identified using RelView's labeling feature. Relation-algebraic specifications of the Condorcet non-losers, the Schwartz set, the top cycle, the uncovered set, the minimal covering set, the Banks set, and the tournament equilibrium set are delivered. We present an example of a tournament on a small set of alternatives, for which the above choice sets are computed and visualized via RelView.

■ MC-47

Monday, 12:30-14:00
Y10-2

Competitive Analysis in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Anton Ovchinnikov*, University of Virginia, Darden School of Business, 100 Darden Blvd, 22903, Charlottesville, VA, United States, aovchinnikov@darden.virginia.edu

1 - Strategic Consumer Cooperation in a NYOP Channel
Tatsiana Levina, School of Business, Queen's University, 143 Union str, K7L 3N6, Kingston, Ontario, Canada, tlevin@business.queensu.ca, *Yuri Levin*, *Jeff McGill*, *Mikhail Nediak*

We study the benefits of cooperation between strategic consumers in NYOP opaque product markets. The forms of cooperation include exchange of information as well as bid coordination with and without risk pooling.We propose an egalitarian total utility-maximizing mechanism for coordination and risk pooling in a bidding club and describe characteristics of consumers for whom participation in the club is rational.

2 - A Bilevel Approach for Energy Pricing Problem
Sezin Afsar, Dolphin, Inria Lille Nord Europe, Parc Scientifique de la Haute Borne 40 Avenue Halley, Bât B — Park Plaza, 59650, LILLE, France, sezin.afsar@inria.fr, *Luce Brotcorne*, *Patrice Marcotte*, *Gilles Savard*

Pricing models for demand side management methods are traditionally used to control electricity demand which became quite irregular recently and resulted in fluctuations and inefficiency in supply. We propose several bilevel models to explore the relation and conflict between energy suppliers and customers who are connected to a smart grid. Besides, this approach enables to integrate customer response into the optimization process of supplier who aims to maximize revenue or minimize capacity requirements. The models are reformulated as single level MIPs which can be solved by any solver.

3 - Dynamic Pricing and Service Competition when Consumers Learn about Service
Qian Liu, IELM, HKUST, Hong Kong, qianliu@ust.hk, *Song Zheng*

We consider a market with a large number of firms which provide differentiated service products at different prices and waiting times. The problem is formulated into a dynamic game model of price and service competition over an infinite time horizon in which consumers use observed past information on waiting times to update their estimates. We show how to analyze this complex game by an approximate game in which each firm maximizes its profit only with respect to the long-run average price and average waiting time.

4 - Strategic Consumers, Myopic Retailers
Anton Ovchinnikov, University of Virginia, Darden School of Business, 100 Darden Blvd, 22903, Charlottesville, VA, United States, aovchinnikov@darden.virginia.edu, *Mirko Kremer*, *Benny Mantin*

This paper is first to investigate observed human behaviors in a competitive dynamic pricing situation with strategic consumers. We characterize the equilibrium pricing policy in a stylized two-period model and contrast it with the observed behaviors. Our main insight is that subjects exhibited a significant degree of myopia: they act so that to obtain higher revenue and sell more inventory in the main selling season, but by doing so significantly limit their ability to generate revenue in the clearance season, which, in the presence of strategic consumers could be a major source of revenue.

■ MC-48

Monday, 12:30-14:00
Y11-1

Financial Evaluation and Risk Analysis

Stream: Simulation Methods in Finance
Invited session

Chair: *Aysegul Iscanoglu Cekic*, Statistics, Selcuk University, KONYA, Turkey, iscanoglu@yahoo.com
Chair: *Harun Yonar*, Department of Statistics, Fırat University-Selcuk University, Turkey, harunyonar@hotmail.com

1 - Extreme Returns in Turkish Stock Market
Muslu Kazım Körez, Statistic Department, Faculty of Science, Selcuk University, 42225, Konya, Turkey, kkorez@selcuk.edu.tr, *Aysegul Iscanoglu Cekic*, *Aşır GenÇ*

This study employs an analysis to model the distributions of the extreme daily returns of the Turkish stock market data. For this purpose parameters of Generalize Extreme Value (GEV), and Generalized Pareto (GP) distributions are estimated by using Turkish stock market data and the best fitted distributions are selected. Finally, a risk analysis study on Turkish Stock Market is implemented by using both extreme value distributions and the classical approaches of Value at Risk (VaR).

2 - A Portfolio Risk Decomposition of International Investors
Harun Yonar, Department of Statistics, Fırat University-Selcuk University, Turkey, harunyonar@hotmail.com, *Aysegul Iscanoglu Cekic*, *Aşır GenÇ*

For international investors the exchange rate risk plays a crucial role in returns. Therefore the correlations between the stock markets and the exchange risk should be considered in investment plans. In this study we aim to decompose the portfolio VaR into risk factors caused from individual foreign investments. For this purpose we make a comparison analysis by using stock market data of some developing and developed countries.

3 - The Examination of Stock Exchange Returns by Fuzzy Principal Component Analysis
B.Baris Alkan, Statistics, Sinop University, Sinop University, Faculty of Science and Arts, Department of Statistics, 57000, Sinop, Turkey, bbalkan@sinop.edu.tr, *Alper Sinan*, *Nesrin Alkan*

Principal component analysis (PCA) is a powerful method which could be used by financial managers and researchers in the field of stock market. PCA is negatively affected by the presence of outliers. In this case, it is needed to use alternative approaches of PCA. In this study, we have used fuzzy PCA for the analyze of Istanbul Stock Exchange Data. The results show that the importance of using fuzzy PCA to examine stock exchange returns.

■ MC-49

Monday, 12:30-14:00
Y11-2

Risk Analysis and Financial Modelling 1

Stream: Life Insurance, Risk and Ruin Theory, Financial Modelling
Invited session

Chair: *Jean-Francois Renaud*, UQAM, 201 av. President-Kennedy, PK-5151, H2X3Y7, Montreal, Quebec, Canada, renaud.jf@uqam.ca

1 - Quantifying the risk of portfolios containing stocks and commodities

Sila Halulu, Industrial Engineering, Istanbul Kultur University, Istanbul, Turkey, s.halulu@iku.edu.tr, *Wolfgang Hörmann*

Copula method is used to model the multivariate return distributions of stock portfolios and is implemented for risk measuring.Gold and crude oil are added to the stock portfolios and copulas are fitted to the joint return data to examine their effects to the portfolio risk.Back testing is implemented to check the validity of the models.t and generalized hyperbolic distributions are suitable for modeling financial instruments returns and t copula is the best model to represent the dependence structure between them.Besides,adding gold to the stock portfolios decreases the risk of portfolios.

2 - A Component Dynamic Conditional Correlation Model for High and Low Frequency Correlations

Vasiliki Skintzi, Department of Economics, University of Peloponnese, 21100, Tripolis, Greece, vikiski@uop.gr

This paper proposes a new approach for modeling the dynamics of correlation between asset returns. The correlation matrix is decomposed into a high-frequency and a low-frequency component combining the univariate spline GARCH model and a simple DCC specification. Conditional correlations are allowed to mean-revert to the slowly time-varying unconditional correlations. The proposed methodology is used for modeling return correlation between twelve stock markets. For most pairs of countries the proposed component dynamic correlation model outperforms the standard DCC model.

3 - Ruin, bankruptcy and restructuration for Lévy insurance risk processes

Jean-Francois Renaud, UQAM, 201 av. President-Kennedy, PK-5151, H2X3Y7, Montreal, Quebec, Canada, renaud.jf@uqam.ca

We introduce an insurance ruin model where default and bankruptcy are distinguished, and where restructuration is considered. In this model, the premium rate is increased as soon as the wealth process falls into the "red zone" and is brought back to its regular level when things get better. Since computing the probability of bankruptcy requires knowledge of the time spent by the underlying surplus process in the red zone, results on the distribution of occupation times for refracted spectrally negative Lévy processes will be presented.

■ MC-51

Monday, 12:30-14:00
Y11-4

Portfolio optimization 2

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *Yacine Ait-Sahalia*, Dept of Economics, Princeton University, 08540, Princeton, NJ, United States, yacine@princeton.edu

1 - On optimal partial hedging in incomplete discrete markets

Alexey Soloviev, Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Russian Federation, alex.solo.88@mail.ru, *Vladimir Morozov*

The following study investigates the problems of portfolio optimization under partial hedging of contingent claims. We consider arbitrage-free incomplete discrete markets representing them in form of scenario trees. Two well-known problems of quantile hedging and hedging with minimal risk of shortfall are analyzed. We discuss methods of solving them for two cases of European and American contingent claims applying some decomposition techniques and principles of optimality. Besides, the dynamic programming algorithm is described to build the superhedging strategy.

2 - An Intelligent Water Drops Algorithm Combined with Differential Evolution Algorithm for Solving Cardinality Constrained Portfolio Optimization Problems

Mualla Gonca Yunusoglu, Industrial Engineering, Dokuz Eylul University, Turkey, gonca.yunusoglu@deu.edu.tr, *Adil Baykasoğlu*

In this study, Markowitz's portfolio optimization model is considered with some additional constraints like cardinality and bounding constraints. The extended model is basically a mixed integer quadratic programming problem. To solve the present problem effectively, a hybrid algorithm which combines intelligent water drops algorithm and differential evolution algorithm is developed. The proposed algorithm is applied to several standard test problems from the literature. In general, the performance of the proposed algorithm is comparable to the state of the art algorithms of the literature.

3 - Portfolio Choice in Markets with Contagion

Yacine Ait-Sahalia, Dept of Economics, Princeton University, 08540, Princeton, NJ, United States, yacine@princeton.edu, *Tom Hurd*

We consider the problem of optimal investment and consumption in a class of multidimensional jump-diffusion models in which asset prices are subject to mutually exciting jump processes. This captures a type of contagion where each downward jump in an asset's price results in increased likelihood of further jumps, both in that asset and in the other assets. We solve in closed-form the dynamic consumption-investment problem of a log-utility investor in such a contagion model, prove a theorem verifying its optimality and discuss features of the solution, including flight-to-quality.

4 - On the Impact of Copulas on VaR Forecasts: A Simulation Study

Theo Berger, Empirical Economics and Applied Statistics, University of Bremen, Wilhelm-Herbst-Str. 5, Bremer Forum, Raum 0.16, 28359 , Bermen, Germany, theoberger@uni-bremen.de

An ex-post separation between the isolated impact of misspecified margins and misspecified dependency on portfolio risk forecasts represents a staggering task in modern portfolio analysis. In addition to Fantazzini (2009), who addresses the theoretical impact of misspecified margins on the estimation of copula parameters, we focus on the impact of decoupled dependency modeling in the context of Value-at-Risk (VaR). We simulate return series with realistic dependency schemes accounting for time varying dependency as well as tail dependence, and show that the choice of copula is crucial.

■ MC-52

Monday, 12:30-14:00
B13-1

Forecasting for Logistics and Supply Chain Management II

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Mohamed Zied Babai*, BEM-Bordeaux Management School, 680 cours de la libération, 33405, Talence, Gironde, France, mohamed-zied.babai@bem.edu
Chair: *John Boylan*, Business & Management, Bucks New University, Queen Alexandra Road, High Wycombe, United Kingdom, john.boylan@bucks.ac.uk

1 - R tools for forecasting hierarchical time series

Rob Hyndman, Econometrics & Business Statistics, Monash University, Clayton, Victoria, Australia, Rob.Hyndman@monash.edu

Hierarchical time series occur in manufacturing contexts where forecasts of sales need to be made for a range of different products and locations.

The hts package for R provides several methods for analysing and forecasting hierarchical time series. These include the classic "bottom-up" method, various "top-down" methods, "middle-out" approaches, as well as the recent optimal combination modelling approach.

Research issues include how to generate prediction intervals that account for the hierarchical structure, and how to implement the methods fast enough for operational purposes.

2 - Aggregate Demand Forecasting of Non-Stationary IMA(1,1) Demand Processes: Top-Down vs. Bottom-Up
Bahman Rostami Tabar, BEM-Bordeaux Management School, France, bahman.rostami@BEM.edu, *Mohamed Zied Babai*, *Yves Ducq*, *Aris A. Syntetos*

In this paper we consider an Integrated Moving Average IMA(1,1) demand process, with an SES forecasting method, to evaluate the performance of top-down and bottom-up approaches to aggregate demand forecasting. Theoretical variances of the forecast error of both approaches are derived to evaluate forecasting performance. In addition, simulation experiments are conducted to identify the conditions under which each approach is preferable. The analysis is supported by an empirical investigation. Valuable insights are offered to practitioners and some avenues are proposed for further research.

3 - The value of competitive information in forecasting FMCG retail product sales and category effects
Robert Fildes, Management Science, Lancaster University, Management School, Lancaster University, LA1 4YX, Lancaster, United Kingdom, R.Fildes@lancaster.ac.uk, *Tao Huang*

Sales forecasting at UPC level is important for retailers to manage inventory logistics. We propose more effective methods to forecast UPC sales by incorporating competitive information. Competitive information has been neglected by previous studies because of the high-dimensionality of the promotional variables. Under such a circumstance, time series models can easily become over-fitted, producing poor forecasts. This paper considers the circumstances where competitive information is of most value using methods new to the literature which significantly outperform industry benchmark models.

4 - Analysis of the Bullwhip Effect under Periodic Ordering Policies
Mohamed Zied Babai, BEM-Bordeaux Management School, 680 cours de la libération, 33405, Talence, Gironde, France, mohamed-zied.babai@bem.edu, *Mohammad Ali*, *John Boylan*, *Aris A. Syntetos*

A major problem associated with supply chain forecasting is the amplification of demand variability as orders move upstream in a supply chain. This phenomenon, termed as the Bullwhip Effect, has received considerable attention due to its implications for planning. However, most of the literature has focused on the periodic (T,S) policy due to its mathematical attractiveness without considering other possible, and often used, ordering policies such as the periodic (T,s,S). In this paper, we analyse the bullwhip effect under both policies and we offer important managerial insights.

■ MC-53

Monday, 12:30-14:00
B13-2

Energy Economics II

Stream: Energy Economics
Invited session

Chair: *Yves Smeers*, CORE, Université catholique de Louvain, Louvain-la-Neuve, Belgium, Voie du Roman Pays, 34, 1348, Louvain-la-Neuve, Belgium, yvessmeers@me.com

1 - Wind Power, Congestion Management and the Variability of Power Prices
Endre Bjørndal, Dept. of Business and Management Science, NHH Norwegian School of Economics, Helleveien 30, 5045, Bergen, Norway, endre.bjorndal@nhh.no, *Mette Bjørndal*, *Linda Rud*

New interconnectors and added intermittent generation capacity will expose the Nordic market to more variability. While price variations from uncorrelated wind power production may cancel out, variability may be enhanced due to the network topology and capacity. This has implications for congestion management. In a model of the Nordic electricity market and its transmission system, we study implications of spot market volatility given various scenarios of wind power and transmission investment, using different methods of congestion management.

2 - Congestion Management by Dispatch or Re-Dispatch: Flexibility Costs and Market Power Effects
Linda Rud, Business and Management Science, NHH Norwegian School of Economics, Helleveien 30, N-5114, Bergen, Norway, linda.rud@nhh.no, *Endre Bjørndal*, *Mette Bjørndal*

While nodal pricing fully deals with congestion, European electricity spot markets use simplified methods as uniform or zonal pricing, not addressing all congestion and making re-dispatch necessary to get feasible flow. We address the implications for efficient congestion management of the interaction of the spot and the re-dispatch market. Limitations in re-dispatch participation and extra costs of readjustment may make this an expensive way to handle congestion. We also study market power in the spot and re-dispatch model, showing that this market set-up may enhance market power.

3 - Supply function equilibria in networks with transport constraints
Par Holmberg, Research Institute of Industrial Economics, SE-102, Stockholm, Sweden, Par.Holmberg@ifn.se, *Andy Philpott*

Transport constraints limit competition and arbitrageurs' possibilities of exploiting price differences between goods in neighbouring markets, especially when storage capacity is negligible. We analyse this in markets where strategic producers compete with supply functions, as in wholesale electricity markets. For networks with a radial structure, we show that existence of supply function equilibria (SFE) is ensured if demand shocks are sufficiently evenly distributed, and we solve for SFE in symmetric radial networks with uniform multi-dimensional nodal demand shocks.

4 - Equilibrium based two stage stochastic analysis of imperfect wind forecast
Yves Smeers, CORE, Université catholique de Louvain, Louvain-la-Neuve, Belgium, Voie du Roman Pays, 34, 1348, Louvain-la-Neuve, Belgium, yvessmeers@me.com, *Jose Aguado*, *Sebastian Martin*

We consider the problem of the joint submission of dispatchable and non-dispatchable (wind) bids in a two-settlement system where the real time is either a market or a balancing mechanism (which in this case only differ by a single parameter). Wind benefits from a premium on top of the spot price. Firms are risk averse and there is no possible risk trading between day-ahead and real-time. Besides usual sensitity analysis, we examine the impact of the absence of risk trading on the behaviour of the firms depending on whether the real time system is a market or a balancing mechanism.

■ MC-54

Monday, 12:30-14:00
B14-1

Stochastic Models and Simulation in Power Systems

Stream: Energy, Environment and Climate
Invited session

Chair: *Nikita Ivkin*, Faculty of Management and Applied Mathematics, Moscow Institute of Physics and Technology (State

University), Institutskiy Pereulok, 9, 141700, Dolgoprudny, Moscow Region, Russian Federation, ivkinnikita@gmail.com
Chair: *Tim Bedford*, Management Science, Strathclyde University, 40 George St, G1 1QE, Glasgow, United Kingdom, tim.bedford@strath.ac.uk

1 - Optimal design of feed-in-tariffs to stimulate investments in renewable energy sources — a real options analysis
Ingmar Ritzenhofen, Kuehne Foundation Endowed Chair in Logistics Management, WHU - Otto Beisheim School of Management, Burgplatz 2, 56179, Vallendar, Germany, ingmar.ritzenhofen@whu.edu, *Stefan Spinler*

Feed-in-tariffs (FITs) are widely used as policy instruments to promote investments in renewable energy sources (RES). This paper aims at quantifying the relationship between FIT design features and the propensity to invest in RES. By adopting a real options approach, we analyze timing and capacity choice for a single RES investor under different FIT designs subject to regulatory ambiguity. We derive analytical results with comparative statics and conduct a numerical case study. We provide insights to investors and regulators on investment timing and the impact of specific FIT design features.

2 - A Hybrid Stochastic-Robust Dynamic Investment Policy in Renewables: a Real Option Approach
Bruno Fanzeres, Electrical Engineering, Pontifical Catholic University of Rio de Janeiro, Rua Marques de Sao Vicente, 225, Gavea, Office L435, 22451-900, Rio de Janeiro, RJ, Brazil, bsantos@ele.puc-rio.br, *Aderson Passos*, *Alexandre Street*, *Alexandre Moreira*, *Alvaro Veiga*

The complementarity between renewable sources allows trading energy with less exposure to short-term market uncertainty. In this talk we present a real option model to drive the optimal risk-averse investment policy of a generation company that can invest in two complementary renewable sources: wind and small hydro units. The optimal portfolio is dynamically obtained through a hybrid robust and stochastic optimization portfolio model, in which renewable generation is accounted for by means of scenarios and probabilities and short-term prices by means of a polyhedral uncertainty set.

3 - Optimal Capacity Choice in Renewable Energy Investment
Önay Batur, INDUSTRIAL ENGINEERING, KOÇ UNIVERSITY, Koç Universitesi, Rumeli Feneri Yolu, Sarıyer, 34450, İstanbul, Turkey, obatur@ku.edu.tr, *Metin Turkay*

The goal of this study is to analyze electricity production capacity level decision in case of incremental capacity choice in renewable energy project decision process. The analysis is carried by adopting Real Options Analysis (ROA). Uncertainty in the investment time interval is accounted by using Geometric Brownian Motion, considering stochastic behavior of energy and raw material prices. We performed our analysis on Nordic region data and find that incremental capacity choice is effective in the growth of the installed capacity of wind farm.

4 - Uncertainty in availability growth for offshore wind turbines
Tim Bedford, Management Science, Strathclyde University, 40 George St, G1 1QE, Glasgow, United Kingdom, tim.bedford@strath.ac.uk, *Athena Zitrou*, *Lesley Walls*, *Kevin Wilson*, *Keith Bell*

European governments around the North Sea are stimulating the development of large scale offshore farms of wind turbines for electrical power. The scale of projected investment is huge, and plans envisage the use of novel equipment in environments that are challenging for both equipment and operations. We present preliminary results of a project which is developing a simulation model to look at state-of-knowledge uncertainties around performance in the early years of operation. This model will aid the cost-benefit analysis of pre-deployment testing and other measures to reduce uncertainty.

■ MC-55

Monday, 12:30-14:00
B14-2

Network and capacity planning for biomass-based supply chains

Stream: Biomass-based Supply Chains
Invited session

Chair: *Magnus Fröhling*, Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT), Hertzstraße 16, D-76187, Karlsruhe, Germany, magnus.froehling@kit.edu
Chair: *Taraneh Sowlati*, Wood Science, University of British Columbia, 2931-2424 Main Mall, V6T1Z4, Vancouver, BC, Canada, taraneh.sowlati@ubc.ca

1 - Strategic design of biofuel supply chains: a process systems engineering perspective
Fabrizio Bezzo, Department of Industrial Engineering, University of Padua, 35131, Padua, Italy, fabrizio.bezzo@unipd.it

Bioethanol promotion has been acknowledged as a viable solution for a sustainable transportation system. Over the last years a number of contributions have appeared where mathematical programming techniques have been exploited to analyse and optimise several biofuel supply chains, in terms of the overall economics or by taking into account both profitability and environmental metrics. Here we will critically present the main contributions from the process systems engineering community, and discuss current research and future challenges to be tackled.

2 - Supply Chain Design for Advanced Biofuel Production Based on Bio-Oil Gasification
Guiping Hu, Iowa State University, Industrial and Manufacturing Systems Engineering Bioeconomy Institute, 50011, Ames, Iowa, United States, gphu@iastate.edu

Commercialization of biomass gasification has been hampered by its high capital and operating costs. A proposed pathway is to convert biomass to bio-oil at distributed fast pyrolysis plants, transport the bio-oil to a centralized gasification facility to upgrade to transportation fuels. In this study, a two-stage stochastic program is formulated to investigate the supply chain design and operational planning problem. A case study in Iowa is presented to illustrate the efficiency of the model.

3 - Developing a hub-based supply chain design model for co-fire of "uniform-format' advanced biomass and coal
Sandra Eksioglu, Industrial and Systems Engineering, University of Florida, 303 Weil Hall, 32611, Gainesville, FL, United States, duni@cao.ise.ufl.edu, *Md. S. Roni*, *Erin M. Searcy*

We propose a Mixed Integer Programming model to design a biomass feedstock supply chain to deliver densified biomass to a coal plant for co-firing. This model considers a hub-based supply chain design, using rail for long-haul, and high-volume shipment of densified biomass. The model identifies hub locations, and the optimal flow of biomass by truck and rail in the supply chain. The numerical analysis uses the existing railway network structure. The results indicate that about 2% of the coal used currently for production of electricity can efficiently be displaced by using densified biomass.

4 - Multi-objective optimization of a forest biomass supply chain
Taraneh Sowlati, Wood Science, University of British Columbia, 2931-2424 Main Mall, V6T1Z4, Vancouver, BC, Canada, taraneh.sowlati@ubc.ca, *Claudia Cambero*

This paper presents the development of a multi-objective optimization model for the design of a forest biomass supply chain for the generation of bioenergy/bioproducts. Objectives are to maximize NPV, maximize the number of generated direct jobs and minimize life cycle global warming potential. The ?-constraint method will be used to obtain a set of Pareto optimal solutions. Decisions include biomass sources; type, size and location of facilities; optimal type and volume of products and; optimal flow of biomass and intermediate. The model will be applied to a case study in British Columbia.

■ MC-56

Monday, 12:30-14:00
B15-3

Applied OR at SINTEF

Stream: OR Applications in Industry
Invited session

Chair: *Tomas Eric Nordlander*, Applied Math. Optimization, SINTEF ICT, Forskningsvn. 1, Oslo, Oslo, Norway, tomas.nordlander@sintef.no

1 - Optimizing Settlement on the Norwegian Stock Exchange

Oddvar Kloster, SINTEF ICT, Postboks 124 Blindern, 0314, Oslo, Norway, okl@sintef.no

We present a MIP-based solution method that runs nightly to optimize the settlement on the Norwegian stock exchange, with over 60 000 transactions worth EUR 12 billion. Settlement transfers shares and money between accounts, completing transactions that have been agreed upon earlier. However, transactions must be rejected if an account does not have enough shares or money. This can cause other transactions that resell some of the same shares, to also be rejected. The settlement optimization problem is to decide which transactions to reject, in order to maximize the total settled value.

2 - Real-life routing at SINTEF

Geir Hasle, Applied Mathematics, SINTEF ICT, P.O. Box 124 Blindern, NO-0314, Oslo, Norway, geir.hasle@sintef.no

SINTEF is a large contract research organization in Norway. For almost 20 years we have developed models, solution algorithms, and software for a wide variety of routing problems, in close collaboration with our clients. The results have been commercialized through spin-offs and licensing. This talk will focus on industrial aspects, rich models, and robust solution methods that are important factors to success in real-life applications. Concrete examples will be given from freight transportation, newspaper distribution, multi-modal personal travel, and maritime inventory routing.

3 - Personnel scheduling research at SINTEF

Tomas Eric Nordlander, Applied Math. Optimization, SINTEF ICT, Forskningsvn. 1, Oslo, Oslo, Norway, tomas.nordlander@sintef.no

Personnel scheduling has been subject to extensive studies over decades and occurs in areas like hospitals, transportation, airline crew, call centres, etc.. Our group has conducted research in personal scheduling for about 10 years and built and implemented personnel scheduling engines for organizations since 2004. The scheduling engines are tailored for specific hard constraints (labour laws, union regulations, etc.) and soft constraints (e.g. employees' preference) and need to ensure fairness between employees. We are working on systems for organizations in the transport and health domain.

4 - SINTEF's experiences in the Air Traffic Management industry

Patrick Schittekat, ICT, SINTEF, Forskningsveien 1, 0314, Oslo, NORWAY, Norway, patrick.schittekat@sintef.no, *Dag Kjenstad*, *Carlo Mannino*, *Morten Smedsrud*

Air Traffic Control guides the flow of traffic on the airport and the adjacent airspace. This has to be done in a safe and effective manner: a very complex task. As traffic is forecasted to grow, this industry can significantly benefit from applying OR. However, many hurdles need to be overcome to put OR into practice. SINTEF collaborates intensively with industry in the SESAR program, a very large EU program aimed at lifting the European aviation industry to a higher level. This experience can help other OR researchers to narrow the gap between theory and practice.

■ MC-57

Monday, 12:30-14:00
B15-4

Risk Management Applications

Stream: IBM Research Applications
Invited session

Chair: *Marco Laumanns*, IBM Research - Zurich, 8803, Rueschlikon, Switzerland, mlm@zurich.ibm.com

1 - Building Bayesian Belief Networks from Multiple Sources

Stephane Deparis, IBM Research - Ireland, 15, Dublin, Ireland, stephane.deparis@ie.ibm.com, *Lea Deleris*

We address the problem of building the structure of a Bayesian Belief Network from multiple sources, a situation which arises in practice when using multiple experts or when relying on literature to identify dependence or independence among variables. The difficulty lies in the fact that statements (be they from experts or from texts) may be conflicting while at the same time incomplete. We implement and compare several aggregation methods borrowed from the fields of decision analysis (expert aggregation) and artificial intelligence (structure learning from data).

2 - Multi-objective Constraint Optimization with Tradeoffs

Abdul Razak, Computer Science, University College Cork, 4C, Room 2-15, Western Gateway Building, Western Road, UCC, 0000, Cork, Cork, Ireland, arazak@4c.ucc.ie, *Nic Wilson*, *Radu Marinescu*

In this paper, we show how multi-objective constraint optimisation algorithms can be extended to the case where there are additional tradeoffs. This is based on a logical model of tradeoffs between multi-attribute vectors, where the inputs come from direct user preferences of one vector over another. It turns out that even a small number of additional tradeoffs can greatly reduce the number of optimal solutions. We focus especially on branch-and-bound algorithms which use a mini-buckets algorithm for generating the upper bound at each node (in the context of maximising values of objectives).

3 - Pre-Disaster Planning by Mixed-Integer Stochastic Programming with Scenario Bundling

Marco Laumanns, IBM Research - Zurich, 8803, Rueschlikon, Switzerland, mlm@zurich.ibm.com, *Steven Prestwich*, *Ban Kawas*

We consider a real-world example of pre-disaster planning: finding optimal investments to strengthen links in a transportation network, given that the links are subject to stochastic failure. The objective is to facilitate rescue operations by minimising the sum of expected shortest path lengths between different locations, which can be modelled as a 2-stage stochastic program. We exploit network properties to group scenarios into large bundles. This reduces the size of the problem by several orders of magnitude and allows the exact solution of cases previously considered intractable.

■ MC-58

Monday, 12:30-14:00
B15-6

Software for OR/MS I - Optimization

Stream: OR in Industry and Software for OR (contributed)
Contributed session

Chair: *Bjarni Kristjansson*, Maximal Software, Ltd., Boundary House, Boston Road, W7 2QE, London, United Kingdom, bjarni@maximalsoftware.com
Chair: *Robert Fourer*, AMPL Optimization, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com

1 - Optimal IT service provisioning in virtual data centers — a linear programming approach
Holger Schrödl, Otto-von-Guericke University Magdeburg, Germany, holger.schroedl@ovgu.de

The optimized allocation of resources in IT datacenters is of vital interest for IT service providers. Abundance of resource is cost-intensive, reducing IT resources leads to bottlenecks. Resource factors in datacenters are processor schedules, storage, applications, and manpower. Existing approaches are limited how these resource factors are considered in planning and operation processes. First, the authors describe IT service provision as an assignment problem in a linear programming approach. Second, possible solutions and, moreover, benefits and limitations of this approach are discussed.

2 - A global optimization method for naval structure optimization
Maud Bay, HEC - Management School, University of Liège, Rue Louvrex, 14, 4000, Liège, Liège, Belgium, maud.bay@ulg.ac.be, *Yves Crama*, *Philippe Rigo*

The paper proposes a global optimization method for the preliminary structural design of large vessels in shipbuilding industry. We face a combinatorial problem of large size, with constraints modelled as implicit functions with nonlinear behaviour. We present a heuristic method that performs a global search over the feasible solution space, combining a large neighbourhood search and a heuristic local search. Experiments on actual structural optimization problems show that the heuristic converges towards discrete feasible solutions of good quality.

3 - Customer-centric pricing at Germany's leading tour operator
Alexander Baur, University of Augsburg, 86135, Augsburg, Germany, alexander.baur@wiwi.uni-augsburg.de

The optimization problem presented in this talk is based on a joint project between IBM and the Chair of Analytics & Optimization (University of Augsburg) at TUI, the leading German tour operator. For every season most tour operators in Germany distribute free catalogues along with a pricing brochure. For every destination offered in this brochure the pricing manager in charge has to determine up to 100,000 prices. To support this task we consider the travel behaviour of different customer segments and develop a linear mixed-integer programming formulation which is solved with IBM ILOG CPLEX.

■ MC-59

Monday, 12:30-14:00
B15-5

Collective Learning Procedures II

Stream: Machine Learning and Its Applications
Invited session

Chair: *Michael Khachay*, Ural Branch of RAS, Institute of Mathematics and Mechanics, S.Kovalevskoy, 16, 620990, Ekaterinburg, Russian Federation, mkhachay@imm.uran.ru

1 - New advances in learning DNF formulas in PAC model
Yury Maximov, Laboratory of structural methods of data analysis in predictive modeling, Moscow Institute of Physics and Technology, Kerchenskaya street, 1A, building 1, 117303, Moscow, Moscow, Russian Federation, yury.maximov@phystech.edu

The probably approximately correct (PAC) learning is discussed. One of the central open problems of PAC learning is the polynomial time learnability of DNF formulas, posed by Valiant. The DNF exception problem is the problem to update a DNF formula D to get a new DNF which is false on a selected list of points, and otherwise it is equivalent to D. Broad and Pitt showed that these two problems are closely related to each other. Here we present a new upper bound to the complexity of the DNF exception problem and consider its influence on the complexity of learning DNF formulas in the PAC model.

2 - Piece-wise Linearization of Complex Non-Linear Production Systems
Firat Uzman, Industrial Engineering, KOÇ University, Rumeli Feneri Yolu/Sarıyer, 34450, Istanbul, Turkey, fuzman@ku.edu.tr, *Metin Turkay*

Complex production systems usually exhibit nonlinearities due to the nature of the processes involved. The use of these complex nonlinear models, especially when combined with discrete decisions, poses a significant challenge in the optimization studies. A well-accepted approach is to use linearization of these functions. In this work, we test different linearization techniques including piecewise linear functions to maintain an acceptable level of accuracy in the model representation. We present the mixed-integer nonlinear programming approach and results on a wide variety of test problems.

3 - Upper bounds on complete cross-validation.
Nikita Zhivotovskiy, Faculty of Control and Applied Mathematics, Moscow Institute of Physics and Technology, Russian Federation, nikita.zhivotovskiy@phystech.edu, *Evgeny Sokolov*

Complete Cross-Validation (CCV) is based on averaging test error over all permissible train / test partitions of data. Although CCV is a fairly accurate generalization ability estimator, its calculation complexity grows exponentially with size of data. In case of empirical risk minimization for binary classification problem we prove some tight effectively computable upper bounds on CCV which depend on geometry of classifiers set and are based on concentration of measure phenomenon. We apply these results in model selection problem.

4 - Synthesizing Group AHP Evaluations by Numerical Analysis
Szabolcs Duleba, Economics and Logistics, College of Nyíregyháza, Hungary, 4400 Nyíregyháza, Ferenc krt.2., 4400, Nyíregyháza, Hungary, duleba@nyf.hu

For creating a common consensus among different groups of evaluators in Analytic Hierarchy Process (AHP), the use of "voting power' is recommended. This approach however makes the AHP procedure more subjective, and this is very difficult in some cases to assign weights to the evaluators. In this paper, we introduce another approach; the AHP scores are considered as group wisely aggregated vectors and by numerical analysis, we search for those weights that minimize the Euclidean distance of the vectors. An application for transport system evaluation is also introduced.

■ MC-62

Monday, 12:30-14:00
R18-1

Branch-and-bound and Branch-and-cut for MINLP

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Juan Pablo Vielma*, MIT, Cambridge, MA, United States, jvielma@mit.edu

1 - Quadratic Outer Approximation for Convex Integer Programming
Long Trieu, Fakultät für Mathematik, Technische Universität Dortmund, 4422, Dortmund, Germany, long.trieu@mathematik.tu-dortmund.de, *Christoph Buchheim*

We present a quadratic outer approximation scheme for solving general convex integer programs, where suitable quadratic approximations are used to underestimate the objective function instead of linear approximations. As a resulting surrogate problem we consider the problem of minimizing a function given as the maximum of finitely many convex quadratic functions having the same Hessian matrix. A fast algorithm for minimizing such functions over integer variables is presented. Experimental results for a class of convex integer problems with exponential objective functions are presented.

2 - A Branch and Bound Approach for the Optimal Control of System Dynamics Models
Ingmar Vierhaus, Optimization, Zuse Institute Berlin, Takustr. 7, 14195, Berlin, Germany, vierhaus@zib.de, *Armin Fügenschuh*

The System Dynamics (SD) methodology is a framework for modeling and simulating the dynamic behavior of socioeconomic systems. Instead of a local approach to the optimal control of such a system, we propose a branch-and-bound approach to the solution of the NLP transcription of the problem. This approach is based on a) a bound propagation method, b) primal heuristics, and c) spatial branching on underlying nonlinear functions of the SD model. Our methods are implemented in the MINLP solver SCIP. Numerical results for test instances will be presented.

3 - Intersection cuts for Mixed Integer Conic Quadratic Sets
Kent Andersen, About Aarhus University " Department of Mathematics, Aarhus University, 8000, Aarhus, Denmark, kent@imf.au.dk

Balas introduced intersection cuts for mixed integer linear sets. Intersection cuts are given by closed form formulas and form an important class of cuts for solving mixed integer linear programs. In this paper we suggest an extension of intersection cuts to mixed integer conic quadratic sets. We identify the formula for the conic quadratic intersection cut by using tools from computational algebraic geometry. The intersection cut we present generalizes a conic quadratic cut introduced by Modaresi, Kilinc and Vielma.

4 - Mixed Integer Gomory Cuts for Quadratic Programming: The Power of Extended Formulations
Juan Pablo Vielma, MIT, Cambridge, MA, United States, jvielma@mit.edu, *Sina Modaresi*, *Mustafa Kilinc*

Mixed Integer Gomory (MIG) cuts for linear MIP can be constructed from basic feasible solutions (BFS) and are equivalent to MIR and split cuts. MIR and split cuts have been extended to quadratic MIP, but these extensions do not preserve the BFS construction of MIGs. We show that MIRs for quadratic MIP are in fact MIGs for the linear part of a quadratic extended formulation. This gives natural BFSs from which to effectively generate cuts. While these quadratic MIGs are not equivalent to quadratic split cuts, they can provide a computational advantage.

■ MC-63

Monday, 12:30-14:00
R18-2

Mechanism Design in Organizations

Stream: Operational Research and Control Problems
Invited session

Chair: *Nikolai Korgin*, Lab of Active Systems, Institute of Control Sciences of Russian Academy of Sciences, 65,, Profsoyuznaya st., 117997, Moscow, Russian Federation, nkorgin@ipu.ru
Chair: *Dmitry Novikov*, Institute of Control Sciences, Russian Academy of Science, Profsojuznaya st., 65, 117997, Moscow, Russian Federation, novikov@ipu.ru

1 - An efficient mechanism for resource allocation by voting with transferable utility
Nikolai Korgin, Lab of Active Systems, Institute of Control Sciences of Russian Academy of Sciences, 65,, Profsoyuznaya st., 117997, Moscow, Russian Federation, nkorgin@ipu.ru

The problem of allocation of limited amount of infinitely divisible good among a finite number of agents is considered. Each agent has his or her own utility function, which is private information. For a situation when utility is transferable among agents, the efficient Nash-implementation mechanism is offered. The resource allocation problem is presented as amultidimensional voting problem and the "Groves-Ledyard quadratic government" is applied. We provide conditions when the allocation according to the mechanism is individually rational and achievable via learning strategies.

2 - Control of Reflexive Decision-Making
Dmitry Novikov, Institute of Control Sciences, Russian Academy of Science, Profsojuznaya st., 65, 117997, Moscow, Russian Federation, novikov@ipu.ru

Mathematical modeling of reflexive processes in control covers reflexive games of agents making decisions based on an hierarchy of beliefs. Analyzing the properties of informational and reflexive structures enables suggesting informational and reflexive equilibria as solutions of corresponding games. The models of informational and strategic reflexion allow posing and solving the problems of informational and reflexive control in organizational, economic, social, and other systems, in military applications, etc.

3 - Double and One Sided Moral Hazard in the Three-tier hierarchical Organization of the Venture Capital Finance
Ayi Gavirel Ayayi, Science de la gestion, Université du Québec, 3351 Boulevard des Forges, G9A 5H7, Trois Rivières, Québec, Canada, ayi.ayayi@uqtr.ca

The paper studies double-sided moral hazard problem (MHP) between venture capitalists (VCs) and entrepreneurs and one-sided MHP between the investors in the venture capital funds and VCs because of the direct impact of the moral hazard on the performance of the funds as well as on the growth and the success of the investees. I show that an optimal compensation contract can reconcile the different needs and concerns of the three contracting parties; given the information distribution and the behavioral assumptions. Global optimization program is use to solve goal congruence optimal contract.

4 - Combinatorial Supergames for TechnoSocial Systems with Applications
Umberto Perna, Analytics, KMAC - Management Consulting, Italy, umberto.perna@gmail.com, *Raissa DSouza*, *Samuel Johnson*

Interactions between social and technological components in modern systems have never found a unique framework of analysis, capable of capturing relevant features of their interplay for prediction of future vulnerabilities and failures and to guide policy decisions. We propose a supergame class considering separate mathematical treatment for human and technological networks, allowing for (nonlinear) interactions among the two. We focus on the long-run interplay between the two components. Applications to diverse settings such as power companies and open source software are explored in detail.

■ MC-64

Monday, 12:30-14:00
R18-3

Defence and Security II

Stream: Defence and Security
Invited session

Chair: *Ana Isabel Barros*, Military Operations, TNO, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - Online UAV Mission Planning under Uncertainty with Time Windows
Lanah Evers, Defence, Security and Safety, TNO, P.O. Box 96864, 2509 JG, The Hague, Netherlands, lanah.evers@tno.nl, *Ana Isabel Barros*, *Herman Monsuur*

Reconnaissance Unmanned Aerial Vehicles mission planning incorporates several practical challenges: collecting imagery of the locations with the highest possible total information value, where time windows are associated to the locations and travel and recording times are stochastic. Also, new time-sensitive targets may appear during the flight. We introduce a fast approach to plan and re-plan the mission if necessary, which explicitly takes uncertainty into account and directs the UAV towards areas where new targets are likely to appear. The benefits of this approach will be illustrated.

2 - Modelling and Analysis of Different Localization of Joint Strike Fighter Squadron Using Fuzzy Causal Maps

Pawel Zdanowicz, Engineering and Computing, Coventry University, United Kingdom, zdanowip@uni.coventry.ac.uk, *Dobrila Petrovic*, *Colin Irwin*

This paper presents a new model of Defence Lines of Development (DLoDs) and their relationships with Military Capability. The model employs Rule Based Fuzzy Causal Maps (RBFCM) to advise on improvements to resource allocation in order to produce more cost effective and militarily capable Force Elements and Capability Packages. The model operates using complex fuzzy causal relations that cannot be specified using precise mathematical concepts, but can only be described by uncertain, imprecise or incomplete information and knowledge.

3 - Determine the Unmanned Aerial Vehicle Selection Criteria with Fuzzy Analytic Hierarchy

Erhan Berk, Defence Science, Hava Duragi Lojmanlari 4.Blok Daire:1, 06790, Ankara, Turkey, erhanberk@hotmail.com

Unmanned aerial vehicles are currently operating in each sector due to the use of a multi-purpose and the low operating costs. In our study we focused on unmanned aerial vehicles in the defense sector. Firstly, Delphi method was used to determine the criteria for the selection of UAV and then the calculation of the weights of the criteria are analyzed with Fuzzy Analytic Hierarchical Process. The resulting criteria weights are used in a sample application for the existing UAVs.

■ MC-65

Monday, 12:30-14:00
R18-5

Innovative studies of games and management applications

Stream: Emerging Applications in Game Theory and Management
Invited session

Chair: *Nikolay Zenkevich*, Graduate School of Management, St. Petersburg University, 1-3, Volkhovsky Pereulok, 199004, St. Petersburg, Russian Federation, zenkevich@gsom.pu.ru

1 - Model and applications of service quality level choice in oligopoly

Margarita Gladkova, Graduate School of Management, St. Petersburg University, Volkhovsky Per. 3, 199004, St. Petersburg, Russian Federation, rita.gladkova@gmail.com, *Nikolay Zenkevich*

The development of information and communication technologies and competition causes the necessity of innovative approaches to strategic decision-making that allow gaining the leading position in mid-term and long-term perspective. One of the instruments that increases company's competitiveness is the improvement of the service quality. Research objectives are: analyze consumer satisfaction with the service; develop game theory models of service providers' interaction; define strategy of service quality level choice; develop practical recommendations for companies to implement the strategy.

2 - Cooperative strong equilibria in vehicle routing game

Nikolay Zenkevich, Graduate School of Management, St. Petersburg University, 1-3, Volkhovsky Pereulok, 199004, St. Petersburg, Russian Federation, zenkevich@gsom.pu.ru, *Andrey Zyatchin*

A variant of the vehicle routing problem with several distributors under competition is introduced. Under this scenario a solution may contain unserved customers and elementary routes with no customer visits. The problem is described as a vehicle routing game (VRG). We provide a computable procedure to calculate strong equilibrium in the VRG (it is stable against deviation of any coalition), and proof, that strong equilibrium exists in a VRG. We also introduce a semi-cooperative strong equilibrium, which helps to reduce a set of strong equilibria in the VRG. A numerical example is calculated.

3 - A game theoretic approach to optimal product selection, inventory, and pricing strategy

Syed Asif Raza, Management and Marketing Department, Qatar University, College of Business and Economics, 2713, Doha, Qatar, Qatar, syedar@qu.edu.qa

The two major objectives of Product Line Design (PLD) are, customers' satisfaction, and the firm's profit maximization. In literature, several models are proposed, however, these models fall short of considering the customers' behavior such as cannibalization, and market competition. This paper addresses these concerns by proposing a game theoretic model for PLD which also considers both customer cannibalization and competition. The model is a game theoretic, NP-hard mixed integer nonlinear program. Efficient exact and meta-heuristic algorithms are developed to solve the problem.

4 - Cost-reducing r&d with free spillovers and price competition in a dynamic duopoly

Fouad El Ouardighi, Operations Management, ESSEC Business School, Avenue Bernard hirsch, BP 105, 95021, Cergy Pontoise, France, elouardighi@essec.fr, *Matan Shniderman*, *Federico Pasin*

The objective in this paper is to study the R&D investment and pricing strategies of two firms competing for consumer demand in a dynamic setup. A firm's R&D is production cost-reducing and can benefit the rival firm without payment. The paper compares open-loop and closed-loop Nash strategies to determine the extent at which they affect the pricing and R&D investment decisions and the payoffs of the competitors.

■ MC-66

Monday, 12:30-14:00
R18-4

OR: Visualization and Clusterization

Stream: OR: Visualization and Arts
Invited session

Chair: *Vitaly Podobedov*, Computational Mathematics and Cybernetics, Moscow State University, Vorobievy Gory, MSU, 119992, Moscow, Russian Federation, vetix@or-art.org
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Interval Predictor Models for Obtaining the Confidence Level of the Optimal Number of Clusters

Mikhail Morozkov, Sankt-Petersburg State University, 198504, St. Petersburg, Russian Federation, mmorozkov@gmail.com

Finding the true number of groups in a data set is a challenging cluster analysis problem. Previously we offered randomized approach in the framework of elbow methodology, where the number of clusters is defined as a jump discontinuity of index function. Probabilistic estimates are given for the confidence interval of such point. In this paper we address this problem from reliability and complexity standpoint. We show that scenario based interval predictor models yeild better results for confidence interval. Finally, we provide several simulation examples and comparisons with previous works.

2 - Planning Troop & Resource Deployments at Military Bases using Exponentially Weighted Voronoi Diagrams

Suchisman Gangopadhyay, Montogmery Township School District, 68 Belle Glades Ln, 08502, Belle Mead, New Jersey, United States, suchismangang@gmail.com

Military presence for maintaining regional and world peace is vital. Optimal resource allocation at a forward military base should be based on the actual needs such as the level of insurgent activity. Optimization for area alone is addressed by a traditional Voronoi tessellation. In this paper, a resource allocation algorithm based on exponentially weighted Voronoi tessellation is used. By using a map of insurgent activity to find the density in each of the Voronoi cells attributed to each base, an exponentially weighted Voronoi is created to reflect Boulder's Loss of Strength Gradient.

3 - Location theoretic consensus points: the impact of distance selection and issue saliences
Tom Blockmans, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussel, Belgium, tblockma@vub.ac.be, *Frank Plastria*

We address the estimation of consensus positions in spatial coalition formation models. In search of consistency in the model assumptions and inspired by location theory, three types of consensus positions are considered by minimising a weighted sum of distances towards the parties' ideal policy positions, using the Squared Euclidean, Euclidean and Rectangular distance functions. Attention is payed to inclusion of issue saliences, representing the parties' policy priorities. Properties, uniqueness, reachability and calculation of the corresponding consensus positions are discussed.

■ MC-67

Monday, 12:30-14:00
R19-1

Decision Support Systems in Health

Stream: Medical Decision Making
Invited session

Chair: *Gultekin Kuyzu*, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Caddesi No:43, Sogutozu, 06560, Ankara, Turkey, gkuyzu@etu.edu.tr

1 - Combining expert system technology and mathematical programming techniques in dietetics
Annette van der Merwe, School of Computer, Statistical and Mathematical Sciences, North-West University, Private bag X6001, 2520, Potchefstroom, Northwest, South Africa, annette.vandermerwe@nwu.ac.za, *Hennie Kruger*, *Tjaart Steyn*

An interactive expert system, utilising mathematical programming techniques and rules for food preferences, was developed to provide a solution to an adaptation of the classic diet problem. The aim of the system is to create a balanced, cost effective eating plan for a random female teenager in the South African environment. Goal programming techniques are utilised to determine the nutritional requirements for a specific user and multi-objective integer programming is used to integrate those requirements into a selection of food choices for a specific user.

2 - Brain tumour detection methods
Michal Kvet, Informatics, Zilinska univerzita v Ziline, Univerzitná 8215/1, 01026, Žilina, Slovakia, Slovakia, michal.kvet@fri.uniza.sk, *Karol Matiasko*

Cancer is one of the most serious problem of the currecnt medicine. The project „Brain tumour detection" presents new methods for diagnostics and treatment of the patient. The aim of it is to detect, locate, monitor and visualize anomalies inside the brain and provide information about the type and treatment methods. Developed application processes 26 standard markers and unlimiteed amount of own markers defined in the application. The anomaly is visualized in 2D, 3D models to show everything strange coloured.

3 - Determining Simulation inputs for long-term antiretroviral therapy (ART) survival estimation: Survival Analysis results from a longitudinal national HIV database
E Mushota Kabaso, School of Mathematics, University of Southampton, Building 54, School of Mathematics, Highfield Campus, SO17 1BJ, Southampton, United Kingdom, United Kingdom, mushota.kabaso@soton.ac.uk, *Sally Brailsford*, *Christine Currie*

With a generalised HIV epidemic driven by heterosexual contact and vertical transmission from mother to child (78% and 10% new infections resp.), factors which define the heterogeneity of the pandemic include gender, age, geographical location, etc.

This research combines the estimation of the survival of ART patients and the economic cost of providing ART in Zambia using a Discrete Event Simulation (DES) model parameterised from survival analysis output. Hazard and survival functions will be analysed with different factors that determine the heterogeneity of the epidemic as covariates.

■ MC-69

Monday, 12:30-14:00
R19-3

OR Applications for Renewable Energy Development in Developing Countries I

Stream: OR for Development and Developing Countries
Invited session

Chair: *Youssef Masmoudi*, University of Sfax, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef.masmoudi@gmail.com
Chair: *Habib Chabchoub*, LOGIQ, Institut Supérieur de Gestion Industrielle, 3018, Sfax, Sfax, Tunisia, Habib.chabchoub@fsegs.rnu.tn

1 - Integration of Renewable Energy Sources in North Africa into the European Energy System
Daniel Schweer, Institute of Power Systems and Power Economics, RWTH Aachen University, Schinkelstr. 6, 52056, Aachen, Germany, sc@iaew.rwth-aachen.de, *Christian Kraemer*, *Albert Moser*

The general framework of energy supply fundamentally changed within the last years due to an increasing environmental awareness and a corresponding political will to significantly reduce greenhouse gas emissions. Instead of a subsidization of renewable energies in Europe, the construction in much more efficient solar and wind locations in North Africa could be aimed for. This work illustrates limitations and potentials of the integration of African renewable energy sources into the European energy system by the application of lagrangian-based market simulation and network calculation tools.

2 - Learning Curves Modelling for Renewable Energy in Developing Countries: The Colombian Case
Jessica Arias, Facultad de Minas, Universidad Nacional de Colombia, cra 60 # 62-05, Medellin, Antioquia, Colombia, jariasg@unal.edu.co, *Santiago Arango*, *Sandra Carvajal*

Learning curves are usually modeled only as learning-by-doing costs reduction and/or as R&D; however, learning curves usually do not differentiate between developed and in developing countries. In this paper, we present a simulation model to consider the effect of learning curves in development country to see the effect on renewable energies, applied to the Colombian case. Initial results show the importance of an appropriate learning curve for a proper analysis of renewable energy diffusion, especially in regions with high renewable potential like Latin-America.

3 - Optimal Investment Planning for Hydro Electric Energy
Mustafa Akan, management, haliç university, Sishane, 34420, istanbul, turkey, Turkey, mustafaakan@halic.edu.tr

The objective is to investigate optimal investment planning in hydro electric energy.The government,acting as a monopolist,controls the price of energy with the requirement that it meets the demand by renewable energy (hydroelectric) and imported oil.Its objective is to maximize long term discounted profits by optimally deciding the price of energy and the investment in hydroelectric energy.There will always be a positive level of investment in hydro energy if the price of oil is high enough compared to unit cost of investment in hydro energy and vice versa.

4 - Sustainable smart grid
Shantanu Biswas, Infosys Ltd., India, shantanu.biswas@gmail.com

Sustainable development involves responsible use of the available resources towards environmental, economic, and social dimensions. Energy is one such resource that requires immediate attention towards its sustainable generation and usage. We consider a collaborative network of different businesses within a limited geographical area. The collaboration is aimed towards achieving sustainability in electricity usage and production. Our focus in this paper is to study the formation of a collaborative network to increase the usage of renewable distributed energy sources.

■ MC-71

Monday, 12:30-14:00
R16-1

Humanitarian Logistics Applications

Stream: Humanitarian Logistics
Invited session

Chair: *Serhan Duran*, Industrial Engineering, Middle East Technical University, Orta Dogu Teknik Universitesi, Endustri Muh. Bolumu, 06531, Ankara, Turkey, sduran@metu.edu.tr

1 - A humanitarian logistics model to minimize earthquake losses in large-scale situations by considering transportation network failure: San Francisco case study
Morteza Ahmadi, industrial engineering, amirkabir university of technology (Tehran Polytechnic), 021, tehran, tehran, Iran, Islamic Republic Of, m.ahmadi.ie@gmail.com, *Abbas Seifi*

One of the most significant problems which will occur aftermath of an earthquake is failure of transportation network infrastructures. We propose a mixed integer location-routing model to minimize losses in a humanitarian logistics operation by considering transportation network failure. We have proposed an efficient variable neighborhood search method to solve our humanitarian logistics model. San Francisco's city network as a large scale example is used to implement our model and VNS method. Numerical results show capabilities of model to handle large scale relief operations.

2 - Pre-positioning Disaster Response Facilities and Relief Items Considering Probabilistic Constraints: A Case Study for Istanbul Region
Cigdem Renkli, Industrial Engineering, Middle East Technical University, METU Industrial Engineering Department No: 324, 06800, Ankara, Turkey, renkli@metu.edu.tr, *Serhan Duran*

Pre-disaster planning helps reducing arrival time of relief items to affected areas and efficiently allocating resources aftermath of a disaster. In this study, an MIP model is proposed to pre-position warehouses and determine amount of relief items to be stored. Time between strike of a disaster and arrival of relief to an affected area is minimized. Using probabilistic constraints, the model provides that relief arrives at the affected area in a certain time with a certain reliability. Considering instable fault line on which Istanbul is located, the model is applied to Istanbul region.

3 - A resolution method for a disaster response scheduling problem based on an evolutionary game-theoretic model
Ignacio Vargas, Industrial Engineering, Universidad Diego Portales, Ejercito 441, 8370191, Santiago, Region Metropolitana, Chile, ignacio.vargaso@udp.cl, *Oscar C. Vasquez*, *Luis Osorio-Valenzuela*

We present a particular DRSP motivated by 2010 Chile miners rescue, where response rapidness was pivotal. The problem is defined as an extension of the machine minimization for scheduling jobs with interval constraints, adding a limited machine workload capacity. A resolution method based on a non-cooperative evolutionary game is proposed. The method guarantees a feasible solution of the problem and computational experiments carried out show that its solution is within 5% difference from the optimal solution, but it takes only 5% of the time required to solve the problem to optimality.

4 - An Analysis of Lateral Transshipment Opportunities for Humanitarian Relief Facility Location in Istanbul
Alp Ertem, Industrial Engineering, Cankaya University, Eskisehir Yolu 29.km, L-319, 06810, Yenimahalle, ANKARA, Turkey, alpertem@gmail.com, *Serhat Baskaya*, *Serhan Duran*

Lateral transshipment happens when relief centers transfer items among themselves when they cannot satisfy the need of beneficiaries from their own inventory. We develop a mathematical model deciding the locations of relief centers, amount of relief items in inventory and the amount of lateral transshipment. The model was tested for a possible earthquake in Istanbul. We observe that the lateral transshipment percentage among all relief items sent to demand locations increases as capacity decreases and number of relief facilities opened increases.

■ MC-72

Monday, 12:30-14:00
R16-2

Methodology of societal complexity and sustainable development

Stream: Methodology of Social Complexity
Invited session

Chair: *Eizo Kinoshita*, Urban Science Department, Meijo University, 4-3-3 Nijigaoka, 509-0261, Kani, Gifu, Japan, kinoshit@urban.meijo-u.ac.jp
Chair: *Cathal Brugha*, Management Information Systems, University College Dublin, Quinn School of Business, Belfield, 4, Dublin 4, Ireland, Cathal.Brugha@ucd.ie

1 - An Interpretive Systems Methodology for Structuring the Strategic Problems
Slavica P. Petrovic, Faculty of Economics, University of Kragujevac, D. Pucara 3, 34 000, Kragujevac, Serbia, pslavica@kg.ac.rs

Interactive Planning (IP), as a theoretical, methodological and applicative approach to addressing the complex and ambiguous management problems in organizations has been developed within the interpretive systems paradigm. This approach is focused on designed a desirable future and finding ways for its achieving. Through the five main phases - formulating the problem situation, ends planning, means planning, resource planning, design of implementation and control, IP endeavours to creatively support a process of managing the strategic problems in organizations.

2 - Contemporary «Natural and Artificial Biodiversity» set of problems and COMPRAM method
Nicolae Bulz, National Defence College, Romania, nbulz@yahoo.com

"SUSTAINABLE SURVIVAL' belongs to Natural-Artificial Biodiversity problems / the COMPRAM method belongs to Professor Dorien DeTombe; e.g. contributions: * The transferable university experience on COMPRAM. ** The affirmation on an equivalence between: «problem»/«solve/solution» alongside the text of «Consolation of Philosophy» - Roman philosopher and mathematician Boetius (480—524/5AD), AND Methodology for Societal Complexity. *** The interdisciplinary inquires related to the understanding/explanation of the constructs: SUSTAINABLE SURVIVAL/ Natural-Artificial Biodiversity.

3 - Energy consumption and related- CO2 emissions in Tunisia over 1990-2008: A decomposition analysis using Logarithmic Mean Divisia Index technique
Sana Essaber- Jouini, Economics, ISCAE University of Manouba; Industrial Management and Economy Laboratory (LEGI), Polytechnic School of Tunisia, 22 Rue Ali Belhouane cité Bel Air, 2097, Boumhal, Tunis, Tunisia, sabeursana@yahoo.com

Energy use in various forms plays a critical role in affecting local environment and global climate change. Reducing energy use alone is not be the best solution; qualitative dimension of energy use is becoming increasingly important for sustainable development. Tunisia set up a long term policy of energy management which was based on four instruments: institutional, lawful, financial and tax. By applying the logarithmic mean Divisia index to a dataset of 4 economic-energy-using sectors and the residential sector in Tunisia, we identify the factors of energy consumption and related emission.

4 - On the Role of Education for Sustainable Development, Societal Technology and Humankind

Marjan Vezjak, Environmental Agency of the Republic of Slovenia, 6000 , Koper, Slovenia, marjan.vezjak@gmail.com

Sustainable development and its advanced method, societal technology or development of the Global Community of Humankind - Sustainable Future of Humankind, are of great importance for the survival of Homo sapiens. Education is the answer to any action towards evolutionary achievements of humanity. Education as the truth about nature knowledge is opening new frontiers for future of humankind on earth. However, we are at Globalization era, but we have internet and far better communication techniques commencing from information era and they are a key for better education.

■ MC-73

Monday, 12:30-14:00
R16-3

Supply chains in Agriculture

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *LluisM Pla*, Mathematics, University of Lleida, JaumeII,73, 25001, Lleida, Spain, lmpla@matematica.udl.es

1 - Planning the harvest of a sugar cane milling company by a Revised Multi-Choice Goal Programming model

Fernando Marins, Production, UNESP - São Paulo State University, Av. Ariberto Pereira da Cunha, 333, 12516-410, Guaratinguetá, SP, Brazil, fmarins@feg.unesp.br, *Aneirson Silva*, *José Arnaldo B. Montevechi*

We proposed a Revised Multi-Choice GP model to treat the uncertainty in planning the harvest of a sugar cane milling company. The focus is the agricultural stage, on a weekly planning horizon, and includes the process of managing the condition and choices of cane pruning time, the sizing of the front cutting agricultural and logistics. The objective is to cut cane in the period closest to maximum sucrose content and minimize agribusiness costs. The application of the proposed model in a Brazilian sugar cane milling company produced results that were validated by experts of the company.

2 - Modeling procurement through retailer's fresh food supply chain under product quality and variety constraints

Ming-Chih Tsai, Dept. of Marketing, National Chung Hsing University, 250, Guo-Guang, Road, 402, Taichung, Taiwan, mctsai@nchu.edu.tw, *Tsung-Sheng Chang*

Both product quality and variety may affect retailer profit. A higher quality standard may increase product quality but reduce product variety. Conversely, a wider variety standard may compromise with a lower quality product. Standard sets become an issue in procurement. Thus, this study aims to develop a decision model optimizing retailer procurement for profit under various standards set. Procurement of 15 fresh food categories, each of which is associated with three types of supply chain relationship are sought using parametric analysis on the non-linear optimization model developed.

3 - Optimization of the Wine Supply Chain – A Review

Luigi Moccia, Istituto di Calcolo e Reti ad Alte Prestazioni - ICAR-CNR, Consiglio Nazionale delle Ricerche, Via P. Bucci 41C, 87036, Rende, Cosenza, Italy, moccia@icar.cnr.it

The paper reviews optimization models and algorithms for operational, and tactical planning in the wine supply chain. Both production (grape harvesting and winery processes) and post-production issues are considered. A special focus is given on environmental impacts of the wine supply chain, and we highlight the contribution of MS/OR methods on this topic. The paper aims at raising awareness amongst actors of the wine supply chain, operational researchers and management scientists of the benefits of using systemic approaches developed in MS/OR.

4 - Optimal production planning by a linear stochastic model for the pig industry

Esteve Nadal, Universitat de Lleida, Spain, enr1@alumnes.udl.cat, *Victor M. Albornoz*, *LluisM Pla*

The profile of the typical farm is changing from a family-based, small-scale to one in which larger firms are more tightly aligned along the pig production and distribution processes integrating and coordinating their operations into pig supply chain structures. This work do a collaborative research with a Spanish company owning more than ten sow farms and around a hundred and fifty rearing-fattening farms, to provide an optimization stochastic model able to find the best solution among all the alternatives to manage the production process and the transportation between the types of farms.

■ MC-74

Monday, 12:30-14:00
R16-4

Teaching OR/MS II

Stream: Teaching OR/MS
Invited session

Chair: *Helena Ramalhinho*, UPF- Barcelona GSE, R. Trias Fargas 25-27, 08005, Barcelona, Spain, helena.ramalhinho@upf.edu

1 - Experience in teaching Soft OR Methods

Mischel Carmen N. Belderrain, Mechanical Engineering, Instituto Tecnologico de Aeronautica, Rua Narcisa Vinhas Ferreira 52, 12244-670, Sao Jose dos Campos, SP, Brazil, carmen@ita.br, *Paloma Santos*

This paper deals with the experience in teaching Soft OR Methods for graduate and undergraduate students. Graduate students quickly realize the potential gains of Soft OR Methods when applied to their day-to-day jobs. On the other hand, teaching Soft OR methods to undergraduate students is somewhat more difficult, since their reasoning is more focused on solving problems with "hard" tools, rather than addressing problems in a systemic way. Specifically, this paper describes the application of SSM to the problem of doubling the number of enrolled students in a School of Engineering.

2 - Teaching Spreadsheet Analytics with Excel VBA

Mehmet Begen, Ivey School of Business, Western University, 1151 Richmond St. N., N6A3K7, London, ON, Canada, mbegen@ivey.uwo.ca

We will present an undergraduate elective course, namely spreadsheet analytics with Excel VBA (a.k.a End User Modelling), taught at the Ivey School of Business. The course teaches analytical modelling, Visual Basic for Applications and advanced Excel features such as pivot tables. We will discuss course objectives, topics covered, evaluation methods, learning materials, projects, class delivery methods and student feedback. We will also share our experiences in teaching the course for the last few years.

3 - Learning and Teaching Experience

Valerie Belton, Dept. Management Science, University of Strathclyde, 40 George Street, G1 1QE, Glasgow, United Kingdom, val.belton@strath.ac.uk, *Kerem Akartunali*

One of the challenges in OR/MS is to go beyond the teaching of methods, to enable students to develop the broader understanding and personal competences needed to use the methods in practice, provide them with opportunities to learn from the experience of trying to do so in different contexts and to be able to assess their performance in doing so in a fair and constructive manner. In this paper we will discuss staff and student experiences of a new capstone class, introduced to the final year of the undergraduate programme.

4 - Teaching VRP in Business Schools
Helena Ramalhinho, UPF- Barcelona GSE, R. Trias Fargas 25-27, 08005, Barcelona, Spain, helena.ramalhinho@upf.edu, *Alex Grasas*

The purpose of this work is to describe the teaching of Vehicle Routing Problems in business schools. We have developed an internet-based OR system to provide in depth experimental learning of the decisions related with the routing issues. The students have to solve a real simple routing problem before any OR is introduced. After facing the difficulty of solving it, the VRP is explained and they use the system to solve again the problem. We have implemented this in several business classes, from undergraduate to MBA, and the motivation to learn OR become very high.

Monday, 14:30-16:00

■ MD-02

Monday, 14:30-16:00
O1-2

Optimal Stopping and Markov Decision Processes 2

Stream: Discrete Optimal Control
Invited session

Chair: *Masayuki Horiguchi*, Department of Mathematics and Physics, Faculty of Science, Kanagawa University, 2946 Tsuchiya,, 259-1293, Hiratsuka, Kanagawa, Japan, horiguchi@kanagawa-u.ac.jp

1 - Bayesian Inference in Markov Decision Processes
Masayuki Horiguchi, Department of Mathematics and Physics, Faculty of Science, Kanagawa University, 2946 Tsuchiya,, 259-1293, Hiratsuka, Kanagawa, Japan, horiguchi@kanagawa-u.ac.jp

We consider statistical inference using intervals of measures in Markov decision processes (MDPs) with unknown transition matrices. Intervals of transition matrices are obtained from the observations of states completely and estimation by interval Bayesian method. We introduce an interval estimated MDPs, by which we have an interval representation of value function. Moreover, we treat Bayesian interval method to decision rules and risk in an optimal sampling problem. As numerical examples, we show constructing method of intervals of probabilities and values.

2 - Optimal Control of Multiple-Facility Queueing Systems
Rob Shone, Mathematics, Cardiff University, United Kingdom, shonerw@cardiff.ac.uk, *Vincent Knight*, *Janet Williams*, *Paul Harper*

In this talk we consider queueing systems which are subject to control (e.g. admission control, routing control) by an external decision-maker. These systems can be modelled using Markov Decision Processes (MDPs), and our aim is to determine an optimal "policy" which specifies the most advantageous decisions to be taken. We discuss how the techniques of stochastic dynamic programming can be used to compute optimal policies, and how the "adaptive" methods of reinforcement learning can be used to find near-optimal solutions when the dimensionality of the problem becomes too large.

3 - On Evaluation and Exercise Strategy of the Swing Option.
Katakai Takafumi, Mathematical Sciences, Shibaura Institute of Technology, 307 Fukasaku, Minuma-ku, 337-8570, Saitama-shi, Saitama-ken, Japan, v09017@shibaura-it.ac.jp, *Katsunori Ano*

This paper studies a kind of optimal multiple stopping problem, known as the Swing option which is the contract with multiple exercise chances, mainly used in the energy market. We evaluate the lower bounds of the price of the option by using Doob decomposition for its corresponding system of dynamic programming equations. As an example, we present an numerical calculation for the price and the optimal exercise strategy, which is characterized by the multiple exercise (stopping) boundaries.

■ MD-03

Monday, 14:30-16:00
O1-3

Games and revenue in queues

Stream: Service Management
Invited session

Chair: *Moshe Haviv*, Department of Statistics, Hebrew University of Jerusalem, Mount Scopus Campus, Har Hatsofim, 91905, Jerusalem, Israel, haviv@mscc.huji.ac.il

Chair: *Achal Bassamboo*, Northwestern University, 60208, Evanston, Illinois, United States, a-bassamboo@kellogg.northwestern.edu

1 - Cooperation in service and homogeneous of degree one games
Moshe Haviv, Department of Statistics, Hebrew University of Jerusalem, Mount Scopus Campus, Har Hatsofim, 91905, Jerusalem, Israel, haviv@mscc.huji.ac.il, *Shoshana Anily*

Servers or customers may cooperate in order to improve their total performance. The next question is how to allocate the cooperation gains among the servers. We formulate such problems as cooperative games with side payments. Through a set of examples, some of which deal with discrete optimization, we show that in many cases these games are subadditive and homogeneous of degree one. Hence, they are totally balanced and cooperation is stable.

2 - Pricing Time-Sensitive Services Based on Realized Performance
Yoav Kerner, Industrial Engineering and Management, Ben Gurion University of the Negev, Israel, kerneryo@bgu.ac.il, *Philipp Afeche*, *Opher Baron*

Services like FedEx charge up-front fees but reimburse customers for delays. However, lead time pricing studies ignore such delay refunds. Our paper contributes to filling this gap. We model such pricing policies under revenue maximization perspective. We assume that customers are risk averse with respect to their payoff uncertainty. among other results, we show that 1. If customers are risk neutral than fix prices are optimal. 2. Fix prices are suboptimal when customers are risk averse.

3 - Information cascades in a queueing system with parallel servers
Ricky Roet-Green, Operation research, Tel Aviv University, Tel Aviv, Tel Aviv, Israel, rgricky@gmail.com, *Rafi Hassin*

When a customer makes an appointment at the doctor, calls the plumber or reserves flight tickets, she learns her position in the service provider's queue. If the customer is unsatisfied with her position, she might consider calling an alternative service provider, hoping to get a better position. In our model, customers search among servers sequentially, until they join the less loaded inspected queue. Each inspection is associates with a cost. The solution of this model is not straightforward, and is characterized by cascades.

4 - Using Estimated Patience Levels to Optimally Schedule Customers
Achal Bassamboo, Northwestern University, 60208, Evanston, Illinois, United States, a-bassamboo@kellogg.northwestern.edu, *Ramandeep. Randhawa*

A common model of impatience is to assume that customers arrive with a "patience clock' and that they abandon if this clock runs out before their service starts. Further, the heterogeneity in the customer's patience are represented using a common distribution, the impatience or abandonment distribution. So, as customers wait in queue, an update can be formed on their willingness to wait. The main research question in this paper is: What is the optimal way to schedule customers given that as the customers wait in the queue, they reveal additional information about their willingness to wait?

■ MD-04

Monday, 14:30-16:00
O4-4

Optimization of Closed Loop Supply Chain Networks

Stream: Mathematical Programming
Invited session

Chair: *Turan Paksoy*, Industrial Engineering, Science, Selcuk University Industrial Engineering Department, Campus, 42100, Konya, Turkey, tpaksoy@yahoo.com

1 - An interactive fuzzy programming approach for a decentralized closed-loop supply chain network design problem
Turan Paksoy, Industrial Engineering, Science, Selcuk University Industrial Engineering Department, Campus, 42100, Konya, Turkey, tpaksoy@yahoo.com, *Eren Ozceylan*

In this paper, we deal with a closed-loop supply chain network design problem which is formulated as a decentralized two-level linear programming problem. We apply an interactive fuzzy programming method to derive a satisfactory solution between three different decision makers. The decision maker who is at the upper level is the manufacturer and there are two decision makers at the lower level who are the suppliers and collection centers.

2 - Fuzzy Mathematical Programming Approaches to the Integration of Reverse Supply Chain Optimization and Disassembly Line Balancing Problems
Abdullah Yildizbasi, Industrial Engineering, Engineering and Natural Sciences, Çankırı Mahallesi Çiçek Sokak, No:3 Altındağ, 06030, Ankara, Turkey, abdullahyildizbasi@gmail.com, *Eren Ozceylan*, *Turan Paksoy*

This paper presents a fuzzy programming approach to the integration of reverse supply chain (RSC) optimization and disassembly line balancing problems. The aim of this study is to apply fuzzy modeling to optimize a RSC that involves customers, collection/disassembly centers and plants while balancing the disassembly lines in disassembly centers, simultaneously. Two types of fuzzy mathematical programming models with different aggregation operators are used. Finally, accuracy and applicability of the model is illustrated and a comparison of fuzzy approaches is done via a hypothetical example.

3 - A Simulated Annealing based Approach for Optimizing a Closed Loop Supply Chain Network
Eren Ozceylan, Industrial Engineering, Natural and Applied Sciences, Selcuk University Industrial Engineering Department, Campus, 42031, Konya, Turkey, eozceylan@selcuk.edu.tr, *Turan Paksoy*, *Tolga Bektas*

In this paper, a mixed integer linear programming (MILP) model is proposed for a closed-loop supply chain (CLSC) network. The design task involves the forward and reverse network design that includes the decisions on product returns, refurbishing, recycling and disposal. A heuristic model based on simulated annealing (SA) is applied to solve MILP model. The effectiveness of the SA has been investigated by comparing the results of GAMS on a set of CLSC design problems to show the effectiveness of the proposed heuristic approach in terms of both of obtained solutions and computational time.

4 - Comparisons of Different Fuzzy Multi-Criteria Decision Making Methods on Closed Loop Supply Chain Networks with Disassembly Line Balancing Problem
Nimet Yapici Pehlivan, Statistics, Selcuk University, Selcuk University Science Faculty, Campus Konya/TURKEY, 42075, Konya, Turkey, nimet@selcuk.edu.tr, *Eren Ozceylan*, *Turan Paksoy*

In this study, nonlinear mixed integer programming model that is developed for the integration of CLSC network and DLB problems is presented. A CLSC network is broadly classified into two groups: (1) forward chain part and (2) reverse chain part. The aim of this study is investigating the effects of different fuzzy multi-criteria decision making methods on a integrated CLSC-DLB problem. Different Fuzzy AHP methods are used for determining the weights of the objective function of the proposed problem,. A numerical example is presented and comparison of the results are given.

■ MD-05

Monday, 14:30-16:00
O4-1

Dynamic Programming III

Stream: Dynamic Programming
Invited session

Chair: *Lidija Zadnik Stirn*, Biotechnical Faculty, University of

Ljubljana, Vecna pot 83, 1000, Ljubljana, Slovenia, lidija.zadnik@bf.uni-lj.si

1 - Optimal delivery of two similar products to n ordered customers with product preferences
Epaminondas Kyriakidis, Statistics, Athens University of Economics and Business, Patission 76, 10434, Athens, Greece, ekyriak@aueb.gr

We develop and analyze a mathematical model for a specific routing problem, in which a vehicle starts its route from a depot and delivers two similar but not identical products to n ordered customers. The demand and the product-preference of each customer are stochastic and they are revealed when the vehicle arrives at his/her site. Under a suitable cost structure a stochastic dynamic programming algorithm is developed for the computation of the optimal routing strategy. Analytical results for the structure of the optimal policy are derived.

2 - Geographical aggregation hierarchy investigation of lateral transshipment by ADP
Xinan Yang, Management Science, Lancaster University, Lancaster University Management School, LA1 4YX, Lancaster, United Kingdom, x.yang3@lancaster.ac.uk, *Kevin Glazebrook*

Lateral transshipment has been proven cost-effective in managing stocks in cooperative inventory networks. Proactive transshipment which re-balances stocks to prevent future shortage, can be beneficial but often costly to operate over a geographically large network. We investigate a proactive transshipment policy for non-homogeneous periodic replenishment review systems, and focus on the development of aggregation hierarchy across locations. Approximate Dynamic Programming is used as the major tool to solve the dimensionality.

3 - Approximate Dynamic Programming for Inventory Systems with Concave Ordering Cost
Fan Wang, Sun Yat-sen Business School, Sun Yat-sen University, 135 West Xingang Road, 510275, Guangzhou, China, wangfan5@mail.sysu.edu.cn, *Shaorui Zhou*

We study a concave ordering cost inventory problem for uncertain demands. We transform the problem into one with n dimensions, applying the notion of K-convexity in Rn to this problem. An approximate dynamic programming is proposed with a hybrid of a piecewise linear approximation and a stochastic sub-gradient. The piecewise linear functions are updated using stochastic sub-gradient information and sample information on the objective function itself. To achieve global optimum, a projection step implementing the stochastic sub-gradient method is performed to jump from local optimums.

4 - Aircraft Collision Detection Using Dynamic Programming
M. Radaei, operational research on flight control, United States, se88.sbu@gmail.com, *M. Navabi*

In this paper, an approach for mid-range conflict detection between two aircrafts with intersecting straight line trajectories has been investigated. By modeling wind disturbance as normally distributed random noise, we compute analytic estimates of the conflict probability for any given conflict scenario. We then formulate the conflict detection problem as finite horizon decision problem where the decision is whether to allow the aircraft to continue on their nominal trajectories or advise an evasive maneuver that modifies the speed and relative heading between the two aircrafts.

■ MD-06

Monday, 14:30-16:00
O4-2

Recent Advances in Global Optimization 3

Stream: Global Optimization
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id

Chair: *Alexander Kruger*, School of Science, Information Technology & Engineering, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

1 - Modeling Super-flexibility Sustainable Distribution Centre of a Supply Chain
Ronsen Purba, Mathematics Dept., STMIK Mikroskil Medan/Graduate School of Mathematics, University of Sumatera Utara, Jalan Thamrin No. 140 Medan North Sumatera, Medan, Indonesia, purbaronsen17@yahoo.com

A supply chain is a network that performs the procurement of raw material, the transportation of raw material to intermediate and end products, and the distribution of end products to retailers or customers. Super-flexibility is defined as the capacity to transform by adapting to new realities. So far, superflexibility has not been included in the model of sustainable supply chain. In this paper, we address a new optimization model to decide distribution centres based on super-flexibility and environmental consideration.

2 - Computational Model of dynamic social networks
Maya Silvi Lydia, Computer Science, University of Sumatera Utara, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, lmayasilvi@yahoo.com

Social network effects are of great importance for under-standing human behaviour. Social interactions are often modeled with networks. The characteristic of the interactions is dynamic, changing continuously over time. This paper proposes a computational model in order to analyze the dynamic interactions in the social networks.

3 - Geometric approach for global optimization in control theory
Dmitri Kvasov, DIMES, University of Calabria, DIMES, Via P. Bucci, Cubo 42C, I-87036, Rende (CS), Italy, kvadim@si.deis.unical.it, *Yaroslav Sergeyev*

Many problems in systems design with parametric uncertainty can be formulated as global optimization problems. Parameters of such systems can be unknown or not uniquely defined, while their functional dependencies can be multiextremal and with no analytical representation. In this case, some novel global optimization techniques developed by the authors in the framework of the geometric approach are proposed. Their brief review is given and results of their comparison with some commonly used in engineering practice methods are reported on several examples from control theory.

4 - Do Combinations Purchase Behaviors Cut Down Total Cost of E-commercial Companies
Wei Zhang, School of Management, Xiamen University, Siming Nan Road 422, 361005, Xiamen, Fujian, China, zwmonkey_2004@163.com, *Di Xu*

E-commercial companies have different strategies for less distribution and inventory fees for each unit goods. For example, free shipping is often given to the order over a certain price. The problem is how the company earns more money from the combinations purchase behaviors when these goods are in different warehouses. In this paper, a model is established to maximize the profit of the seller. The objective function consists the gross profit, the distribution fee, inventory cost and packing expenses. The model is tested with simulated sale data.

■ MD-07

Monday, 14:30-16:00
O4-3

Vector and Set-Valued Optimization III

Stream: Vector and Set-Valued Optimization
Invited session

Chair: *Gabriel Ruiz-Garzón*, Estadistica e I.O., University of Cadiz, Campus de Jerez de la Frontera, Avda. de la Universidad s/n, 11405, Jerez de la Frontera, Cádiz, Spain, gabriel.ruiz@uca.es

1 - A Walrasian economic equilibrium problem without coercivity assumption
Carmen Vitanza, University of Messina, 98166, Messina, Italy, vitanzac@unime.it

We consider a Walrasian economic equilibrium model. To this problem we associate a quasi-variational inequality on a not limited convex, where the operator is the excess demand function and the gradient of the utility function. For this problem we provide the existence of equilibrium when utility functions are concave and differentiable. Under these assumptions the operator of QVI, associated with the equilibrium problem, results not coercive. We are able to remove the coercivity assumption that, as it is well known, is a key point for solving variational problems on not limited sets.

2 - Variational inequality and quasiconvexity for an economic equilibrium problem
Maria B. Donato, Mathematics and Computer Science, University of Messina, 98166, Messina, Italy, mbdonato@unime.it

We consider a mathematical model for a competitive equilibrium problem with exchange and consumption. It is well-known that a very classical and natural hypothesis in mathematical economics is the quasiconvexity on utility functions. Our aim is to show the connection between this equilibrium problem and a variational problem in the general setting of quasiconvex functions. Firstly, we assume that utility functions are quasiconvex and C1 and subsequently we relax the differentiability assumption. An existence results is also achieved.

3 - A competitive equilibrium problem in the setting of generalized quasi-variational inequalities
Monica Milasi, Mathematics and Computer Science, Università degli Studi di Messina, 98166, Messina, Italy, mmilasi@unime.it

We consider a competitive economic equilibrium problem integrated with exchange, consumption and production. In order to obtain a wide applicability in the economic framework, we consider upper semicontinuous utility functions, instead of C1, and, consequently we relax the assumption of differentiability. We show how the competitive economic equilibrium problem can be set into a variational problem, whose operators are set-valued maps. From a mathematical point of view, leads us to consider a class of GQVI for which we want to investigate on the existence of solutions.

4 - Fuzzy Variational-like Inequalities and Fuzzy Vectorial Optimization Problems
Gabriel Ruiz-Garzón, Estadistica e I.O., University of Cadiz, Campus de Jerez de la Frontera, Avda. de la Universidad s/n, 11405, Jerez de la Frontera, Cádiz, Spain, gabriel.ruiz@uca.es, *Yurilev Chalco-Cano*, *Antonio Rufián-Lizana*, *Rafaela Osuna-Gómez*

In this work we show the relationship between fuzzy variational-like inequalities and fuzzy vectorial optimization problems. We show that the concepts of invex fuzzy mapping previously given by Wu and Xu are very restrictive. Then, we present more general concepts of invex and incave fuzzy mappings involving strongly generalized differentiable fuzzy mapping.

■ MD-08

Monday, 14:30-16:00
O3-2

Keynote - E. Benavent López

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Michel Gendreau*, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca

1 - Exact methods for Arc Routing Problems
Enrique Benavent, Estadistica e Investigación Operativa, Universitat de València, c/ Dr. Moliner, 50, 46100, Burjassot, Valencia, Spain, Enrique.Benavent@uv.es

Arc Routing Problems consist of determining the optimal traversal of a subset of arcs or edges of a given graph. The field of arc routing started with the celebrated Königsberg bridges problem in the eighteenth century but its development came mainly from 1950 and it was motivated by the variety and importance of the practical situations in which it appears, such as: garbage collection, road or street maintenance, mail delivery, etc. We will focus in this talk on the development of exact methods devised for these problems. Most of the relevant arc routing problems are NP-hard, and this fact has motivated the development of a lot of efficient heuristic and metaheuristic methods that have been successfully applied to large instances of these problems. Nevertheless, although these methods may produce near optimal solutions, they are not able to give any guarantee on the quality of the provided solutions. On the other hand, exact methods may fail in solving to optimality a given instance in a reasonable amount of computing time, but they can be used to compute tight bounds that give this guarantee. We aim to provide an overview of the main tools and procedures that have been devised to allow the exact resolution of arc routing problems, without considering similar procedures that have been applied to similar variants of the same problem. Thus, we do not try to be exhaustive, but to highlight the core of the methods that can be used to solve these problems. We start with the Chinese Postman Problem (CPP), where a least cost route has to be found that traverses all the edges or arcs of an undirected or a directed graph, respectively. These are the only relevant arc routing problems that can be polynomially solved, and the corresponding procedures have often been used to compute tight bounds for harder arc routing problems. The same problem defined on a mixed or on a windy graph is NP-hard and both have been solved by branch-and-bound and branch-and-cut. We will review some of the formulations that have been used to solve these problems and include details on effective cuts and the corresponding separation algorithms. The Rural Postman Problem (RPP) differs from the CPP in that only a subset of arcs/edges has to be traversed. The problem is motivated by the fact that in most arc routing problems not all the arcs require service. This problem is NP-hard regardless of the type of graph where it is defined, in fact the Travelling Salesman Problem can be easily reduced to it. A rich and deep study of the polyhedron associated with the RPP has been carried out along the last twenty years, giving rise to efficient Branch-and-cut methods to solve it. Again, we will give details of the formulations, additional constraints and separation algorithms that have made it possible to solve this problem with a reasonable computing time. Arc routing problems where several routes have to be constructed seem to be much harder. The reference problem here is the Capacitated Arc Routing Problem, where routes have to satisfy a capacity restriction. A great variety of methods have been proposed for this problem in the last years, including transformations into node routing problems, methods based on computing combinatorial bounds, cutting plane and branch-and-cut methods based on different integer formulations, and column generation and branch-and-price methods. Some methods basically provide lower bounds on optimal solutions. They have to be complemented with good (meta)heuristics for computing solutions and upper bounds that in some cases close the optimality gap and so provide a proof of optimality. The other methods presented here are all variants of branch-and-bound. Despite of the efforts and the variety of the proposed methods there is still much room for the development of efficient procedures for this problem.

■ MD-09

Monday, 14:30-16:00
O3-3

Sponsor - IBM 1

Stream: Sponsors
Sponsor session

Chair: *Andrea Lodi*, D.E.I.S., University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, andrea.lodi@unibo.it

1 - Technical Lessons Learned While Selling Optimization To Business Users
Jean Francois Puget, IBM Software Group, 00100, Nice, France, j-f.puget@fr.ibm.com

Mathematical optimization is IT best kept secret. It is quite surprising that a technology that can achieve extraordinary return on investment isn't used more. This talk will review a series of obstacles to pervasive use of optimization by business users. We will also review possible answers and best practices. In turn these may lead to new research directions to make OR tools easier to consume by business users.

Jean-François Puget is an IBM Distinguished Engineer. He currently oversees the use of analytics and optimization within IBM Industry Solutions products. He led the ILOG Optimization development team for over 22 years. He has a PhD in Machine Learning from Université Paris XI Orsay and is an alumni of Ecole Normale Supérieure Paris-Ulm.

■ MD-10

Monday, 14:30-16:00
G5-1

Diffusion and Influence in Social Networks

Stream: Telecommunication, Networks and Social Networks
Invited session
Chair: *Pedro Ferreira*, CMU, United States, pedrof@cmu.edu

1 - A Computational model for Trust-based Collaborative Filtering - An empirical study of hotel recommendations
Qinzhu Wu, School for Technology and Business Studies, Dalarna University, Sweden, Kornstigen 23 E 2:a, 78452, Borlänge, Dalarna, Sweden, wuqinzhu@hotmail.com

The inherent weakness of data on user ratings collected from the web, such as sparsity and cold-start, has limited data analysis capability and prediction accuracy. To alleviate this problem, trust is incorporated in the CF approaches with encouraging results. We propose a computational model for trust-based CF with a method to generate and propagate trust in a social network. We apply it to measure trusts on users' ratings of hotels and show its feasibility by comparing the testing results with traditional CF methods, e.g., Mean Absolute Error. (Coauthors: W. Song, Z. Yu, A. Forsman)

2 - Properties of the Romanian Entrepreneurs Online Social Network
Eliza Olivia Lungu, National Research Institute for Labour and Social Protection, Povernei 6-8, 051715, Bucharest, Romania, eliza.olivia.lungu@gmail.com, *Mihnea Muraru*

We investigate the networking behaviour of the Romanian entrepreneurs and its relationship with their business performance by looking at their virtual professional social network. We construct their online social network by web scraping the public accessible data from LinkedIn on several key words and we identify patterns in the network at different levels of study: node specific statistics, aggregated network statistics, motifs and communities.

3 - Communities detection in large bipartite graphs using Variable Neighborhood Search
Gilles Caporossi, GERAD and HEC Montréal, Montreal, Canada, gilles.caporossi@hec.ca, *Sylvain Perron*, *Louis-Philippe Sirois*, *Johanne Turbide*

Communities detection in complex networks, or social networks, is an important research topic in data mining, according to the increasing number of research papers in that field. Depending on the situation to which they are associated, complex may have a special structure, and lots of them are bipartite. In this talk, we will present some properties of such graphs and a Variable Neighborhood Search (VNS) algorithm designed to take advantage of this special structure to improve its performance will be proposed.

4 - A Logical Approach to Positional Analysis of Fuzzy Social Networks
Churn-Jung Liau, Institute of Information Science, Academia Sinica, Taiwan, liaucj@iis.sinica.edu.tw, *Tuan-Fang Fan*

In social network analysis, regular equivalence is used to capture the similarity between actors based on their linking patterns with other actors. From a logical viewpoint, social positions based on regular equivalence can be syntactically expressed as well-formed formulas in a kind of modal logic. Hence, actors occupying the same social position satisfy the same set of modal formulas. The corresponding notions in fuzzy social networks are regular similarity and generalized regular equivalence. In this paper, we will present logical characterizations of these notions in fuzzy modal logics.

■ MD-11

Monday, 14:30-16:00
G5-3

Telecommunications, Networks and Social Networks 2

Stream: Telecommunications, Networks and Social Networks (contributed)
Contributed session
Chair: *H.a. Eiselt*, University of New Brunswick, P.O. Box 4400, E3B 5A3, Fredericton, NB, Canada, haeiselt@unb.ca

1 - Cross-layer optimization of routing and flows in networks
Andrzej Karbowski, NASK (Research and Academic Computer Network), ul. Wąwozowa 18, 02-796 , Warszawa, Poland, Andrzej.Karbowski@nask.pl

In the standard approach network flow control algorithms attempt to maximize aggregated utility over source rates, assuming that routing is given. It seems, that it will be more profitable, when we treat transport and network layers together and solve an optimization problem with routing and flows as decision variables. Due to the nonconvexity of the capacity constraints when using Lagrangian relaxation method a duality gap causes numerical instability. It is shown, that the rescue may be the application of the augmented Lagrangian method together with Cohen's Auxiliary Problem Principle.

2 - Energy-aware design of telecommunication networks utilizing flexible hardware operation modes
Frank Pfeuffer, Optimization, Zuse Institute Berlin, Germany, pfeuffer@zib.de, *Axel Werner*

Telecommunication networks consume considerable amounts of energy worldwide. As internet traffic is expected to increase, energy consumption will rapidly grow unless energy-aware network design taking the capabilities of future hardware (flexible power/transmission modes) into account is employed. We present mixed integer programming models for energy-aware multi-level network design assuming such hardware, which enables the adaptation of the network to dynamic traffic changes. We compute practical sets of operation modes a network operator can choose from according to the traffic situation.

3 - Detection of command structures in temporal graphs
H.a. Eiselt, University of New Brunswick, P.O. Box 4400, E3B 5A3, Fredericton, NB, Canada, haeiselt@unb.ca, *Joy Bhadury*

This paper presents a new approach to automatically detect potential terrorist cells and their members. The suggested technique uses layered temporal networks, which capture common past experiences of members as well as present communications. The procedure detects communication chains, comparing them to prior observations to establish the existence of potential terrorist cells as well as the status of their members in the communication chain. The presentation describes a 5-step procedure and uses an example to illustrate the main ideas.

4 - Approximate Methods for Solving Network Intervention Problems
Abhijit Deshmukh, School of Industrial Engineering, Purdue University, 241 Grissom Hall, 47907, West Lafayette, IN, United States, abhi@purdue.edu, *Brandon Pope*, *Eugene Perevalov*

Networks influence the spread of information, disease, and behaviors in many systems and populations. These influences can be incorporated into optimization models, for example, to determine optimal policies for deploying an intervention throughout the network. However, for realistic-sized networks, the size of the problem quickly exceeds the capabilities of existing solution approaches. In this presentation, we formulate a network intervention problem, and explore the ability of approximation algorithms to solve the intervention problem.

■ MD-12

Monday, 14:30-16:00
G5-4

Stochastic Routing and Inventory Routing

Stream: Transportation and Logistics
Invited session

Chair: *Luca Bertazzi*, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, bertazzi@eco.unibs.it

1 - A Generalized Rollout Policy Framework for Stochastic Dynamic Programming with Application to Dynamic Vehicle Routing

Justin Goodson, Operations and IT Management, Saint Louis University, 63108, St. Louis, MO, United States, goodson@slu.edu, *Barrett Thomas*, *Jeffrey Ohlmann*, *Jeffrey Ohlmann*

We present a generalized rollout policy framework for obtaining heuristic solutions to stochastic dynamic programs (SDPs). Our framework unifies look-ahead solution approaches spanning rollout algorithms, rolling horizon methods, and related literature. Motivated by computational considerations, we formalize rollout variants that exploit the pre- and post-decision state variables. Our analytical results provide a common platform for bounding the performance of a variety of heuristic solution methodologies for SDPs. We discuss applications to a dynamic routing problem with stochastic demand.

2 - The Stochastic Production Routing Problem

Raf Jans, Department of Logistics and Operations Management, HEC Montreal, H3T 2A7, Montreal, Quebec, Canada, raf.jans@hec.ca, *Yossiri Adulyasak*, *Jean-François Cordeau*

The Production Routing Problem is an extension of the Inventory Routing Problem with production decisions at the plant. We consider a two-stage setting with demand uncertainty. The production setup decisions and customer visit schedules are determined in the first stage, while the production, inventory and delivery quantities are determined in the second stage. The problem is solved using Benders decomposition, and we propose various enhancements. Finally, we analyse the reoptimization capabilities of the Benders approach.

3 - A hybrid approach to tactical decisions: The Trieste Port-Dry-post case

Walter Ukovich, ORTS - DEEI, University of Trieste, via Valerio, 10, 34127, Trieste, Italy, ukovich@units.it, *Maria Pia Fanti*, *Valentina Boschian*, *Giorgio Iacobellis*, *Chrysostomos D. Stylios*, *George Georgoulas*

This work presents an integrated approach for the development of a Decision Support System (DSS) for a case study considering the port of Trieste (Italy) and the dry port of Fernetti. The DSS is based on a discrete event simulation combined with the Harmony search metaheuristic method, enhanced by an Optimal Computing Budget Allocation stage in order to efficiently search the solution space with minimum total execution time. In order to speed up the procedure a Neural Network metamodel is employed to filter out less promising solution. The research is developed within the IAPP project SAIL.

4 - Exact and robust algorithms for the Inventory Routing Problem with Outsourced Transportation

Luca Bertazzi, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, bertazzi@eco.unibs.it, *Adamo Bosco*, *Demetrio Laganà*

The Stochastic Inventory Routing Problem with Outsourced Transportation arises in the Vendor Managed Inventory context. One supplier has to make decisions on when and how much to deliver to a set of retailers. Deliveries are outsourced to a carrier. First, we propose an exact dynamic programming algorithm and a matheuristic algorithm for the stochastic case. Second, we design an exact dynamic programming algorithm and a MILP-based exact dynamic programming algorithm for the robust case. Computational results show the effectiveness of the proposed algorithms.

■ MD-13

Monday, 14:30-16:00
G5-5

Traffic prediction models

Stream: Traffic
Invited session

Chair: *Gaetano Fusco*, DICEA, Università La Sapienza, via Eudossiana 18, 00184, Rome, Italy, gaetano.fusco@uniroma1.it

1 - Development of estimation method for traffic flow in the metropolitan area of Southeast Asia

Yoichi Shimakawa, Computer Science & Technology, Salesian Polytechnic, 4-6-8 Oyamagaoka Machida-shi, 1940215, Machida, Tokyo, Japan, simakawa@salesio-sp.ac.jp

Our purpose is development of a highly-detailed estimation method for traffic flow that is well applied in the metropolitan area of Southeast Asia. Traffic flow is estimated by Origin-Destination matrix assigned to a road network based on Wardrop's first principle. In addition, we propose a mathematical model correcting the matrix by integrating heterogeneous data. The model is applied to Bangkok metropolitan area. In the aria where road infrastructure is poor, flow is estimated by less-accurate data. Our method is expected to improve the accuracy. As a result, we show usefulness of the model.

2 - Traffic state conditions forecast through different Kalman Filter approach

Livia Mannini, Dep. of Civil Engineering, Roma Tre University, Italy, lmannini@uniroma3.it, *Ernesto Cipriani*, *Stefano Gori*

In the present study different Kalman Filter approach, such as the Extended KF and the Ensemble KF, are analyzed in order to forecast the traffic flow conditions along a freeway stretch. The second order traffic models are corrected taking into account both probe vehicles measurements and fixed ones. The results of several simulations, carried out on a test network, show that EnKF implies an accuracy comparable to the one of EKF, while requiring significantly lower computational times.

3 - Dynamic demand estimation: exploring the SPSA AD-PI method

Andrea Gemma, Roma Tre University, Italy, andrea.gemma@gmail.com, *Ernesto Cipriani*, *Marialisa Nigro*

The knowledge of the dynamic Origin-Destination (OD) matrix is fundamental to assess current traffic state and predict traffic conditions. This work presents an in-depth analysis of a bi-level approach for the off-line estimation of the dynamic OD matrix, that adopts one of the most studied assignment-matrix-free solution method: the SPSA. In particular a sensitivity analysis of the SPSA AD-PI parameters is firstly presented. Then the second order SPSA AD-PI is explored and finally new developments of the method, to keep under control traffic phenomena during the estimation, are proposed.

4 - A general framework for short term traffic prediction and incident detection by using different traffic data sources

Gaetano Fusco, DICEA, Università La Sapienza, via Eudossiana 18, 00184, Rome, Italy, gaetano.fusco@uniroma1.it, *Chiara Colombaroni*, *Stefano Lo Sardo*

Forecasting traffic conditions on freeways is important in order to optimize road system performances and apply predictive strategies of traffic control and traveler information. The work presents a general framework for short term traffic forecasting that integrates different methods: a second order macroscopic model, a data driven artificial intelligence algorithm, and an anomaly detection procedure. The general framework has been applied to a 12 km long expressway stretch in Italy by using different data sources: traditional loop detectors and RFID vehicle detection.

■ MD-14

Monday, 14:30-16:00
G5-6

Metaheuristics for Routing Problems

Stream: Metaheuristics
Invited session

Chair: *Feristah Ozcelik*, Department of Industrial Engineering, Eskisehir Osmangazi University, Meselik, 26480, Eskisehir, Turkey, fdurmaz@ogu.edu.tr

1 - Clustering Customers in the VRPTW with multiple service workers

Gerald Senarclens de Grancy, Institute of Production and Operations Management, University of Graz, Universitätsstrasse 15, Bauteil E3, 8010, Graz, Austria, euro@senarclens.eu, *Marc Reimann*

A lack of parking space at customer locations may require distribution planning to cluster customers around available parkings. Deliveries between parkings and customers occur by foot, causing long service times. In conjunction with time windows, these can lead to inefficient routes between clusters. The possibility of assigning additional workers to some vehicles to reduce service times creates the VRP with time windows and multiple service workers. For this problem, we introduce and systematically evaluate combined clustering and routing strategies in order to obtain high quality solutions.

2 - A variant of the vehicle routing problem for the Cash-in-Transit sector

Luca Talarico, University of Antwerp, Prinsstraat 13, 2000, Antwerp, Belgium, luca.talarico@ua.ac.be, *Kenneth Sörensen*, *Johan Springael*

This work proposes a variant of the vehicle routing problem where a particular kind of risk constraint is introduced to model the problem of routing vehicles in the cash-in-transit industry. The problem has been named Risk-constrained Cash-in-Transit Vehicle Routing Problem with Time Windows (RCTVRPTW). In the RCTVRPTW the presence of a hard time windows constraint delimits the customer's visit to be within a specified time interval and no waiting times are admitted. Two metaheuristics are developed and tested on a set of artificial instances for which the optimal solutions are known.

3 - Genetic Algorithm For Bi-Objective Urban Transit Routing Problem

Lai-Soon Lee, Department of Mathematics, Universiti Putra Malaysia, Faculty of Science, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia, lslee@science.upm.edu.my, *Joanne Suk Chun Chew*, *Hsin-Vonn Seow*

This study considers solving a bi-objective urban transit routing problem with a genetic algorithm approach. The objectives are to minimize the passengers' and operators' costs where the quality of the route sets is evaluated by a set of parameters. The proposed algorithm employs an adding-node procedure which helps in converting an infeasible solution to a feasible solution. A simple yet effective route crossover operator is proposed by utilizing a set of feasibility criterion to reduce the possibility of producing an infeasible network.

4 - A hybrid algorithm for cell formation problem with alternative routings

Feristah Ozcelik, Department of Industrial Engineering, Eskisehir Osmangazi University, Meselik, 26480, Eskisehir, Turkey, fdurmaz@ogu.edu.tr, *Tugba Saraç*

In this study, cell formation problem with alternative routings is taken into account. The problem is considered in the aspect of the natural constraints of real-life production systems such as cell size, separation and co-location constraints. The objective is to minimise the weighted sum of the voids and the exceptional elements. A hybrid algorithm is proposed to solve this problem. The proposed algorithm hybridises the modified sub-gradient (MSG) algorithm with a genetic algorithm. The experimental results show the advantage of combining the MSG algorithm and the genetic algorithm.

■ MD-15

Monday, 14:30-16:00
G5-2

Metaheuristics for Assignment Problems

Stream: Metaheuristics (contributed)
Contributed session

Chair: *Houssem Eddine Hadji*, Department of Computer Science, Badji Mokhtar University, Badji Mokhtar University, 23000, Sidi Amar, Annaba, Algeria, houssem.hadji@gmail.com

1 - A Hybrid Solution Method For Generalized Quadratic Multiple Knapsack Problem

Tugba Saraç, Department of Industrial Engineering, Eskisehir Osmangazi University, Meselik Kampusu, 26480, Eskisehir, Turkey, tsarac@ogu.edu.tr, *Aydin Sipahioglu*

In this study, the Quadratic Multiple Knapsack Problem (QMKP) with setups is generalized by taking into account the assignment conditions and the knapsack preferences of the items. A hybrid solution approach which combines feasible value based modified subgradient (F-MSG) algorithm and GA is developed for solving this problem. The performance of the proposed solution approach is shown by using the randomly generated test instances.

2 - Solving Integrated Berth Allocation and Crane Assignment Problem Using a Tabu Search Metaheuristic

Zeynep Suvak, Industrial Engineering, Bogazici University, Istanbul, Turkey, zeynep.arslan@boun.edu.tr, *Necati Aras*

Container terminal operators have to utilize their limited resources efficiently in order to cope with the rising demand. Since the operations in the quayside are interrelated, a model which unifies berth allocation problem and specific quay crane assignment problem (BACASP) is provided. A tabu search (TS) algorithm, which incorporates local improvement procedures and a shortest path problem, is proposed to solve BACASP. TS is tested on instances with different arrival frequencies and justified to be an efficient method by comparing the results with optimal solution values.

3 - Combinatorial Optimization of the Multiobjective Frequency Assignment Problem in Broadcasting using a Hybrid Evolutionary Algorithm

Akram Bedoui, LORIA-INRIA, 615, rue du Jardin Botanique, 54600, Villers-lès-Nancy, Nancy, France, akram.bedoui@inria.fr, *Lhassane Idoumghar*, *René Schott*, *Philippe Debreux*, *Thierry Schott*

The Frequency Assignment Problem is an NP-Hard combinatorial optimization problem, defined as follows: find a suitable frequency for each transmitter, so that no harmful interference arises in its coverage area. Based on this definition, we are able to formulate the considered FAP into a multi-objective optimization problem and propose an original hybrid meta-heuristic for solving this problem: Probabilistic Tabu Search is used as a non-destructive mutation operator in the modified version of NSGA-II. Application to real world instances shows improvement of the quality of the Pareto front.

4 - A Hybrid PSO Algorithm for The Frequency Assignment Problem
Houssem Eddine Hadji, Department of Computer Science, Badji Mokhtar University, Badji Mokhtar University, 23000, Sidi Amar, Annaba, Algeria, houssem.hadji@gmail.com, *Malika Babes*

The frequency assignment problem (FAP), where the objective is to find the best possible combination that minimizes the total number of violations in an assignment, is studied in this paper using the Particle Swarm Optimization (PSO) algorithm conjunction with the Tabu Search (TS) in order to improve the performance and the effectiveness of original PSO. The basic idea is to really explore and exploit the search space and to escape from local minimum in order to have more chance to find the global optimum.

■ MD-16

Monday, 14:30-16:00
G5-7

Vehicle Routing Problems I

Stream: Routing Problems
Invited session

Chair: *Aristide Mingozzi*, Department of Mathematics, University of Bologna, C.d.L. Scienze dell'Informazione, Via Sacchi, 3, 47023, Cesena, FC, Italy, mingozzi@csr.unibo.it
Chair: *Roberto Roberti*, DEIS, University of Bologna, Via Sacchi, 3, 47521, Cesena, Italy, roberto.roberti6@unibo.it

1 - Advances on the Exact Approaches for the CVRP
Eduardo Uchoa, Engenharia de Producao, UFF, Rua Passo da Patria, 156, sala 440-D, 24210-240, Niteroi, RJ, Brazil, eduardo.uchoa@gmail.com, *Diego Pecin*, *Artur Pessoa*, *Marcus Poggi*

Recent advances in exactly solving the CVRP have just closed the M-n151-k12 instance. Furthermore, they provide indications that soon larger instances will be solved. This talk addresses the main issues in this leap. One of the successful approaches has been enhancing the classical branch-cut-and-price, using only robust cuts that keep the pricing cheap, with the concept of ng-routes and aggressive strong branching. Other successful strategies are based on strong, but non-robust cuts, and on route enumeration.

2 - A Branch-and-Price Algorithm for the Fixed-Charge Transportation Problem Based on a New Mathematical Formulation
Roberto Roberti, DEIS, University of Bologna, Via Sacchi, 3, 47521, Cesena, Italy, roberto.roberti6@unibo.it, *Enrico Bartolini*, *Aristide Mingozzi*

In the Fixed-Charge Transportation Problem (FCTP), destinations request goods from origins. A flow from an origin to a destination incurs a variable cost plus a fixed cost. The objective is to minimize the total cost. Exact methods for the problem were tested on instances with up to 15 origins and destinations whereas generic LP solver can now solve instances with up to 30 origins and destinations. In this talk, we present a new formulation of the problem, several families of valid inequalities, and an exact branch-and-price able to solve instances with up to 70 origins and destinations.

3 - Towards an Adaptive Memory Programming Approach for the Robust Capacitated Vehicle Routing Problem
Panagiotis Repoussis, Howe School of Technology Management, Stevens Institute of Technology, Castle Point on Hudson, Babbio Center, 07030, Hoboken, New Jersey, United States, prepousi@aueb.gr, *Chrysanthos Gounaris*, *Wolfram Wiesemann*, *Christos Tarantilis*, *Christodoulos Floudas*

An Adaptive Memory Programming framework is proposed for the Robust Capacitated Vehicle Routing Problem under demand uncertainty. The framework incorporates novel methods to identify, select and combine elite solution components, and employs a sophisticated Tabu Search algorithm to conduct search in both the feasible and robust-infeasible solution spaces. Two broad classes of polyhedral uncertainty sets for which robust feasibility can be checked efficiently are considered. Results on benchmark data sets are reported, including new best solutions for a total of 123 instances.

4 - An Exact Solution for the Vehicle Routing Problem with Time Windows and Multiple Shifts
Said Dabia, Den Dolech 2, 5600 MB , Eindhoven, Netherlands, s.dabia@tue.nl, *Stefan Ropke*, *Tom Van Woensel*

We solve the Vehicle Routing Problem with Time Windows and Multiple Shifts by a branch-and-cut-and-price algorithm. The master problem is a set partitioning with an additional constraint for every shift. Each constraint requires the total quantity loaded in a shift to be less than its loading capacity. For every shift, a pricing problem is solved by a labeling algorithm. Shift capacity constraints define knapsack structures, hence we use valid inequalities for the knapsack. In particular, we use cover inequalities.

■ MD-17

Monday, 14:30-16:00
G5-8

Network Models with Environmental Considerations

Stream: Sustainable Transport Planning
Invited session

Chair: *Beatriz Brito Oliveira*, Universidade do Porto, Faculdade de Engenharia, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, Portugal, beatrizbritooliveira@gmail.com

1 - Time Dependent Intermodal Transportation in the Region of Marmara
Giray Resat, Industrial Engineering, Koc University, Turkey, gresat@ku.edu.tr, *Metin Turkay*

This research presents a multi-objective optimization model for combining different transportation modes (such as Road, Rail, and Sea) in the design and operation of an intermodal transportation network in a region. The problem is formulated as a mixed-integer optimization problem that accounts for time and congestion dependent vehicle speeds. We represent the modeling approach, data analysis and outline the important characteristics of the mathematical programming problem for minimization of the transportation cost and time simultaneously for the Marmara Region of Turkey.

2 - Tactical Design of Electric Bus Network Using Optimization Tools
Tomás Robenek, Transp-OR, EPFL, GC B3 435, Station 18, CH-1015, Lausanne, Switzerland, tomas.robenek@epfl.ch, *Bilge Atasoy*, *Michel Bierlaire*

In this study, new revolutionary catenary-free 100% electric urban public mass-transportation system is presented. The system consists of a fleet of electric vehicles (buses equipped with electric batteries) and a wayside charging system. The problem is formulated as a mixed integer linear program. The set of decisions includes location of charging stations, size of the batteries on board, energy used by stations, terminals and depot, etc. The model is tested using real life data from the city of Geneva provided by ABB.

3 - Finding the Greenest Path on Time-Dependent Road Networks
Bülent Çatay, Faculty of Eng. & Natural Sciences, Sabanci University, Tuzla, 34956, Istanbul, Turkey, catay@sabanciuniv.edu, *U.Mahir Yildirim*

The time-dependent shortest path problem is concerned with finding the fastest (minimum time) path on a time-dependent network. However, the fastest path does not necessarily correspond to the path causing the minimum fuel consumption or greenhouse gas (GHG) emission. In this study, we consider the external costs associated with the GHG emission and propose new algorithms to determine the greenest path on a time-dependent road network. Computational tests show that the proposed approaches possess potential savings and sustainability benefits over the existing methods.

4 - A network-flow based model for vehicle allocation in a rent-a-car company
Beatriz Brito Oliveira, Universidade do Porto, Faculdade de Engenharia, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, Portugal, beatrizbritooliveira@gmail.com, *Maria Antónia Carravilla*, *José Fernando Oliveira*

A rent-a-car company, when dealing with special types of vehicles whose number of units is small, is forced to do empty repositioning transfers between rental stations in order to meet reservations requirements concerning available time and location. This problem is approached as a network-flow model in which the vehicles are allocated to reservations. The objective is to maximize the profit whilst reducing the empty vehicle transfers, due to their cost and environmental impact. Using real instances, the quality of this approach is assessed.

■ MD-18

Monday, 14:30-16:00
G5-9

Agent-based Simulation

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Markus Günther*, Department of Business Administration and Economics, Bielefeld University, Universitaetsstr. 25, 33615, Bielefeld, Germany, markus.guenther@uni-bielefeld.de

1 - On the impact of technological progress in innovation diffusion: An agent-based approach
Martin Zsifkovits, Department of Business Administration, University of Vienna, Brünner Straße 72 (BWZ), 1210, Vienna, Vienna, Austria, martin.zsifkovits@univie.ac.at, *Markus Günther*, *Kurt Heidenberger*

Most agent-based models of innovation diffusion neglect technological progress over time. Nevertheless, empirical evidence implies that switching to a new technological standard may take more than only one product generation, especially when complementary goods are needed. Therefore we introduce an agent-based model for the hydrogen mobility market that captures the diffusion process based on technological progress. We consider various crucial market players (e.g., consumers, manufacturers, fuel stations) to tackle the inherent chicken and egg problem and highlight some spatial challenges.

2 - Agent-based simulation of public bicycle sharing systems: How to balance asymmetric travel demands
Florian Waldner, Department of Business Administration, University of Vienna, 1210, Vienna, Austria, florian.waldner@univie.ac.at, *Martin Zsifkovits*, *Kurt Heidenberger*

A problem many operators of bicycle sharing systems face is asymmetric travel demand and, therefore, the need to manually redistribute bikes within the system. Commonly a balance is achieved by using a vehicle that transports bicycles from full to empty stations. Our approach is to create monetary incentives for customers to hand in bikes at less attractive stations. By developing an agent-based simulation model of public bicycle sharing systems, we aim at validating the concept and supporting the design of such an incentive scheme for a self-sustaining system.

3 - Using different human actors to model the diffusion of bioplastic: An Agent-based simulation
Shih-Han Cheng-Kostohris, University of Vienna, 2301, Groß-Enzersdorf, Austria, shih-han.cheng@univie.ac.at, *Kurt Heidenberger*

Most agent-based models in innovation diffusion assume rational agents behaving like homo economicus. Nevertheless, consumers behavior can divert from this assumption in real life. Hence, the presented agent-based model allows for comparison of the three known human actors, modeling the adoption decision of consumers: homo economicus, homo psychologicus and homo sociologicus. Using agent-based simulation for the bioplastic example, decision influencing factors for the three agent types can be displayed with the aim to find out which human actor represents the consumers behavior best.

4 - The influence of norms on the multigeneration diffusion of technological innovations
Markus Günther, Department of Business Administration and Economics, Bielefeld University, Universitaetsstr. 25, 33615, Bielefeld, Germany, markus.guenther@uni-bielefeld.de, *Christian Stummer*

We introduce an agent-based simulation approach that allows for analyzing normative influences on the diffusion of technological innovations in addition to various communication events concerning (novel) product attributes (e.g., word-of-mouth, media coverage). To this end, we resort to a social network that reflects both spatial and social proximity between consumer agents. We particularly account for multiple technology generations each with additional features that still need to be grasped by consumers and investigate the inter-generation transition process.

■ MD-19

Monday, 14:30-16:00
G5-10

Facilities Location

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Kenneth Carling*, Dalarna University, Sweden, kca@du.se

1 - New Formulations and Exact Algorithms for the Capacitated p-Center Problem
Hatice Calik, Department of Industrial Engineering, Bilkent University, Bilkent Universitesi Endustri Muhendisligi Bolumu, 06800, Ankara, Turkey, calik@bilkent.edu.tr, *Bahar Yetis Kara*, *Oya Ekin-Karasan*, *Barbaros Tansel*

The capacitated p-center problem is an NP-Hard facility location problem that requires locating p facilities on a given network and assigning clients with demands to facilities so that the maximum distance between a client and its facility is minimized while the amount of demand that needs to be satisfied by any facility does not exceed its capacity. We propose new mathematical formulations and exact algorithms which utilize our formulations. We are able to solve problems with up to 1817 nodes while the largest problem solved in the literature has 402 nodes.

2 - Solution methods for some competitive locations
Katarzyna Krupińska, Department of Operational Research, Wroclaw University of Economics, ul. Komandorska 118/120, 53-345, Wrocław, Poland, katarzyna.krupinska@ue.wroc.pl

We consider leader-follower type competitive locations with the solution concept known as a medianoid and a centroid, and present solution methods for problems with some specific values of the parameters.

3 - Distance measure and the p-median problem in rural areas
Mengjie Han, School of Technology and Business Studies, Dalarna University, Högskolan Dalarna, 79188, Falun, Sweden, mea@du.se, *Kenneth Carling*, *Johan Håkansson*, *Pascal Rebreyend*

Conventionally, the p-median model presumes that the population patronize the nearest facility and that the distance be measured by the Euclidean distance. However, recently the Euclidean distance was found problematic in rural areas on a small problem. We use a refined network and study systematically P varying (2-100 facilities). We find that the network distance give as good a solution as the travel-time network. The Euclidean distance gives solutions some 2-7 per cent worse and the solutions deteriorate with increasing P. Our conclusions extend to intra-urban location problems.

4 - An empirical test of the gravity p-median model
Kenneth Carling, Dalarna University, Sweden, kca@du.se, *Mengjie Han*, *Johan Håkansson*, *Pascal Rebreyend*

A customer is presumed to gravitate to a facility by the distance to it and the attractiveness of it. However, the presumption is that the customer opts for the nearest facility. This paradox is solved by the recent (untested) gravity p-median model. We implement it empirically for three types of businesses, and compare the solutions with those of the p-median model. We find the gravity p-median model to be of limited use for the problem of locating facilities as it either gives solutions similar to the p-median model, or it gives unstable solutions due to a non-concave objective function.

■ MD-20

Monday, 14:30-16:00
G5-11

Rolling Stock, Speed and Energy

Stream: Optimization in Public Transport
Invited session

Chair: *Anita Schöbel*, Institute for Numerical and Applied Mathematics, Georg-August Universiy Goettingen, Lotzestrasse 16-18, 37083, Göttingen, Germany, schoebel@math.uni-goettingen.de

1 - A Framework for Railway Rolling Stock Rescheduling
Richard Lusby, Department of Management Engineering, Technical University of Denmark, 2800, Kgs Lyngby, Denmark, rmlu@man.dtu.dk, *Jørgen Thorlund Haahr*, *Jesper Larsen*, *David Pisinger*

Rolling stock schedules are made months prior to the date of execution. It is, however, rare that everything goes exactly to plan due to unforeseen disturbances. If the disturbances are small, then they may be absorbed by network buffer times. However, if the problems are more severe, changes must be made to the rolling stock schedule and associated depot plans. Here we propose a branch-and-price algorithm for rescheduling rolling stock units and recovering depot plans under disruption. Preliminary results from DSB S-Train, a suburban railway network operator in Copenhagen, are presented.

2 - Comparing two MILP formulations for driver rostering
Marta Mesquita, ISA / CIO, Technical University of Lisbon, Tapada da Ajuda, 1349-017, Lisboa, Portugal, martaoliv@isa.utl.pt, *Margarida Moz*, *Ana Paias*, *Margarida Pato*

The driver rostering problem in public transit companies consists of assigning the company's drivers to a set of crew duties, ensuring transport demand in a specific area during a pre-defined time horizon. We propose and compare two MILP formulations: an assignment/covering model and a multi-commodity network flow model. To enhance the computing efficiency of the models, a lower bound on the number of drivers is derived and different branching strategies are combined with variable fixing techniques. Computational results with data from two Portuguese public transit companies are reported.

3 - Optimisation models to minimise energy consumption of rail systems
Valerio de Martinis, Department of Civil, Architectural and Environmental Engineering, University of Napoli Federico II, 80125, Naples, Italy, vdemartinis@unina.it, *Mariano Gallo*

In this paper we propose two optimisation models for defining the speed profiles that minimise the energy consumption of trains. These models are constrained optimisation models where the speed profile parameters (acceleration, deceleration, maximum speed, starting and ending times of coasting, etc.) assume the role of decision variables. We consider two cases: (a) without energy recovery; (b) with energy recovery (on board or in line). The two cases lead to different models and different optimal solutions. In the paper the proposed models are solved and applied to a test case.

4 - The expansion of movable space by railways in Tokyo metropolitan area
Takeshi Koshizuka, Information Sciences and Engineering, Nanzan University, 27 Seirei-cho, 489-0863, Seto, Aichi, Japan, koshizuk@nanzan-u.ac.jp

This paper studies the effect of the railways on travel time in Tokyo metropolitan area. At first we get the distance distribution in the area by using a method of numerical calculation on the distance distribution which shows the amount of distance between every two points distributed uniformly in an arbitrary region. Next using the railway network data (total length: 4,498km and 2,321 stations) and 100 sample points uniformly distributed in the area, we obtain the travel time distribution. So we discuss these two distributions and compare the changes of travel time.

■ MD-21

Monday, 14:30-16:00
G6-1

Scheduling and Applications

Stream: Scheduling
Invited session

Chair: *Malgorzata Sterna*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Malgorzata.Sterna@cs.put.poznan.pl

1 - Mind the Gap: A Study of Large Subway Tours
Maciej Drozdowski, Institute of Computing Science, Poznan University of Technology, Poznan Univeristy of Technology, Piotrowo 2, 60-965, Poznan, Poland, Maciej.Drozdowski@cs.put.poznan.pl, *Dawid Kowalski*, *Jan Mizgajski*, *Dariusz Mokwa*, *Grzegorz Pawlak*

What is the minimum tour visiting all lines in a subway network? We study the problem of constructing the shortest tour visiting all lines of a city railway system. A set of algorithms is proposed and evaluated on example big cities of the world, as well as on simulated networks. On the basis of the performance of the algorithms we draw conclusions on the nature of the above combinatorial optimization problem and on the utility of the algorithms.

2 - Scheduling Tasks and Production Line Balancing with Workers Assignment
Grzegorz Pawlak, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, Poland, grzegorz.pawlak@cs.put.poznan.pl, *Alf Kimms*, *Tomasz Kujawa*

We consider the optimization of the production rate of the production and assembly line taking into account three sets of variables: operations (tasks), stations(production cells) and workers' qualifications. The single-model assembly line balancing problem is broaden by the introduction of the number of stations, the given value of the maximum cycle time and the set of workers with given skills, with the objective of minimizing the number of stations. The assignment of tasks and workers is carried out based on the principle that one worker can operate more than one machine at the time.

3 - The Special Case in a Malleable Task Scheduling Problem
Maciej Machowiak, Poznan University of Technology, Poland, maciej.machowiak@cs.put.poznan.pl

The problem of scheduling malleable tasks to minimize the makespan is studied. Tasks are malleable, which means that its processing speed depends on the number of assigned processors, and a set of processors can change over time for each task. The processing speed functions are strictly increasing. We present a solution for continuous problem, where a task could be performed on noninteger number of processors and the speed functions were approximated by concave functions and the same for each task. Then this solution has been transformed into descrete solution for the original problem.

4 - System Supporting RFID Application in Production Environment
Malgorzata Sterna, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Malgorzata.Sterna@cs.put.poznan.pl, *Grzegorz Fenrich*, *Kamil Mankowski*, *Mateusz Chrominski*

We proposed the system supporting the process of designing WiFi infrastructure within production environment for usage RFID technology (Radio Frequency Identification). The system allows optimizing the number and the location of routes (receivers) within e.g. manufacturing halls in order to improve the precision of positioning active RFID tags (senders), which can be placed e.g. on automated guided vehicles. The precision of positioning is estimated based on the results of simulation of RFID signal propagation.

■ MD-22

Monday, 14:30-16:00
G6-2

Scheduling

Stream: Scheduling II
Invited session

Chair: *Dario Pacciarelli*, Dipartimento di Informatica e Automazione, Università Roma Tre, via della vasca navale, 79, 00146, Roma, Italy, pacciarelli@dia.uniroma3.it

1 - Aircraft Maintenance Scheduling via Optimization
Engin Bayturk, Department of Industrial Engineering, Istanbul Kultur University, 34156, Istanbul, Turkey, e.bayturk@iku.edu.tr, *Mehmet Yahya Durak*, *Fadime Uney-Yuksektepe*

Turkish Airlines has been announced as the biggest airline company in Europe in 2012 which contains more than 190 aircrafts within its body. These aircrafts are required to be maintained periodically. In this study, scheduling is applied on aircraft maintenance operations. The objective is to minimize the cost of maintenances and to make continuous working schedule for the employees. We will develop a mathematical model to optimize maintenance planning with different scenarios.

2 - Multi-agent scheduling problems with nondisjoint job sets
Alessandro Agnetis, Ingegneria dell'Informazione, Università di Siena, via Roma 56, 53100, Siena, Italy, agnetis@dii.unisi.it, *Dario Pacciarelli*

Multi-agent scheduling concern situations in which K agents share a set N of jobs to be scheduled on common resources. The objective of each agent only depends on the completion times of a subset of jobs. While the literature on multi-agent scheduling has mainly addressed the case in which these subsets all disjoint (competing scenario), here we investigate the more general scenario in which the job sets are nondisjoint. We analyze the minimization of a linear combination of the agents' objective functions, and compare results for competing and nondisjoint scenarios.

3 - On Maximizing Weighted Number of Pseudo Just-In-Time Jobs
Shao-Chin Sung, Department of Industrial and Systems Engineering, Aoyama Gakuin University, Room 415, Building O, 5-10-1 Fuchinobe, Chuo-Ku, 2525258, Sagamihara, Kanagawa, Japan, son@ise.aoyama.ac.jp, *Yuka Kawamata*

We are concerned with the problem of maximizing the weighted number of pseudo just-in-time jobs. The concept of pesudo just-in-time is a relaxation of just-in-time. In our formulation, each job is associated with a time-window instead of due dates, and lengths of all such time-windows is bounded above by a certain values given in advanced. A job is called pseudo just-in-time if it is completed within its time-window. We show that the problem is solvable in polynomial, and moreover, we propose an pseudo polynomial time algorithm for the problem in parallel machines environment.

4 - Simulation Based Dynamic Scheduling for Dual Resources Constrained Problem Using Genetic Algorithm
özcan Aytaç, Industrial Ing., Dokuz Eylul Unv., 288 SK. No:19 D:1, Karabaglar, IZMIR, Turkey, ozcan.aytac@deu.edu.tr, *Latif Salum*

In this study, we consider dual resources constrained problem with stochastic processing times and stochastic arrival time on the aim of the earliest due date minimization. As a solution mechanism, genetic algorithm operates simultaneously with simulation model by using several different dual resources constrained rules to represent the realistic applications with better solutions.For the performance evaluation of the genetic algorithm, earliest due date is considered as response variable representing effectiveness and efficiency of algorithm.

■ MD-23

Monday, 14:30-16:00
G6-3

Advanced flowshop scheduling

Stream: Realistic Production Scheduling
Invited session

Chair: *Ruben Ruiz*, Departamento de Estadistica e Investigación Operativa Aplicadas y Calidad, Universidad Politecnica de Valencia, Camino de Vera S/N, 46021, Valencia, Spain, rruiz@eio.upv.es

1 - A new branch and bound algorithm for solving bi-objective permutation flowshop problems with time lags
Arnaud Vandaele, Mathematics and Operations Research, University of Mons, rue de Houdain, 9, 7000, Mons, Belgium, arnaud.vandaele@gmail.com, *Daniel Tuyttens*, *Emna Dhouib*, *Jacques Teghem*

We consider a permutation flowshop with time lags constraints. These constraints consist to impose some restrictions on the time elapsed between two successive operations of a same job. At each job is associated a due date. Two criteria are taken into consideration : the number of tardy jobs and the makespan. In this work we develop a new branch and bound algorithm to solve this particular flowshop scheduling problem. We also discuss the use of different bounds for the objectives and their effectiveness. We present some promising results in comparison with other methods.

2 - A new benchmark for the permutation flowshop problem
Eva Vallada, Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Cno. Vera s/n Edificio I-3, 46022, Valencia, Spain, evallada@eio.upv.es, *Ruben Ruiz*, *Jose M. Framinan*

The objective of this work is to generate a new benchmark of "hard' instances for the permutation flowshop scheduling problem with the objective to minimise the makespan. The new benchmark consists of 240 large instances and 240 small instances with up to 800 jobs and 60 machines. An exhaustive experimental procedure is carried out in order to select the "hard" instances, which consists of generating thousands of instances and to select the hardest ones from the point of view of a GAP computed as the difference between an upper bound and a lower bound for each instance.

3 - Mixed no-idle flowshops. New results and algorithms
Ruben Ruiz, Departamento de Estadistica e Investigación Operativa Aplicadas y Calidad, Universidad Politecnica de Valencia, Camino de Vera S/N, 46021, Valencia, Spain, rruiz@eio.upv.es, *Quan-Ke Pan*

In the no-idle flowshops all machines must continuously work without interruption. It is more common in real life to find that only some stages have this no-idle constraint. This is the mixed no-idle flowshop problem. This work is the first to study this setting. In this talk we propose new algorithms in the form of heuristics, metaheuristics as well

as accelerations for the calculation of the makespan value. Our results indicate that the presented methods outperform all other adapted procedures from the literature by a significant margin in detailed computational and statistical experiments.

■ MD-24

Monday, 14:30-16:00
G6-4

Project Management and Scheduling V

Stream: Project Management and Scheduling
Invited session

Chair: *Xiao-qiang Cai*, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Shatin, NT, Hong Kong, xqcai@se.cuhk.edu.hk

1 - Subcontracting games with Uniform processors

George Vairaktarakis, Operations, Case Western Reserve University, 44106, Cleveland, Ohio, United States, gxv5@case.edu

Consider multiple manufacturers each with the option of in-house production or subcontracting part of their work to a single third party (3P). Each mode of production comes at a cost per unit, in addition to time sensitive completion cost. In an effort to minimize his total cost, each manufacturer has to decide how much to subcontract to 3P accounting for the fact that the production speed at 3P is different than the in-house speed. These decisions have to be made within a non-cooperative Nash game led by 3P.

2 - Project Investment Game

Chi Chung Kwan, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Flat 1008, Wing Shui House,, Lek Yuen Estate, Shatin, Hong Kong, Hong Kong, Hong Kong, Hong Kong, cckwan@se.cuhk.edu.hk, *Xiao-qiang Cai*, *Nicholas Hall*

The cooperation between the investors who are interested in a single project is considered. The investors could cooperate in order to increase the chance of getting the project, as well as the profit of the project. This is modeled as a cooperative game. In addition, a model such that the project owner who offers the project to the investors may obtain a profit proportional to the profit of the project is also considered. Result shows the project owner could maximize its profit by controlling the probability of getting the project of the investors.

3 - Stochastic Online Scheduling on Uniform Machines to Minimize Total Weighted Completion Time

Xiang Li, Nankai University, China, xiangli@nankai.edu.cn, *Lianmin Zhang*, *Xiao-qiang Cai*

We study the stochastic online version of the uniform machine scheduling problem to minimize the total weighted completion time. Both the preemptive and nonpreemptive cases are considered. For the preemptive case, we derive an algorithm with competitive ratio 2 for a class of machines. For the nonpreemptive case, we demonstrate that our algorithms can derive performance guarantees that are related to the number of machines and the ratio between the largest speed and the total speeds of machines.

4 - Least Squares Approximation to the Stochastic Project Completion Time

Zhichao Zheng, Singapore Management University, Blk 773, Woodlands Drive 60, #11-210, 730773, Singapore, Singapore, zzc2758@gmail.com, *Karthik Natarajan*, *Chung Piaw Teo*

This paper is motivated by the question to approximate the distribution of the completion time of a project with random activity duration. Linking this problem to the classical Stein's Lemma, we show that the least squares normal approximation of the random project completion time can be computed by solving the persistency problem. Our analysis shows that the criticality index is crucial in estimating the variability in the project completion time, and the new approach significantly outperforms most existing methods numerically.

■ MD-25

Monday, 14:30-16:00
G9-1

Auctions, Sourcing and Supply Chains

Stream: INFORMS MSOM Stream
Invited session

Chair: *Damian Beil*, Technology and Operations, University of Michigan, 701 Tappan St, 48109, Ann Arbor, MI, United States, dbeil@umich.edu
Chair: *Aadhaar Chaturvedi*, Business Administration, Université de Namur, Rempart de la Vierge 8, 5000, Namur, Belgium, aadhaar.chaturvedi@fundp.ac.be

1 - Global Dual Sourcing and Order Smoothing: The Impact of Capacity and Leadtime

Robert Boute, Vlerick Business School and KU Leuven, Belgium, robert.boute@vlerick.com, *Jan Van Mieghem*

We study a dual sourcing policy motivated by the recent trend of offshoring manufacturing, while keeping some local facilities to better respond to changes in market demand. We consider the total landed cost, including sourcing, capacity and inventory costs and provide exact and simple formulae for the strategic base or offshore allocation and the value of dual sourcing. The formulae provide insight on the impact of financial, operational and demand parameters. Two distinguishing features of our model are that it captures the capacities of, and the leadtime difference between, both sources.

2 - Optimal Learning and Development Strategy for Entrepreneurial Product Launch

Onesun Yoo, Management Science and Innovation, University College London, United Kingdom, onesun.yoo@ucl.ac.uk, *Tingliang Huang*

For an early stage entrepreneurial firm with a new product concept, it must make the best use of its limited resources to maximize the probability of a successful product launch. To avoid developing a product nobody wants, practitioners suggest an iterative (lean) approach to development, which recommends that the firm iteratively launches an unfinished product to learn what the consumers want and to alter the final product goal whenever necessary. We formalize this approach via the Bayesian learning framework, and investigate the optimal development strategy.

3 - When to Deploy Test Auctions in Sourcing

Damian Beil, Technology and Operations, University of Michigan, 701 Tappan St, 48109, Ann Arbor, MI, United States, dbeil@umich.edu, *Brendan See*, *Izak Duenyas*

We investigate when a buyer may find it advantageous to run a "test auction" in which she has incumbent suppliers bid on a portion of her desired total demand. The test auction reveals incumbent supplier cost information that helps the buyer determine how many entrants (if any) to qualify prior to awarding the remaining units. We characterize the attractiveness of the test auction procedure relative to the more conventional approach where the buyer auctions off her entire demand in one shot. We allow the buyer to use a credible reserve price and take-it-or-leave-it offer.

4 - White-box optimization from historical data

Yingqian Zhang, Econometrics, Erasmus University Rotterdam, Burg. Oudlaan 50, 3062 PA, Rotterdam, Select U.S. States, Netherlands, yqzhang@ese.eur.nl, *Sicco Verwer*, *Qing Chuan Ye*

One challenge when applying mathematical optimization is to construct a mathematical model describing the properties of a system. We demonstrate how to learn such a model entirely from data using machine learning methods. Specifically, we take the outcome of a decision tree and map it into linear programs that can be used for optimization. We illustrate our approach by an auction optimization problem: ordering the items to sell in sequential auctions to maximize the auctioneer's expected revenue. Our experiments show that the proposed optimization method based on historical data is promising.

■ MD-26

Monday, 14:30-16:00
G9-7

Decomposition approaches to combinatorial optimization

Stream: Combinatorial Optimization I
Invited session

Chair: *François Vanderbeck*, Institut de Mathématiques de Bordeaux, Université Bordeaux1 & INRIA Bordeaux, 351 cours de la Libération, F-33405, Talence- CEDEX, France, fv@math.u-bordeaux1.fr

1 - Decomposition for robust problems with uncertain penalties for capacity constraints violations

Michael Poss, CNRS, UTC, France, michael.poss@hds.utc.fr, *Artur Pessoa*

We study robust optimization problems with random recourse where adjustable variables represent penalties for violating the constraints. We prove that the problems are strongly NP-hard even in the continuous case. We present reformulations based on robust constraints with quadratic dependency on the uncertainties. We tackle the reformulations through a decomposition approach, solving the subproblems by a spatial branch-and-bound algorithm. Our computational experiments prove the effectiveness of our approach, improving over SDP reformulation of ellipsoidal uncertainty.

2 - Stabilization techniques for Column Generation: towards automated schemes.

François Vanderbeck, Institut de Mathématiques de Bordeaux, Université Bordeaux1 & INRIA Bordeaux, 351 cours de la Libération, F-33405, Talence- CEDEX, France, fv@math.u-bordeaux1.fr, *Artur Pessoa*, *Ruslan Sadykov*, *Eduardo Uchoa*

Stabilization procedures are critical feature to accelerate the convergence of column generation algorithms. Standard techniques include penalty functions that drive the dual solution close to the incumbent, or smoothing techniques that can be viewed as interior point cutting plane strategies in the dual. Our paper is a critical review of such methods, developing further convergence proof and proposing extensions. The efficiency of stabilization heavily rely on proper parametrization. To address this key issue, we develop auto-regulating strategies that aim to replace parameter tuning.

3 - Dual aggregation strategy in column generation methods

François Clautiaux, Laboratoire d'Informatique Fondamentale de Lille, Cité Scientifique, 59650, Villeneuve d'Ascq, France, francoisclautiaux@gmail.com, *Daniel Porumbel*

A way to cope with the prohibitively large MIPs that result from extended formulations is to approximate them. This can be done by restricting the MIP to a subset of variable and/or constraints. These models are typically solved by column-and-row generation. Another way of obtaining a tractable model is to apply aggregation to the constraints or to the variables. In this talk, we explain how we extend previous aggregation strategies to more complex structures of dual solutions. We focus on cases where subproblems can be solved by integer linear programming.

4 - The Vehicle Routing Problem with Time Windows, Limited Number of Vehicles and Exact Operation Synchronization (m-VRPTWEOS)

Marcus Poggi, Informatica, PUC-Rio, R. M. S. Vicente 225, 22591-900, Rio de Janeiro, RJ, Brazil, poggi@inf.puc-rio.br, *Fabian Castilla*, *Ruslan Sadykov*, *François Vanderbeck*

This work introduces the m-VRPTWEOS. It arises in real life applications in ports and mines operations. Each customer may demand different types of vehicles to perform a task collaboratively. Vehicles are allowed to wait at the locations but demanded vehicles must start operating at the same time. The objective is to route the available vehicles in a way that maximizes the (weighted) number of served customers and minimizes the total distance traveled. Models and algorithms are presented. They are implemented on top of BaPCod. Tests are run on classes of proposed benchmark instances.

■ MD-27

Monday, 14:30-16:00
G9-8

Boolean Methods in Computer Science

Stream: Boolean and Pseudo-Boolean Optimization
Invited session

Chair: *Tiziano Villa*, Dipartimento d'Informatica, Universita' di Verona, Ca' Vignal, 2, Strada Le Grazie, 15, 37134, Verona, Italy, tiziano.villa@univr.it

1 - Exploiting Flexibility in Circuit Optimization Using Boolean Relations

Tiziano Villa, Dipartimento d'Informatica, Universita' di Verona, Ca' Vignal, 2, Strada Le Grazie, 15, 37134, Verona, Italy, tiziano.villa@univr.it, *Anna Bernasconi*, *Valentina Ciriani*, *Gabriella Trucco*

Boolean relations allow to express flexibility in digital logic. As an example we discuss the complete flexibility of P-circuits, which realize a Boolean function by projecting it onto given subsets by means of a generalized Shannon decomposition. If the complete flexibility of P-circuits is exploited by minimizing an incompletely specified function, there is no guarantee to find the best implementation. Instead, to explore all solutions we must set up the problem as the minimization of a Boolean relation, because there are don't care conditions that cannot be expressed by single cubes.

2 - Evaluation of Boolean Functions with Non-Uniform Costs: Beyond Monotonicity

Ferdinando Cicalese, Universita di Salerno, 84084, Salerno, Italy, cicalese@dia.unisa.it

We study the problem of evaluating Boolean functions in a variant of the decision tree model where the costs of probing variables are non-uniform and competitive analysis is employed as a measure of performance. We provide non-trivial lower and upper bounds for classes of Boolean functions which are not included in the class of monotone Boolean functions. For symmetric functions our bounds are matching and we exactly characterize the best possible competitiveness achievable by a deterministic algorithm. Our upper bound is obtained by a polynomial time algorithm.

3 - Control Software Synthesis from System Level Formal Specifications

Enrico Tronci, Computer Science, Universita di Roma La Sapienza, Via Salaria, 113, 00198, Roma, Italy, tronci@di.uniroma1.it

Given the problem of control software synthesis from system level formal specifications, we model the plant as well as safety and liveness properties as Boolean combinations of linear constraints over real as well as discrete variables. We use a Mixed Integer Linear Programming (MILP) solver (namely, GLPK), to explicitely compute a suitable finite state automaton overapproximating the plant behaviour and use Ordered Binary Decision Diagrams (OBDDs) to compute a controller meeting the given specifications and to generate a C implementation for such a controller.

4 - Classification using small Training Sets based on Boolean Logic and Statistical Analysis

Renato Bruni, Dip. Ingegneria Informatica, Automatica e Gestionale, University of Roma "Sapienza", Via Ariosto 25, 00185, Roma, Italy, renato.bruni@dis.uniroma1.it

We address the problem of producing a fast and accurate binary classification of data records, given an already classified set of records with the same structure and nature of the former ones. We solve it with the approach of Logical Analysis of Data, enriched by statistical information. In particular, we compute the quality of each cut-point on the basis of how it splits the data, by considering not only the training data, but also an estimation of their distribution. We compute pattern weights and a classification threshold by solving an optimization problem to maximize accuracy.

■ MD-28

Monday, 14:30-16:00
G9-2

Geometric Clustering 3

Stream: Geometric Clustering
Invited session

Chair: *Julien Darlay*, e-lab, Bouygues SA, 32 avenue Hoche, 75008, Paris, France, jdarlay@bouygues.com

1 - A formulation for k-partitioning and polyhedral results

Arnaud Knippel, Laboratoire de Math, INSA Rouen, INSA Rouen - LMI, Avenue de l'Universit, 76801, Saint-Etienne du Rouvray, France, arnaud.knippel@insa-rouen.fr, *Zacharie Ales*, *Alexandre Pauchet*

We propose a new formulation for partitioning n vertices of a graph in k clusters, based on edge variables and representative variables. Results are presented on the dimension of the resulting polyhedron. We have characterized all the facet-defining inequalities of the formulation and have studied some other families of valid inequalities, including the so-called two chorded inequalities and the two partition inequalities, for which we know when they define facets or not. This is used in a Branch and Cut framework to solve instances coming from a dialogue analysis problem.

2 - Distribution of Distance Frequencies and Efficiency of Approximate Approach to the p-Median Problem

Jaroslav Janacek, Transportation Networks, University of Zilina, Univerzitna 1, 01026, Zilina, Slovakia, jaroslav.janacek@fri.uniza.sk, *Marek Kvet*

This contribution deals with the approximate approach to large p-median problems based on the radial formulation. This approach pays for shorter computational time by a loss of accuracy. The accuracy can be improved by suitable determination of dividing points which are used for distance approximation. We suggest a new concept of the dividing point deployment based on distance relevance estimation. The relevance of given distance expresses our expectation that it belongs to the optimal solution. Hereby, we study the impact of the relevance on effectiveness of the approximate approach.

3 - Constraint programming for large-scale p-median problems in sparse networks

Štefan Pesko, Mathematical Methods, University of Žilina, Univerzitná 1, 01026, Žilina, Slovakia, stefan.pesko@fri.uniza.sk

Let us have a set of client sites and the subset of sites - possible locations for facilities in sparse network. There are many important problems dealing with opening a set of p facilities and assigning each client to the closest open facility. We propose several new formulations for the p-median, weighted p-median and the capacited p-median problems in sparse networks using constraint programming frameworks. We bring some computational experiments on a set of large-scale benchmark instances.

4 - Partition into dense subgraphs: LocalSolver model and complexity

Julien Darlay, e-lab, Bouygues SA, 32 avenue Hoche, 75008, Paris, France, jdarlay@bouygues.com

The density of a subgraph is defined as the ratio between the number of edges and the number of vertices of this subgraph. We define the density of a vertex partition as the sum of the densities of each subgraph induced by a class of the partition. Main applications of this problem lie in the field of community detection. We show that this problem is NP-hard and we present some computational experiments with LocalSolver.

■ MD-29

Monday, 14:30-16:00
G9-3

Emergency Medical Services

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Rob van der Mei*, Centrum Wiskunde & Informatica, 1098 XG, Amstedam, Netherlands, R.D.van.der.Mei@cwi.nl

1 - Near-optimal Policies for a Nearly Realistic Dynamic Ambulance Management Model

Thije van Barneveld, Stochastics, Center for Mathematics and Computer Science, Science Park 123, 1098 XG, Amsterdam, Netherlands, Netherlands, t.c.van.barneveld@cwi.nl

We study the Dynamic Ambulance Management problem in which one tries to retain the coverage of a region based on the number of available ambulances and possibly their locations. The road network is modeled as a graph with two types of vertices: nodes in which an accident can occur and nodes in which this cannot happen. We develop a Markov Decision Process that can solve this problem exactly, under some assumptions. For large problem instances, we combine the MDP with simulation and learning algorithms (e.g., temporal difference learning) to obtain nearly optimal policies.

2 - Ambulance redeployment policies for complex situations

Caroline Jagtenberg, CWI, Netherlands, jagtenbe@cwi.nl, *Sandjai Bhulai*

We address the problem of dynamic ambulance redeployment in urban regions, where the goal is to minimize the percentage of ambulances arriving later than a certain threshold value. We model the problem as a Markov decision problem, leading to a large state space in order to accurately represent realistic situations. We develop a discrete event simulation model that captures many aspects of the uncertainties that occur in practice. We use techniques from ordinal optimization to gain insight into the difficulty of the problem. We develop heuristics to obtain efficient redeployment policies.

3 - A location Model for Emergency Medical Vehicles with Stochastic Travel Times

Pieter van den Berg, Delft Institue for Applied Mathematics, TU Delft, Netherlands, P.L.vandenBerg@tudelft.nl

In most ambulance location models in the literature the travel times between potential base locations and demand points are considered to be known and fixed. In practice, however, travel times may have a stochastic structure. In this paper we consider a location model for emergency medical vehicle where we assume stochastic travel times. We compare the results with location models with deterministic travel times and see that we can obtain better results.

4 - ETFAR: Evaluation Tool For Ambulance Research

Martin van Buuren, Centrum Wiskunde & Informatica, Netherlands, buuren@cwi.nl

Excellent ambulance care is of paramount importance in today's society. This warrants research on the development of new methods for facility locations and dynamic ambulance planning. However, the evaluation of such methods in a realistic setting in which the complete process of ambulance dispatching is simulated is of equal importance. For this purpose, we have developed a performance evaluation tool ETFAR which can handle, e.g., multiple vehicle types, advanced routing, and even simulates the emergency medical call center.

■ MD-30

Monday, 14:30-16:00
G9-10

Advances in Discrete and Global Optimization I

Stream: Discrete and Global Optimization
Invited session

Chair: *Leonidas Pitsoulis*, Mathematical and Physical Sciences,

Aristotle University of Thessaloniki, 51124, Thessaloniki, Greece, pitsouli@gen.auth.gr
Chair: *José Paixão*, Dept. Statistics and Operations Research, Faculty of Sciences - University of Lisbon, Bloco C6 - Campo Grande, 1749-016, LISBOA, Portugal, jpaixao@fc.ul.pt

1 - A New Formulation for the 0/1 Knapsack Problem
Ebru Mutlu, Mathmatics, Pamukkale University, Pamukkale Üniversitesi, Eğitim Fakültesi, İlk Öğretim Matematik, Kınıklı, 20070, Denizli, Turkey, emutlu@pau.edu.tr, *Özcan Mutlu*

In the single objective 0/1 knapsack problem (KP), the goal is to find the subset of the items that maximize the total profit without exceeding the knapsack capacity. However, if the problem has alternative solutions, then the decision maker should select the solution that has the minimum capacity usage because it provides the same profit with a less capacity usage. We call this solution as the best alternative solution (BAS). In this study, we propose a new formulation for the 0/1 KP that finds the BAS when it has alternative solutions.

2 - Signed Graphs and their Matroids
Leonidas Pitsoulis, Mathematical and Physical Sciences, Aristotle University of Thessaloniki, 51124, Thessaloniki, Greece, pitsouli@gen.auth.gr

A signed graph is an ordinary graph where each edge has been assigned either a positive or negative sign. The importance of signed graphs stems from the fact that their incidence matrices define a class of well solved integer programming problems much in the same way as network matrices of graphs. In this talk we will present results regarding the matroids of signed graphs. Specifically, we will present a decomposition theorem that will be useful towards constructing an algorithm for recognizing whether a matrix is the incidence matrix of a signed graph.

3 - An O(n2) algorithm for computing the cycle mean of an n x n triangular Toeplitz matrix
Peter Szabó, Dept. of Aerodynamics and Simulations, Technical University of Kosice, Rampova 7, 04001, Kosice, Slovakia, peter.szabo@tuke.sk

The work presents an O(n2) algorithm for computing the maximum cycle mean (or eigenvalue) of n x n triangular Toeplitz matrix in max-plus algebra. For a general n x n real matrix there exist standard O(n3) algorithms for computing the cycle mean. In the case of triangular Toeplitz matrix, the result improves algorithms generally used for computing the cycle mean or eigenvalue.

4 - Upper and Lower Bounds for the Maximum Number of Solutions Generated by the Simplex Method
Shinji Mizuno, Industrial Engineering and Management, Tokyo Institute of Technology, 2-12-1 Oh-Okayama, Meguro-ku, 152-8552, Tokyo, Japan, mizuno.s.ab@m.titech.ac.jp, *Tomonari Kitahara*

We present recent results on upper and lower bounds for the maximum number of distinct basic feasible solutions generated by the simplex method for linear programming. One of the upper bounds is polynomial in the number of variables, the number of constraints, and the ratio of the maximum to the minimum positive components in all the basic feasible solutions. We show that upper bounds are small for some special linear programming problems including those on 0-1 polytopes and those with totally unimodular matrices. We also discuss how good are the upper bounds by showing lower bounds.

■ MD-31

Monday, 14:30-16:00
G9-11

Retail Supply Chain Planning I

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Michael Sternbeck*, Supply Chain Management and Operations, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt/Donau, Germany, Michael.Sternbeck@ku-eichstaett.de

1 - Online versus Bricks-and-Mortar Retailing: A Comparison of Price, Assortment, and Delivery Time
Masoud Talebian, University of Newcastle, NSW 2308, Callaghan, NSW, Australia, Masoud.Talebian@newcastle.edu.au, *Erick Li*, *Steven Lu*

We develop a framework for selecting the appropriate channel for a retailer among the online, the traditional, and the mixed strategies. Under the traditional model, the retailer displays and sells the assortment in a physical store, whereas under the online model, the retailer accepts orders online and then delivers the products. The traditional retailer determines breadth, depth, and price, while the online retailer determines breadth, price, and delivery time. We examine how inventory cost, delivery cost, and consumer behaviors affect the distribution strategy and customer service.

2 - Optimal returns management with secondary market
Rita Maria Difrancesco, Production Management Department, WHU - Otto Beisheim School of Management, Burgplatz 2, 56179, Vallendar, Germany, rita.difrancesco@whu.edu, *Arnd Huchzermeier*

Managing returns is very costly as it requires many extra activities. Especially in the last years, due to the significant growth of online business, attention to an appropriate return management has increased substantially. In our paper, we investigate the scenario where returns are allowed to re-enter the loop more than once and we model the economic impact of returns aging and delays (at the customers and through the loop) on the closed-loop supply chain profit. We then validate our model with data from an online retailer and underline the managerial insights deriving from our approach.

3 - Experiments on Newsvendor Contracting
Murat Kaya, Faculty of Engineering and Natural Sciences, Sabanci University, Sabancı Universitesi, MDBF Orhanli Tuzla, 94305, Istanbul, Turkey, mkaya@sabanciuniv.edu, *Ummuhan Akbay*

We conduct experiments on a manufacturer-retailer supply chain, where both firms are represented by human subjects. The goal is to understand the factors that affect the manufacturer's contract parameter decisions and retailer's stock quantity decision in this human-to-human strategic interaction. In particular, we study the effects of inequality aversion, learning and retailer's newsvendor heuristics under wholesale, buyback and revenue sharing contracts.

■ MD-32

Monday, 14:30-16:00
G8-1

Robust models in Supply Chains

Stream: Supply Chain Optimization
Invited session

Chair: *Dolores Romero Morales*, Said Business School, University of Oxford, Park End Street, OX1 1HP, Oxford, United Kingdom, dolores.romero-morales@sbs.ox.ac.uk

1 - A new robustness index for multi-objective optimization problems
Weijun Wang, IRCCYN, Ecole Centrale de Nantes, 17, Rue Rue De Jussieu, 44300, NANTES, FRANCE, Bat.S : 201, ECN , 1, Rue de la Noe BP 92 101, 44321 Nantes,FRANCE, 44300, Nantes, Other/Not Applicable, France, Weijun.Wang@irccyn.ec-nantes.fr, *Stéphane Caro*, *Fouad Bennis*

In the presence of multiple optimal solutions in multi-objective optimization problems, the designer may be interested in the robustness of those solutions to make a decision. In this paper, the robustness of each Pareto optimal solution is treated as a vector defined in the robustness function space. One dimension is a new robustness index which deals with large variations in the design environment parameters. The other dimension is a robustness index which deals with small variations in the design variables and the design environment parameters.

2 - A Stochastic Programming Approach For Multi-Echelon Inventory Control Management
Bülent Çekiç, Business Administration, Hacettepe University, Turkey, bulentc@hacettepe.edu.tr

In this paper, the inventory problems with fixed ordering costs under stochastic and non-stationary demand were adapted to multi-echelon inventory systems and offering flexible stochastic programming approaches to this difficult inventory control problem. In this manner, two mathematical models were developed in order to obtain optimal cost under these assumptions of inventory control approaches. Also these models are compared in terms of cost values to be obtained as a result of these approaches under various demand and cost parameters using hypothetical inventory test problems.

3 - Multi-location inventory problems with lateral transshipments under stochastic demand
Olga Rusyaeva, Kuehne Logistics University, Germany, olga.rusyaeva@the-klu.org, *Joern Meissner*

The use of lateral transshipments is a widely known strategy to pool inventories between stocking locations of the same echelon. Most studies consider transshipments as an emergency tool to quickly response to stock outs. In contrast, we consider proactive transshipments that response to the risk of stock outs. Our model allows for transshipments during an order cycle. We analyze heuristics to find the transshipment policy that maximize overall expected profit. Numerical experiments show a competitive performance of the proposed algorithm against the state-of-the-art methods in the literature.

4 - Polynomial time algorithms for Cardinality Constrained Robust Lot Sizing models
Dolores Romero Morales, Said Business School, University of Oxford, Park End Street, OX1 1HP, Oxford, United Kingdom, dolores.romero-morales@sbs.ox.ac.uk, *Dong Li*

In this talk, we study robust versions of the well-known economic lot-sizing (ELS) model and the capacitated lot-sizing (CLS) model with time-invariant capacities. We use the absolute robust criterion with the so-called cardinality constrained uncertainty sets. For the ELS, we present a polynomial time algorithm when both the production cost function and the demand are uncertain, improving existing running times in the literature. For the CLS, we present a polynomial time algorithm when the production cost function is uncertain, and study the implications of uncertain demand for the CLS.

■ MD-33

Monday, 14:30-16:00
G8-3

Production and supply chain design

Stream: Production and the Link with Supply Chains
Invited session

Chair: *Farouk Yalaoui*, Institut Charles Delaunay, ICD LOSI, University of Technology of Troyes, 12, Rue Marie Curie BP 2060, 10000, Troyes, France, farouk.yalaoui@utt.fr
Chair: *De Souza Mauricio*, Departamento de Engenharia de Produção, Universidade Federal de Minas Gerais, Av. Presidente Antônio Carlos, 6627 , Belo Horizonte, Brazil, mauricio.souza@pq.cnpq.br

1 - Optimized supply chain design in the fast moving consumer goods industry
Marcus Brandenburg, Chair of Supply Chain Management, University of Kassel, Untere Königsstr. 71, D-34117, Kassel, Germany, brandenb@uni-kassel.de

We focus on a realistic case example of supply chain (SC) design for new product introduction (NPI) at a globally operating fast moving consumer goods manufacturer. Due to short product life cycles (PLC), the SC design decisions have to be made before the product is launched in the marketplace and must reflect the whole PLC. Different regional launch plans and pipeline filling requirements that decouple market demands from production capacity increase the problem complexity. A MILP formulation is chosen to optimize the SC design with regards to efficiency, effectiveness and net present value.

2 - An optimisation model for the warehouse design and product assignment and allocation problem
Carla A. S. Geraldes, Department of Industrial Management, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 134, 5301-857, Bragança, Portugal, carlag@ipb.pt, *Sameiro Carvalho*, *Guilherme Pereira*

Warehouse design and planning is a great challenge in the field of Supply Chain Management. In this paper we discuss an optimisation model aiming to support some warehouse management decisions. In particular a mixed-integer programming model (MILP) is presented to determine product assignment and allocation to the functional areas, as well as the size of each area. Our aim is to capture the trade-offs among the different warehouse costs in order to achieve global optimal design satisfying throughput requirements.

3 - Supplier selection under workload constraint and order allocation
Burak Efe, Industrial Engineering, Gazi University, Ankara, Ankara, 06930, Ankara, Turkey, Turkey, efecihangir@gmail.com, *Ömer Faruk Efe*, *Mustafa Kurt*

We study a fuzzy inference in case based reasoning (FICBR) for supplier selection under cost, quality, delivery constraints. We use fuzzy extended AHP method to determine weights of these three constraints. Overall similarity calculation between customer and supplier firms is determined with FICBR. Ten suppliers are considered on supplier selection. We select three suppliers that have the highest overall similarity rate. Order quantities are allocated to these three suppliers using multi objective linear programming under workload constraint. Efficiency of model is analyzed on a test problem.

4 - An approach for the detection of critical disturbances in integrated production and transport systems
Jens Hartmann, BIBA - Bremer Institut für Produktion und Logistik GmbH at the University of Bremen, Hochschulring 20, 28359, Bremen, Bremen, Germany, hmn@biba.uni-bremen.de, *Carlos Ernani Fries*, *Bernd Scholz-Reiter*

Manufacturing processes take place in networks of collaborating partners connected via transport operations. These integrated systems are subject to dynamic influences that might put a given schedule at risk, e.g. machine break-downs, traffic congestions or rush orders. Thus, it is important to detect disturbances at an early stage and to decide whether they are critical or not. This work presents a signal based fuzzy control method that can trigger a rescheduling to mitigate negative effects of critical disturbances. The methods capabilities are shown by means of a simulated test scenario.

■ MD-34

Monday, 14:30-16:00
G8-4

Demand Management: Demand fulfillment 1

Stream: Supply Chain Planning
Invited session

Chair: *Herbert Meyr*, Department of Supply Chain Management, University of Hohenheim, (580 C), 70593, Stuttgart, Germany, H.Meyr@uni-hohenheim.de

1 - Allocation Planning in Make-to-Stock (MTS) Environments with Stochastic Linear Programs (SLP)
Stephanie Eppler, Department of Supply Chain Management, Prof. Dr. Herbert Meyr, University of Hohenheim, 70593, Stuttgart, Germany, s.eppler@uni-hohenheim.de, *Herbert Meyr*

Uncertain demand of heterogeneous customer classes and scarce capacity in MTS environments implies transferring Revenue Management ideas to MTS settings. We present SLP models as an approach for multi-period, multi-class allocation planning models for MTS which account for demand uncertainty. We focus on interactions between the

allocation planning and the subsequent consumption process by anticipating consumption rules already in the allocation planning model. The benefit of the anticipation will be confirmed by results obtained from a simulation of the allocation and consumption processes.

2 - Advanced real-time order promising in MSTS with transport considerations
Herbert Meyr, Department of Supply Chain Management, University of Hohenheim, (580 C), 70593, Stuttgart, Germany, H.Meyr@uni-hohenheim.de, *Jaime Cano Belmán*

Demand Fulfillment (DF) is the planning process to fulfill customer demand. If customers have different priorities, Revenue Management (RM) provides approaches to effectively manage customer heterogeneity. In our work we extend single-site approaches to Networks situations, in which also relevant transport aspects such as transport modes, lead times, or cost, are considered. Deterministic LP Models for Make-and-Ship-to-Stock system are proposed to operate in real-time.

3 - Two-Stage Stochastic Make-and-Ship-to-Stock Framework with Networks and Customer Heterogeneity
Jian Cui, Supply Chain and Network Management, TU Darmstadt, Pfefferstr. 4, 70619, Stuttgart, Baden-Württemberg, Germany, jian.cui@gmail.com, *Herbert Meyr*

Two-stage stochastic programming with recourse (2SSP) is one of the most promising methods to model the dynamic stochastic process due to the evolution of the uncertainties and the decision process over time. A make-and-ship-to-stock (MSTS) demand fulfillment policy by considering networks with transportations and customer heterogeneity is modeled in a disaggregated fashion and extended to 2SSP settings with multi-period demand uncertainties which lead to a two-stage stochastic linear programming model. Consequently, a novel two-stage stochastic MSTS framework is proposed in this contribution.

4 - Service Differentiation with Numerous Customer Classes
Benedikt Schulte, Lehrstuhl für Logistik und Quantitative Methoden in der Betriebswirtschaftslehre, Würzburg University, Germany, benedikt.schulte@stud-mail.uni-wuerzburg.de

We study critical level policies as means to provide differentiated service levels to more than two classes of customers. First, we derive explicit service level expressions for a single-period critical level policy with an arbitrary number of customer classes (with Poisson demand). We then provide an algorithm to compute the required starting inventory and associated critical levels. Based on these results, we develop analytical insights into the system's behavior. Specifically, we study how inventory pooling is affected by an increase in the number of customer classes.

■ MD-36

Monday, 14:30-16:00
G7-1

Preference Learning III

Stream: Preference Learning
Invited session

Chair: *Roman Slowinski*, Institute of Computing Science, Poznan University of Technology, Laboratory of Intelligent Decision Support Systems, Street Piotrowo 2, 60-965, Poznan, Poland, roman.slowinski@cs.put.poznan.pl

1 - Wavelet-based methods for ranking
Eric Sibony, Institut Mines-Telecom, LTCI, Telecom Paristech / CNRS, 37-39 rue Dareau, 75014, Paris, – Select –, France, eric.sibony@telecom-paristech.fr, *Stephan Clémençon*, *Jeremie Jakubowicz*

We use a recently introduced framework for multiresolution analysis on the symmetric group to predict rankings. Viewing preferences as sets of permutations, ranking prediction implies to handle probability distributions on the symmetric group, which usually leads to untractable storage or computations. We define a new smoothing technique based on wavelet decompositions that allows to obtain sparse representations for a large class of probability distributions. We show that in many practical cases, our method performs efficiently in terms of storage and from a computational cost perspective.

2 - Multilabel Classification and Ranking with Partial Feedback
Claudio Gentile, DiSTA, Universita' dell'Insubria, Via Mazzini 5, 21100, Varese, Italy, claudio.gentile@uninsubria.it

In this talk, we report on very recent research activity on multilabel classification and ranking problems with partial preference feedback, where the feedback is not in the form of pairwise (or listwise) preference delivering explicit ranking information to the system. We introduce a simple (generalized) linear model for the data, then we design upper-confidence-based algorithms working within this model, and present an associated regret analysis. Finally, we report on simple comparative experiments with full information counterparts to the above algorithms. (Joint with F. Orabona)

3 - Kernel-Based Learning of Conditional Utility Functions
Tapio Pahikkala, Department of Information Technology, University of Turku, Finland, 20014, Turku, Finland, aatapa@utu.fi

In this work, we consider the problem of learning cardinal utility functions with a condition. The condition being, for example, a query object given at prediction time, the learned utility function assigns to it the cardinal utility values of a set of target objects, also given at prediction time. On one hand, we analyze the universal approximation properties of kernel-based regression algorithms on this task, and on the other hand, we study how the generalization properties of the algorithms can be improved via incorporation of certain invariances inherent to the considered task.

4 - Preference-based Racing Algorithms
Eyke Hüllermeier, Phillipps-Universität Marburg, 35032, Marburg, Germany, eyke@mathematik.uni-marburg.de

We consider the problem of selecting an optimal subset of fixed size from a set of options, based on noisy information about the their quality. Unlike existing sampling methods, we do not assume that options are real-valued random variables and that samples are taken from these variables. Instead, we only assume that options can be compared in terms of pairwise preferences. We propose a general preference-based racing algorithm that we instantiate with three specific ranking procedures and corresponding sampling schemes. Experiments are presented to show the efficiency of our approach.

■ MD-37

Monday, 14:30-16:00
G7-4

Multicriteria Decision Making and Its Applications I

Stream: Multicriteria Decision Making
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Valerie Belton*, Dept. Management Science, University of Strathclyde, 40 George Street, G1 1QE, Glasgow, United Kingdom, val.belton@strath.ac.uk

1 - A New Fuzzy Decision Making Approach for Selection Among Energy Alternatives in Turkey
Melike ErdoĞan, Industrial Engineering Department, Yildiz Tecnical University, Yildiz Tecnical University Industrial Engineering Department Beşiktaş /İstanbul, İstanbul, Turkey, melike@yildiz.edu.tr, *İhsan Kaya*

Countries require energy to sustain both social and economic lives. The demand for energy is increasing as a result of population growth, industrialization and urbanization. In this paper, we investigate the most appropriate energy alternative for Turkey. For this aim, the alternatives that are nuclear, biomass, hard coal and lignite, oil, geothermal, natural gas wind and solar energy are evaluated with regards to technological, environmental, socio-political and economical criteria by using fuzzy TOPSIS method based on type-2 interval.

2 - Visual and interactive approaches for Robustness Analysis in Multicriteria Decision Aid
Athanasios Spyridakos, Mathematics, TEI of Piraeus, P. Ralli and Thivon 250, 12244, Aigaleo, Athens, Greece, tspyr@teipir.gr, *Yannis Siskos*, *Denis Yannacopoulos*, *Nikos Tsotsolas*

The robustness of the estimated preferences model through the multicriteria Disaggregation — Aggregation Approach constitutes a sensitive point for the identification and acceptance of the estimated preference models. This research work presents the software RAVI (Robustness Analysis with Visual and Interactive approaches) accompanying the MIIDAS Systems. RAVI supports the 3d graphs presentations for cases with a low degree of robustness. In addition, the system includes a set of interactive processes through which the exploration and adaptation of the preference model can e achieved.

3 - Academic faculty evaluation models: What approach is appropriate for European universities?
Jan Stoklasa, Dept. of Mathematical Analysis and Applications of Mathematics, Faculty of Science, Palacky University Olomouc, tr. 17. listopadu 1192/12, 771 46, Olomouc, Czech Republic, jan.stoklasa@upol.cz, *Jana Talasova*, *Pavel Holeček*

In this paper we analyze the mathematical basis of several academic faculty evaluation models used in the USA and Australia in context of the HR management at European universities, its goals and restrictions. We propose linguistic fuzzy modeling as an appropriate tool for designing new academic faculty evaluation models suitable for European universities. We discuss the advantages of linguistic fuzzy modeling and the implications of its use for the implementation of new evaluation systems in universities. A case study of one such linguistic fuzzy model for Czech universities is presented.

4 - Climate Change — a challenge for MCDA?
Valerie Belton, Dept. Management Science, University of Strathclyde, 40 George Street, G1 1QE, Glasgow, United Kingdom, val.belton@strath.ac.uk, *Luis Rivera*, *Serban Scrieciu*

Climate change is a major challenge of our time, giving rise to impacts that are global in scope and unprecedented in scale. The UNEP sponsored MCA4climate initiative provides a framework to aid governments in preparing climate change mitigation and adaptation strategies. It incorporates a MCDA model which provides a basis for evaluation and prioritisation of potential policy actions. We discuss the process of model development, the challenges to MCDA posed by this ambitious initiative and progress on a project using the framework to explore the adaptation of the agricultural sector in Peru.

■ MD-39

Monday, 14:30-16:00
G7-3

Analytic Hierarchy Process 3

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Aliye Ayca Supciller*, Industrial Engineering, Pamukkale University, Muhendislik Fakultesi Endustri Muhendisligi Bolumu, Kınıklı, 20070, Denizli, Turkey, asupciller@pau.edu.tr

1 - Calibrated Fuzzy AHP for current bank account selection
Alessio Ishizaka, Portsmouth Business School, University of Portsmouth, Richmond Building, Portland Street, PO1 3DE, Portsmouth, Hampshire, United Kingdom, alessio.ishizaka@port.ac.uk, *Nam Nguyen*

Fuzzy AHP is a hybrid method that combines Fuzzy Set Theory and AHP. It has been developed to take into account uncertainty and imprecision in the evaluations. Fuzzy Set Theory requires the definition of a membership function. At present, there are no indications of how these membership functions can be constructed. In this paper, a way to calibrate the membership functions with comparisons given by the decision-maker on alternatives with known measures is proposed. This new technique is illustrated in a study measuring the most important factors in selecting a student current account.

2 - Ranking Stroke-Related Instruments for a Rehabilitation Context Through an Analytical Hierarchical Process
Fredrik A. Dahl, Health Services Research, Akershus University Hospital, Sykehusveien 27, 1474 Nordb, Lørenskog, Norway, fredrik.dahl@ahus.no, *Mathias Barra*

Our task was to prioritize instruments/questionnaires used for evaluating the health status of stroke patients. This is a complex domain with different sub-goals, and AHP was chosen as the theoretical framework. WHO's ICF model defines the function levels bodily function/structure, activities of daily living and participation. These were sub-goals, which were further refined. The format was a 4-hour workshop with 28 health workers in a neurological rehabilitation clinic. Weighting of sub-goals and scoring of 15 specific instruments was done in groups, reaching a high level of consensus.

3 - The weighted compromise decision in group decision making in a multi-objective or multi-criteria problem via AHP
Mustafa Semiz, Department of Statistics, Selcuk University, KONYA, Turkey, msemiz@selcuk.edu.tr

The AHP procedure are applicable to individual and group decision settings. If the achievement of a consensus of group participants cannot be reached in making judments, then weighted compromise decision of the individuals' judgments can be calculated. Two procedures are investigated for a weighted compromise decision: weighting judge-by-judge for every decisions making each step and for overall decisions. An algorithm was developed for the determination of the best weigted compromise solution in group decision.

4 - Multi-criteria inventory classification with fuzzy Analytic Hierarchy Process (AHP)
Aliye Ayca Supciller, Industrial Engineering, Pamukkale University, Muhendislik Fakultesi Endustri Muhendisligi Bolumu, Kınıklı, 20070, Denizli, Turkey, asupciller@pau.edu.tr, *Esra Avdan*

In companies, large amounts of inventory cause idle capacity and unnecessary stock costs, little or no inventory leads to expensive production and disruptions. ABC analysis is one of the most common methods used for inventory control. This study is focused on multicriteria ABC inventory classification with fuzzy AHP. The criteria are weighted using fuzzy AHP, and then the inventory items are classified according to their priority levels with ABC analysis. The method is implemented in a textile machinery factory and the results are presented.

■ MD-40

Monday, 14:30-16:00
Y12-1

Decision Analysis, Decision Support Systems III

Stream: Decision Analysis, Decision Support Systems, DEA and Performance Measurement (contributed)
Contributed session

Chair: *Pascale Zaraté*, Institut de Recherche en Informatique de Toulouse, Toulouse University, 118 route de NarBonne, 31062, Toulouse, France, zarate@irit.fr

1 - The evaluation of the political redistricting and the robustness of the electoral district for the population movement
Keisuke Hotta, Faculty of Information and Communication, Bunkyo University, 1100 Namegaya, 253-8550, Chigasaki, Kanagawa, Japan, khotta@shonan.bunkyo.ac.jp

In Japan, 300 seats of the House of Representatives are elected by the single-seat constituency system. Each electoral district is made by the apportionment to the 47 prefectures and the redistricting in each prefecture. The gap in the value of individual votes is more than 2. The situation was considered to be against a constitutional purpose by the Supreme Court in 2012. In this research, the effect of the relaxation of some constraints to improve the disparity is evaluated. The robustness of the district according to the population movement is also studied.

2 - A proactive maintenance methodology to minimize expected total number of replacements in thermal power plants
Demet Ozgur-Unluakin, Industrial Engineering Department, Bahcesehir University, Turkey, demet.unluakin@bahcesehir.edu.tr, *Mo'tasem Abushanap*

Thermal power plants are complex dynamic systems with many interrelated aging components and subsystems. We propose a proactive maintenance methodology for thermal power plants to minimize expected total number of replacements in a given horizon such that the reliability of the most critical process in system never falls down below a predetermined threshold level. We use dynamic Bayesian networks to represent the problem and to do inference. Based on the observations simulated in each period, replacement decisions for components are made. Results are compared using various threshold levels.

3 - Automatic Benders' Decomposition
Marcel Hunting, Paragon Decision Technology, Schipholweg 1, 2034 LS, Haarlem, Netherlands, marcel.hunting@aimms.com

Implementing Benders' decomposition for a particular problem is a non-trivial and error-prone task. We present an implementation of Benders' Decomposition, in the AIMMS modeling language, that is easy to use on a broad class of problems. The user only needs to specify which variables belong to the master problem and which to the subproblem. The Benders' Decomposition algorithm is implemented as a white box algorithm.

4 - Discrete Consensus for Distributed Task Assignment
Agostino Marcello Mangini, Department of Electrical and Information Engineering, Polytechnic of Bari, 70125, Bari, Italy, mangini@deemail.poliba.it, *Maria Pia Fanti*, *Giovanni Pedroncelli*, *Walter Ukovich*

The research proposes a novel distributed algorithm for a multi-agent assignment problem, in which a group of agents has to reach a consensus on an optimal distribution of tasks. The problem is formalized as a distributed consensus algorithm, i.e., as a procedure using which the agents can exchange messages and update their assigned tasks. The distributed algorithm aims to minimize the task costs assuming that each agent can perform a subset of the available tasks and can communicate with a subset of agents. Some results prove that the convergence to a task assignment consensus is reached.

■ MD-41

Monday, 14:30-16:00
Y12-5

DEA Applications IX

Stream: DEA and Performance Measurement II
Invited session

Chair: *Andreia Zanella*, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-465, Porto, Portugal, andreia.zanella@fe.up.pt

1 - Assessment of residential building sustainability: a comparison of municipalities' performance
Isabel Horta, Faculdade de Engenharia, Universidade do Porto, R. Dr. Roberto Frias, 4200-465, Porto, Portugal, imhorta@fe.up.pt, *Ana Camanho*, *Teresa Galvão Dias*

This paper assesses residential buildings' sustainability during the operation phase, focusing on resources consumption. The assessment is carried out at a municipality level, enabling decision makers to know the relative position of their municipalities compared to others. The paper also explores the factors associated with better levels of municipality performance. The study uses an enhanced stochastic frontier panel model to evaluate municipalities' performance over time. The analysis is based on data of energy, water and materials consumption in Lisbon municipalities.

2 - DEA as a tool for constructing composite indicators: efficiency assessment of statistical and cartographic activities
José L. Pino, Estadística e Investigación Operativa, Universidad de Sevilla, Avenida Reina Mercedes s/n, 41012, Sevilla, Spain, jlpino@us.es, *Pedro L. Luque Calvo*, *M[a] Teresa Cáceres*

The choice of method to determine weights in the calculation of a composite indicator is a source of controversy. Data Envelopment Analysis is a useful tool when using the approach called "Benefit of the Doubt." The research group Quantitative Methods in Assessment of the University of Seville (Spain) and the Institute of Statistics and Cartography of Andalusia have developed a methodology for evaluating the efficiency of statistical and cartographic activities, based on the DEA framework, used in the planning processes under the European Statistics Code of Practice and the Directive INSPIRE.

3 - Data Envelopment Analysis for Official Development Assistance for Post 2015 UN Development Agenda
Bokyeong Lee, Yonsei university, Korea, Republic Of, move314@hotmail.com, *So Young Sohn*

In 2000, the UN launched the MDGs (Millennium Development Goals) publically declaring its ambition to reduce human suffering by 2015. The purpose of this research is to set a Post-2015 development agenda based on the efficiency of 60 recipient countries of ODA. We employed the super efficiency CCR model of DEA considering mutisectoral funds and 7 MDG targets for the efficiency analysis. Tobit regression was used to identify endogenous economic factors associated with sustainable efficiency for Post-2015 agenda.

4 - Human well-being and environmental quality: an assessment of European cities
Andreia Zanella, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-465, Porto, Portugal, andreia.zanella@fe.up.pt, *Ana Camanho*, *Teresa Galvão Dias*

This study aims to develop a composite indicator (CI) to assess human well-being and environmental quality of European cities. The CI can also be used for benchmarking purposes by suggesting the peers and targets that cities should look in order to improve performance. As the assessment includes undesirable outputs, a Data Envelopment Analysis model specified with a Directional Distance Function (DDF) was used to construct the CI. The DDF has the advantage of preserving the interpretability of data, as no changes to the original measurement scales of the undesirable outputs are required.

■ MD-42

Monday, 14:30-16:00
Y12-3

Judgements in Decision Processes and Resource Allocation

Stream: Decision Processes
Invited session

Chair: *Jeffrey Keisler*, Management Science & Information Systems, University of Massachusetts Boston, 100 Morrissey Blvd, M/5-249, 02125, Boston, MA, United States, jeff.keisler@umb.edu

1 - Hope, Dread, Disappointment, and Elation from Anticipation in Decision Making
Jim Dyer, Management Science and Information Systems, University of Texas at Austin, CBA 5.202, 78712, Austin, Texas, United States, jim.dyer@mccombs.utexas.edu, *Ying He*

We model anticipation and disappointment in decision making by defining hope as anticipating a gain and dread as anticipating a loss. In our model, anticipation for a lottery is a subjectively chosen lottery outcome that influences the decision maker's reference point. The decision maker experiences elation or disappointment when comparing the received outcome with the anticipated one. Our model captures the trade-off between a utility gain from higher anticipation and a utility loss from higher disappointment. It contains some earlier disappointment decision models as its special cases.

2 - Guided Decision Processes
Rakesh Sarin, Anderson Graduate School of Management, UCLA, 110 Westwood Plaza, Box 951481, 90095-1481, Los Angeles, CA, United States, rakesh.sarin@anderson.ucla.edu, *Manel Baucells*

The heuristics and bias research program has convincingly demonstrated that our judgments and choices are prone to systematic errors. Decision analysis requires coherent judgments about beliefs (probabilities) and tastes (utilities), and a rational procedure to combine them so that choices maximize subjective expected utility. A guided decision process is a middle-of-the-road between decision analysis and intuitive judgments in which the emphasis is on improving decisions through simple decision rules.

3 - Preference Models for US Hospital Resource Allocation
Don Kleinmuntz, Strata Decision Technology, 200 E Randolph St 49th Floor, 60601, Chicago, IL, United States, DNK@stratadecision.com

Health care reform in the USA poses unique challenges for US hospitals and health care providers. This presentation will analyze the implications for modeling organizational preference for objectives related to cost, quality of care, and patient outcomes in the context of a decision analytic approach to resource allocation. The approach will be contrasted to approaches used in the UK and elsewhere for cost-effectiveness analysis. The discussion is informed by experience in implementing decision-analytic resource allocation models in hundreds of US hospitals.

4 - Value of flexibility in funding radical innovations
Eeva Vilkkumaa, Department of mathematics and systems analysis, Aalto University, School of science, Systems analysis laboratory, Aalto University, P.O.Box 11100, 00076 Aalt, Espoo, Finland, eeva.vilkkumaa@aalto.fi, *Ahti Salo*

In funding projects over time, funds may be tied to unsuccessful projects which do not yield much value. Thus, the decision maker can benefit from the flexibility to abandon projects before completion. We study the value of this flexibility when the objective is to (i) maximize the expected total value of the project portfolio or to (ii) maximize the share of projects with exceptionally high value. These two objectives are shown to lead to different optimal funding policies, which implies that some radical outlier projects will be missed when seeking to maximize expected portfolio value.

■ MD-43

Monday, 14:30-16:00
Y12-2

Recent Trends and Advances in Economics

Stream: Experimental Economics and Game Theory
Invited session

Chair: *Irina Dolgopolova*, Economics and Administrative Sciences, Middle East Technical University, Odtu Kent, Konuk Evi 1, B Block, 108, Ankara, Turkey, 06420, Ankara, Turkey, irina.dolgopolova@gmail.com
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Miray Hanım Yıldırım*, Institute of Applied Mathematics, Middle East Technical University; Department of Industrial Engineering, Çankaya University; European Commission, Joint Research Centre, Institute for Energy and Transport, Institute of Applied Mathematics Middle East Technical University, 06531, Ankara, Turkey, e160106@metu.edu.tr

1 - Modeling financial market through the percolation theory
Anastasiya Byachkova, Faculty of Economics, Department of information systems and mathematical methods in economics, Perm State University National Research, Bukireva Street 15, corp.12, aud. 206, 614000, Perm, Russian Federation, stasechka28@yandex.ru

Our research uses econophysical approach to modeling financial markets. Considered model is based on percolation theory, which describes phase transition in physical systems. The model result is simulated sample of single period market returns. In the research we calibrate the model, using Russian stock index market data. We estimate model parameters in such way, that model distribution is close to real market distribution in terms of Kolmogorov-Smirnov test.

2 - Eigenbehaviors in Closed Economies
Gabriel Turbay, Pensamiento Sistemico y Teoria de Juegos, Sociedad Colombiana de Economistas, Carrera 20 No 36-41., 90210, Bogotá., Cundinamarca, Colombia, gt.gabrielturbay@gmail.com

The world economy is a closed system. Based on Heinz von Foerster principle that eigenbehaviors emerge in operationally closed systems, using Krilov sequences, the dynamic feedback price formation process is shown to converge to the technology matrix eigenvectors with equilibrium and resilience properties. The closure principle is validated and a general equilibrium constructive proof is obtained. Game theory views are considered to explain fluctuations around the eigenprices relating thus macroeconomic structural price formation with microeconomic supply-demand price determination processes.

3 - Application of recurrent neural networks to the futures prices formation in the case of two traders: producer-consumer
Salima Kendi, Operational Research, University of Bejaia, 06000, Bejaia, Bejaia, Algeria, salima_kendi@yahoo.fr, *Fodil Laib*, *Mohammed Said Radjef*

The study of the futures market mechanism requires the recourse to the tools of the dynamic systems modeling. In the literature, the futures prices formation is based on the assumption that, the history is repeated by examining the passed prices. In this work, we propose an approach of modeling of the futures prices generation phenomena for one producer and one consumer which considers the dynamic character of the process. We have represented the system by a recurrent neural network capable of reacting to the variations of supply and demand in the fixation of futures prices and quantities.

■ MD-45

Monday, 14:30-16:00
Y10-3

Mathematical Models in Macro- and Microeconomics 3

Stream: Mathematical Models in Macro- and Microeconomics
Invited session

Chair: *Alexander Vasin*, Operations Research, Lomonosov Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su

Chair: *Andrey Subochev*, Economics, National Research University Higher School of Economics, ul. Gogolya 13/8 - 58, 142800, Stupino, Moscow region, Russian Federation, asubochev@hse.ru

1 - A theory for the optimal government debt control: explicit formula for the optimal debt ceiling
Abel Cadenillas, Mathematical Sciences, University of Alberta, CAB 632, T6G2G1, Edmonton, Alberta, Canada, abel@ualberta.ca, *Ricardo Huaman*

Motivated by the current debt crisis in the world, we consider a government that wants to find the optimal control of its debt ratio. The debt generates a cost for the country. The government can reduce the debt ratio, but there is a cost associated with this reduction. We obtain a solution for the government debt problem. In particular, we obtain an explicit formula for the optimal debt ceiling.

2 - A polyhedral complementarity approach for searching an equilibrium in linear exchange models
Vadim Shmyrev, Sobolev Institute of Mathematics, pr. Akad. Koptyuga 4, 630090, Novosibirsk, Russian Federation, shmyrev.vadim@mail.ru

An original approach to the equilibrium problem in a linear exchange model and its variations is clarified. The conceptual base of this approach is the scheme of polyhedral complementarity suggested by the author for the linear exchange model with fixed budgets and extended later to the general case of the model. The approach may be treated as a realization of the main idea of the simplex-method. It has no analogs and makes it possible to obtain the finite algorithms for some variations of the exchange model.

3 - Alternative versions of the Global Competitiveness Ranking: a Social Choice approach
Andrey Subochev, Economics, National Research University Higher School of Economics, ul. Gogolya 13/8 - 58, 142800, Stupino, Moscow region, Russian Federation, asubochev@hse.ru, *Fuad Aleskerov*, *Igor Zahlebin*

Annually the World Economic Forum publishes the Global Competitiveness Index, reflecting relative ability of nations to sustain wellbeing of their residents. GCI is determined as a weighted sum of 12 subindices. We criticize this cardinal aggregation technique and propose an ordinal approach based on methods borrowed from Social Choice: we aggregate twelve sub-rankings by simple majority rule into a binary relation and employ a set of methods (Copeland rule, Markov chains etc.) to obtain final rankings. We compare new rankings with the old one through analysis of rank correlations.

4 - The imperfect competition in spatially price models of economic systems
Alexey Kovalenko, faculty of economy and of management, Samara state university, street of academician Pavlov 1, faculty of economy and of management, 443011, Samara, Russia, Russian Federation, alexey.gavrilovich.kovalenko@rambler.ru

The model of the dispersed market is set of networks. Producers, consumers and dealers exchange goods at the balance prices in knots of network. Dealers transport goods between knots. If to describe models of subjects in the form of extreme tasks, it is possible to set any structures of the markets of knots. It allows to describe huge variety of structures of economic systems of spatially price equilibrium. We can solve such tasks.

■ MD-46

Monday, 14:30-16:00
Y10-1

Game Solutions and Structures

Stream: Game Theory, Solutions and Structures
Invited session

Chair: *Encarnación Algaba*, Applied Mathematics II, Seville University, C/Camino de los Descubrimientos s/n, Isla de la Cartuja., 41092, Sevilla, Spain, ealgaba@us.es

1 - On the restricted cores and the bounded core of games on distributive lattices
Michel Grabisch, CES, Universite Paris I - Pantheon-Sorbonne, 106-112 Bd de l'Hopital, 75013, Paris, France, michel.grabisch@univ-paris1.fr, *Peter Sudhölter*

We consider TU-games with restricted cooperation, where the set of feasible coalitions is a distributive lattice. Since the core may be unbounded, one has to select a bounded part of the core. The restricted core is obtained by imposing equality constraints in the core for sets belonging to normal collections. The bounded core proves to be the union of all restricted cores. We prove that a game is convex if and only if all restricted cores corresponding to the minimal nested normal collections are nonempty, and in this case the union of these restricted cores is the bounded core.

2 - The least square values for games with restricted cooperation
Ilya Katsev, St. Petersburg Institute for Economics and Mathematics, Russian Academy of Sciences, Tchaikovsky st. 1, 191187 St. Petersburg, Russia, 195067, Saint-Petersburg, Russian Federation, katsev@yandex.ru

We consider cooperative games with restricted cooperation and a generalization of the Shapley value. Our approach to construct this generalization based on the fact that the Shapley value is the solution of some optimization problem which can be formulated also for games with restricted cooperation. We consider the family of least square values for games with restricted cooperation. We prove several facts about this family and characterize the generalization of the Shapley value with the set-consistency axiom.

3 - The proportional partitional Shapley value
Julian Costa, Faculty of Computer Science, Universidade da Coruña, Campus de Elviña, 15071, A Coruña, Spain, julian.costa@udc.es, *José María Alonso_meijide*, *Francesc Carreras*, *Ignacio García-Jurado*

The Aumann-Drèze value was introduced in 1974 for TU games with a coalition structure under the hypothesis of isolated unions (local efficiency). We propose a new value under this hypothesis which reflects the outside options of the players. The main difference between this value and the Aumann-Drèze value is that the allocations within each union are not given by the Shapley value of the restricted game but proportionally to the Shapley value of the original game. We provide axiomatic characterizations of the new value and examples illustrating its application.

4 - A Characterization of the Shapley value for cooperative games on accessible union stable systems
Encarnación Algaba, Applied Mathematics II, Seville University, C/Camino de los Descubrimientos s/n, Isla de la Cartuja., 41092, Sevilla, Spain, ealgaba@us.es, *Rene van den Brink*, *Chris Dietz*

In order to study organizations that have communication as well as hierarchical features, we introduce a new set system or network structure that generalizes cooperation restrictions in communication networks as well as hierarchies. We discuss the axioms of fairness and component efficiency for the class of accessible union stable systems and provide a subclass where the Shapley value is characterized by component efficiency and fairness.

■ MD-47

Monday, 14:30-16:00
Y10-2

Contemporary Issues in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Fredrik Odegaard*, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond Street North, N6A 3K7, London, Ontario, Canada, fodegaard@ivey.uwo.ca
Chair: *Mihai Banciu*, School of Management, Bucknell University, 119 Taylor Hall, 17837, Lewisburg, PA, United States, mmb018@bucknell.edu

1 - Power Approximations in Network Revenue Management
Christiane Barz, Anderson School of Management, UCLA, 110 Westwood Plaza, Gold Hall, B510, 90024, Los Angeles, CA, United States, christiane.barz@anderson.ucla.edu, *Dan Adelman*, *Canan Uckun*

We consider a new approximation architecture for the network revenue management problem using power functions to express concavity. We address a number of technical challenges in fitting parameters and demonstrate numerical performance compared against other approximations.

2 - On the Effect of Strategic Consumer Behavior: Pricing Evidence from the Airline Industry
Benny Mantin, Dept. of Management Sciences, University of Waterloo, 200 University ave. w., N2L3G1, Waterloo, ON, Canada, bmantin@uwaterloo.ca, *Eran Rubin*

Online decision support systems that provide consumers with information about future distributions of prices can facilitate strategic consumer behavior. We empirically demonstrate the magnitude effects of strategic consumer behavior in the context of the airline industry. We find that the availability of such information is associated with lower transacted airfares.

3 - Optimal Bundling with Dependent Valuations
Mihai Banciu, School of Management, Bucknell University, 119 Taylor Hall, 17837, Lewisburg, PA, United States, mmb018@bucknell.edu, *Fredrik Odegaard*

Bundling together two or more separate products and selling as a whole, is a prevalent industry and revenue management practice, e.g., airlines offering add-on services. In this talk, we introduce a novel approach of pricing bundles which explicitly addresses the relationship between the individual valuations of the components. We contrast our approach with the typical assumption of independent valuations and discuss the revenue implications of ignoring dependence.

4 - Some under-researched practical problems in revenue management
Peter Bell, Western University, Ivey School of Business, N6A 3K7, London, Canada, pbell@ivey.uwo.ca

Research on pricing and revenue management is expanding rapidly but research has not kept up with new pricing and booking schemes appearing in practice. The presentation will examine a number of new practices schemes and suggest some research opportunities.

■ MD-48

Monday, 14:30-16:00
Y11-1

Financial Modelling I

Stream: Simulation Methods in Finance
Invited session

Chair: *Zhan Pang*, Department of Management Science, Lancaster University, Lancaster University Management School, LA1 4YX, Lancaster, United Kingdom, z.pang@lancaster.ac.uk

1 - Optimal Liquidity Execution Planning using Stochastic Programming and Robust Optimization
Helgard Raubenheimer, Centre for BMI, North-West University, Hoffman Street 11, 2520, Potchefstroom, South Africa, Helgard.Raubenheimer@nwu.ac.za, *Fanie (SE) Terblanche*

The Basel framework requires banks not only to manage a dedicated portfolio of quality liquid assets but also to strategize its response to liquidity crisis in advance. We investigate optimization techniques for resource allocation in the liquidity execution process. We propose a stochastic programming model and a robust optimisation model assessing uncertainty and worst cases in terms of "market depth" and liquidity stress. We will discuss the formulation of these models, which minimizes the cost of the liquidity execution, and discuss how they can be used in liquidity execution planning.

2 - The Link between Crude Oil Prices and Selected Stock Markets
André Salles, Industrial Engeneering, Federal University of Rio de Janeiro - UFRJ, Av. Ataulfo de Paiva, 348 ap. 501 - Leblon, 22440033, Rio de Janeiro, Rio de Janeiro, Brazil, as@ufrj.br

Crude oil is directly or indirectly present in every productive activity. Crude oil price fluctuations directly influence the international financial markets. This way the oil market is related to the capital market once it is the stock market that provides resources for investment and financing of production. The aim of this work is to determine the linkage of crude oil price returns and selected stock market index returns. To achieve this objective causality, cointegration and dynamic correlation were studied to gauge the relationship between selected capital markets and the oil market.

3 - Dynamic Financial Hedging Strategies for a Storable Commodity with Demand Uncertainty
Zhan Pang, Department of Management Science, Lancaster University, Lancaster University Management School, LA1 4YX, Lancaster, United Kingdom, z.pang@lancaster.ac.uk, *Panos Kouvelis*, *Qing Ding*

We consider a firm that is managing a storable commodity in the presence of demand uncertainty, a volatile spot market and associated financial derivatives. The objective is to coordinate the replenishment and financial hedging decisions to maximize the mean-variance utility of the terminal wealth over a finite horizon. We characterize the structure of optimal time-consistent policies. Our results shed new light into the interface between corporate risk management and operations management.

4 - A Study on Optimal Strategy of Constant Proportion Portfolio Insurance
Aysegul Iscanoglu Cekic, Statistics, Selcuk University, KONYA, Turkey, iscanoglu@yahoo.com, *Özge Sezgin Alp*, *Ralf Korn*

In this paper, the performance of Constant Proportion Portfolio Insurance (CPPI) strategy over constant proportion strategy (CPP) is examined under the presence of jumps in risky assets. Then, the optimal CPPI strategy is derived by using dynamic programming approach by solving quadratic problem and result is compared with Balder's CPPI strategy. In addition, according to the comparison results the quadratic problem is modified and all results are examined with numerical examples.

■ MD-49

Monday, 14:30-16:00
Y11-2

Risk Analysis and Financial Modelling 2

Stream: Life Insurance, Risk and Ruin Theory, Financial Modelling
Invited session

Chair: *Ezgi Nevruz*, Hacettepe university, Turkey, ezginevruz@hacettepe.edu.tr

1 - Measuring the model risk of contingent claims
Nils Detering, Finance, Frankfurt School of Finance and Management, Sonnemannstraße 9-11, 60314, Frankfurt, Hessen, Germany, n.detering@fs.de, *Natalie Packham*

We devise risk measures for the potential losses arising from holding positions that can be hedged only with model-dependent strategies. Model uncertainty is expressed by a set of models from which we derive the distribution of losses. On this loss distribution, we define value-at-risk and expected shortfall for model risk, and show how these risk measures fit into an existing framework of axioms for model uncertainty. As the risk measures are compatible with risk measures for other risk types, such as market risk, they are suitable for devising appropriate capital charges against model risk.

2 - Allocation of Risk Capital: the Lorenz method
Aleksandrs Smilgins, University of Copenhagen, Denmark, alsm@foi.ku.dk, *Jens Leth Hougaard*

Several allocation methods have been proposed for risk capital allocation problems, where the goal is to share the risk of the grandportfolio between its subportfolios in a fair way. Even though the Lorenz method is a well-known method in game theory, it has not been considered as a candidate. In this paper we seek to allocate the risk by using the Lorenz method. We propose a set of axioms, which the Lorenz method satisfies, while other methods don't. A well-known fact is that the uniqueness of the Lorenz method cannot be guaranteed, and we investigate whether this is a practical problem.

3 - Reactions of real economy on financial market instability. Results from Markov-Switching vector autoregression models
Magdalena Ulrichs, Department of Econometrics, Univeristy of Lodz, Poland, magdau@uni.lodz.pl

There are strong bilateral relations between financial market and real economy. The strength of these relations depends on the development of the financial market. Hence it seems important to verify whether the apparent instability of the financial market may cause increased reactions in the real economy. The conclusions from the estimated Markov-Switching-VAR model confirm that on the Polish financial market structural changes were associated with changes in the reactions of the real economy.

4 - Risk Measurement and Extreme Value Theory: An Application for Emerging Financial Markets
Ezgi Nevruz, Hacettepe university, Turkey, ezginevruz@hacettepe.edu.tr, *Ayse Arik*, *Ugur Karabey*

Financial crises occured in recent years have highlighted the importance of risk measurement. In this study, our aim is to analyze stock indexes of some different volatile emerging markets which includes Turkish IMKB-100. Extreme value theory is preferred to use in the modelling stage. By a simulation study, we calculate traditional risk measures. Furthermore, we suggest linear combination of coherent risk measures and try to determine which one performs better.

■ MD-51

Monday, 14:30-16:00
Y11-4

Decision Theory and Analysis

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *Emanuele Borgonovo*, Decision Sciences and ELEUSI Research Center, Bocconi University, Via Roentgen 1, 20135, Milano, Italy, emanuele.borgonovo@unibocconi.it

1 - On the analysis of an unconventional investment opportunity: the Quina Lottery
Armando Zeferino Milioni, Departamento de Organizacao, Instituto Tecnologico de Aeronautica, CTA ITA IEMB, 12228-900, Sao Jose dos Campos, Sao Paulo, Brazil, milioni@ita.br, *Jaques Castello*

With an average expected return of 31 cents per dollar, lotteries in Brazil are seldom a good investment. In 2011, however, the 5 winners of the first edition of the special drawing of Quina were granted a prize of R$13.5 million each, while one could afford to cover all possible outcomes with R$8.6 million. The same happened in 2012. This paper provides a thorough analysis of a theoretical investment in the special drawing of 2013, including lesser prizes earnings, effects of the own investment in the jackpot, probabilities of sharing the prizes and outcomes covering methods.

2 - Efficiency Analysis of Commercial Banks Using a Nonparametric, Unconditional Approach
Anamaria Aldea, Informatics and Economic Cybernetics, The Bucharest Academy of Economic Studies, 010374, Bucharest, Romania, anamaria_aldea@yahoo.com, *Luiza Badin*, *Carmen Lipara*

The latest crisis, either it started as a financial or as an economic crisis, left a visible mark on banks' financial statements, drawing attention to regulators, clients, investors, employees. In this paper, we consider listed commercial banks from FactSet database, as their reduced activity on financial markets is usually associated with lower risk, contrary to investment banks. We use a preliminary test of the returns to scale using a bootstrap algorithm (Simar and Wilson, 2002) and an unconditional, hyperbolic alpha-quantile estimator of efficiency (Wheelock and Wilson, 2007).

3 - Risk aversion in mean-variance decision models
Donata Kopanska-Brodka, Operational Research, University of Economics in Katowice, UL. 1-Maja 50, 40-287, Katowice, Poland, broda@ae.katowice.pl

The expected utility model (EU) and the mean-variance model (M-V) are the most common approaches to analyzing choices under uncertainty. These two models produce the preference relations which are only consistent under additional restrictions. The decision makers select alternatives by comparing their risk, and various risk measures are employed. Variance as a measure of risk is widely utilized but generally, it is not equivalent to the others. The main aim of the paper is to compare various concepts of measures of risk and present some conditions providing consistency in these approaches.

4 - Foundations of Probabilistic Sensitivity Analysis
Emanuele Borgonovo, Decision Sciences and ELEUSI Research Center, Bocconi University, Via Roentgen 1, 20135, Milano, Italy, emanuele.borgonovo@unibocconi.it, *Gordon Hazen*, *Elmar Plischke*

Probabilistic sensitivity analysis is essential to support the decision-making process accompanied by quantitative models. In OR it has been introduced by Wagner (1995; Operations Research). We show that all probabilistic sensitivity measures rest on a common rationale and that they can be estimated from the same design. The design is turned into a post-processing tool directly applicable to given data or data produced through Monte Carlo simulation. Application to the giant cell arteritis case study illustrates the insights gained in a pre- and post-optimality setting.

■ MD-52

Monday, 14:30-16:00
B13-1

Forecasting Evaluation

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Fotios Petropoulos*, Management Science, Lancaster University, Bailrigg Campus, Lancaster, LA1 4YX, Lancaster, Lancashire, United Kingdom, f.petropoulos@lancaster.ac.uk

1 - A preferable accuracy measure to mean absolute percentage error
Chris Tofallis, Business School, University of Hertfordshire, College Lane, AL10 9AB, Hatfield, Herts., United Kingdom, c.tofallis@herts.ac.uk

The mean absolute percentage error is the most widely used measure of relative accuracy. It is often used to compare methods. Yet, when used as the fitting criterion for building a prediction model, most of the predictions are too low. We investigate an alternative accuracy measure based on the forecast to actual ratio, and show that it overcomes this problem for strictly positive data. The associated regression model involves a multiplicative error rather than an additive one. It predicts the geometric mean rather than the arithmetic mean (and so is less affected by outliers).

2 - Flu incidence variations in azerbaijan for the years 1976-2000: non-linear modelling and forecasting
Borislav D Dimitrov, Academic Unit of Primary Care and Population Sciences, University of Southampton, South Academic Block, SGH, Tremona Road, SO166YD, Southampton, United Kingdom, b.dimitrov@soton.ac.uk, *Elchin S Babayev*

Multicomponent dynamics in flu (influenza) incidence (cycles of 1, 2-3, 5-6, 11 years) was found earlier. We aimed at modelling cyclicity and best non-linear estimates. New monthly cases from Grand Baku were used (n=300). We split series in fit (1976-96), evaluation (1997) and forecasting (1998-00) sets. We used autocorrelation, periodogram (PRA) and ARIMA analyses (SPSS, SAS). We found seasonal (1 year) and multiannual (2-3, 6-7, 12-14) cycles. The best model (out of 8) was ARIMA (0,1,1) - smallest AIC (196) and RMSE (3039). We confirmed complex cyclicity of flu and provided robust forecasts.

3 - An evaluation of simple forecasting model selection rules
Fotios Petropoulos, Management Science, Lancaster University, Bailrigg Campus, Lancaster, LA1 4YX, Lancaster, Lancashire, United Kingdom, f.petropoulos@lancaster.ac.uk, *Robert Fildes*

Model selection aims to identify the 'best' method of forecasting for an individual series within the data set. The current study attempts to explore the circumstances under which individual model selection is beneficial. Measures for characterising the data series (predictability, trend and seasonality), the pools of methods (number of methods, correlation between methods) and stability of methods' performance are considered. The efficacy selection of the appropriate model individually per series is contrasted to aggregate selection and simple combination of methods.

■ MD-53

Monday, 14:30-16:00
B13-2

Energy Economics III

Stream: Energy Economics
Invited session

Chair: *Bert Willems*, Tilburg University, Netherlands, bwillems@uvt.nl

1 - The influence of a capacity market on investments in peak-load generation in markets with increasing shares of renewable energy sources (RES) — a real options analysis
Daniel Hach, Kuehne Foundation Endowed Chair in Logistics Management, WHU - Otto Beisheim School of Management, Burgplatz 2, 56179, Vallendar, Select, Germany, daniel.hach@whu.edu, *Stefan Spinler*

The purpose of our paper is to assess the effect of capacity markets on investments in gas-fired power plants in the presence of different degrees of RES penetration. We use a real options approach to evaluate decisions and timing of a single investor and model the capacity market as an alternative revenue stream. Our model provides analytical and numerical solutions with comparative statics and uses stochastic processes for electricity and gas prices. The research is of value to investors developing valuation methods for future projects and to regulators discussing policy decisions.

2 - Non-linear combined scheduling and capacity planning for hydrogen energy storage plants
Simon Schulte Beerbühl, Institute of Industrial Production, Karlsruhe Institute of Technology, Hertzstrasse 16, 76187, Karlsruhe, Germany, schultebeerbuehl@kit.edu, *Magnus Fröhling*, *Frank Schultmann*

A non-linear convex combined scheduling and capacity planning approach for hydrogen storage is presented. Electrochemical characteristics of the electrolyzer require non-linear modelling, as specific energy demand decreases for lower loads. Therefore, linear modelling, as done for conventional storage systems, is not suitable. The presentation explains the approach, discusses the aspects of non-linearity, the convexity and its real world implications. Finally the results of the NLP are compared to a simplified linear and quadratic approach both at scheduling and capacity planning level.

3 - Optimal Sizing of Distributed generation coupled with electricity storage technologies: Insights from a community case study
Junwei Zeng, School of Economics and Management, Beihang University, A1151, New Main Building, Beihang University, NO.37 XueYuan Rd, HaiDian Dist, 100191, Beijing, Beijing, China, zengjunwei@yeah.net, *Pedro Crespo Del Granado*, *Zhan Pang*, *Stein W. Wallace*

The end-user is playing a key role in deciding the optimal cost-benefit sizing of local energy generation. This paper provides analytical insights on how synergies of local energy generating units work for a small community (university campus). Through a dynamic optimization model we consider the inter-temporal dynamics of price, demand and renewable fluctuations and their effects to the optimal sizing for a community's distributed generation profile. We assess how much storage capacity we actually need to make a gain from fluctuations of renewable. A real end user case study is analyzed.

4 - Relaxing competition through speculation: Committing to a negative supply slope
Bert Willems, Tilburg University, Netherlands, bwillems@uvt.nl, *Par Holmberg*

We demonstrate how suppliers can take strategic speculative positions in derivatives markets to soften competition in the spot market. In our game, suppliers first choose a portfolio of call options and then compete with supply functions. In equilibrium firms sell forward contracts and buy call options to commit to downward sloping supply functions. Although this strategy is risky, it reduces the elasticity of the residual demand of competitors, who increase their mark-ups in response.

■ MD-54

Monday, 14:30-16:00
B14-1

Policy Planning and Optimization in Power Systems

Stream: Energy, Environment and Climate
Invited session

Chair: *Nikita Ivkin*, Faculty of Management and Applied Mathematics, Moscow Institute of Physics and Technology (State University), Institutskiy Pereulok, 9, 141700, Dolgoprudny, Moscow Region, Russian Federation, ivkinnikita@gmail.com
Chair: *Haris Doukas*, Electrical & Computer Engineering, National Technical University of Athens, Greece, h_doukas@epu.ntua.gr

1 - The role of R and D sector with continuous spectrum of heterogeneous technologies in the evolution of economy and environment degradation.
Anton Bondarev, Department of Business Administration and Economics, Universität Bielefeld, Bielefeld, Germany, abondarev@wiwi.uni-bielefeld.de, *Alfred Greiner*

In this paper we develop a dynamic model of world economy which includes evolution of environment and explicit research sector with heterogeneous horizontal and vertical innovations. We find out, that there exist two different steady states of this economy, one with higher productivities and less new technologies being developed and the other with more new technologies. In the first steady state environmental degradation is faster, than in the second one. It is argued, that the amount of R&D expenditures is the key factor in determining which steady state of the economy will realise.

2 - Analysis of resource adequacy in energy only market and quantity-based capacity market models
Marina Dolmatova, Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Leninskie Gory, MSU, 2nd educational building, 119991, Moscow, Russian Federation, ms.marina.dolmatova@gmail.com

We examine market mechanisms to deliver reliability in power system. We focus on the aspect of generation adequacy and provide an overview of this characteristic for three models: an energy only market (taking NEM, Australia as an example), capacity market (PJM, USA), reliability options (New England, USA). In each case we study dependence of system reliability from model design and parameters, provide assessment of the strengths and weaknesses of the model and a description of experiences to-date.

3 - Valuation of flexible power plants, optimal switching with storage constraints
Juan Salvador Inda Diaz, Forest Economics, Swedish University of Agricultural Sciences, Sweden, juan.inda@slu.se, *Chandra Kiran Krishnamurthy*

We use an optimal switching approach to value power plant facilities with a restricted production capacity. Particularly, our interest focuses on accounting for market and input uncertainties, where production constraints include among others storage capacity, switching costs and minimum on-off times. We consider our approach a suitable method to value a hydropower plant that sells electricity at fluctuating prices, with a water reservoir filled up by a river downstream and a finite capacity, under a scheme of switching costs due to interruption and resumption of production.

4 - Incorporating energy and environmental corporate responsibility in capital budgeting: A multiobjective approach
Haris Doukas, Electrical & Computer Engineering, National Technical University of Athens, Greece, h_doukas@epu.ntua.gr, *George Mavrotas*, *Panagiotis Xidonas*, *Olena Pechak*, *John Psarras*

Corporate Social Responsibility (CSR) is an issue of paramount importance. In the present approach energy and environmental CSR is used along with an economic performance criterion in order to allocate funds. The inevitable evaluation uncertainty is addressed using a combination of Monte Carlo simulation and multiobjective optimization. The exact Pareto set is calculated at every iteration using the augmented epsilon-constraint method. The number of appearances of each efficient portfolio across the Pareto sets indicates the robustness of the portfolio.

■ MD-55

Monday, 14:30-16:00
B14-2

Logistics and transportation in biomass-based supply chains

Stream: Biomass-based Supply Chains
Invited session

Chair: *Magnus Fröhling*, Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT), Hertzstraße 16, D-76187, Karlsruhe, Germany, magnus.froehling@kit.edu
Chair: *Taraneh Sowlati*, Wood Science, University of British Columbia, 2931-2424 Main Mall, V6T1Z4, Vancouver, BC, Canada, taraneh.sowlati@ubc.ca

1 - BtL vs. Fossil Fuel Supply Chains: an Economical, Ecological and Energetic Comparison
Harald Müller, Department for AgriculturalTechnology, Georg August University, Göttingen / MüLog Management & Consulting, Iserbarg 11b, 22559, Hamburg, Hamburg, Germany, harald.mueller@muelog.de

EFB pellets, Ground-Rice Husks, wood pellets and woodchips comply with the requirements of a sustainable BtL production. The BtL supply chains based on this feedstock will be economically, ecologically and energetically compared with a similar fossil fuel supply chain. The results of the comparison show generally that the biomass supply chains are ecologically and energetically superior and economically inferior to the fossil fuel supply chain. Taking certain circumstances into account wooden biomass for BtL-production from Europe or the Atlantic can be even economically competitive.

2 - Modeling the life-cycle biogenic carbon of biomass-to-bioenergy supply chains based on a biomass production optimization system
Catalin Ristea, Forestry, University of British Columbia, 2045-2424 Main Mall, Forest Sciences Centre, V6T 1Z4, Vancouver, BC, Canada, ristea@mail.ubc.ca, *Thomas Maness*

This paper describes the integration of the Carbon-aware Biomass production Optimization System C-BOS, a biomass afforestation production model for tactical analysis, with the Biogenic Carbon Dynamics model Bio-CarbD, a biogenic carbon balance model. C-BOS models the biomass production supply chain such that all biogenic carbon sequestration and emissions can be quantified by Bio-CarbD over a time horizon. The models are designed as decision-support tools for assessing the viability of displacing gasoline with ethanol from wood as a climate mitigation strategy.

3 - Multiple-objective modeling of railway transportation and storing to increasing imports of Russian wood for the energy plants
Teijo Palander, Faculty of Science and Forestry, University of Eastern Finland, Finland, teijo.s.palander@uef.fi

The different logistics alternatives of an energy production company under increasing supply of Russian wood are optimized and discussed. The basic situation described the railway transportation strategy of the purchaser of the Russian wood before Russia's World Trade Organization (WTO) membership. The MOLP model presented in this paper is recommended as a contribution to the procurement logistics because the adaptation of Russian wood import to the complicated railway transportation environment would require continual and optimizations of wood and the wagon traffic flows to be carried out.

4 - Supply Chain Analysis of Combined Heat and Power Generation from Woody Biomass: a Case Study from British Columbia, Canada
Mahdi Mobini, Department of Industrial Engineering, University of Tehran, University of Tehran, Faculty of Engineering, Department of Industrial Engineering, 11155/4563, Tehran, Iran, Islamic Republic Of, mahdi_mobini@yahoo.com

Logistics of supplying biomass to the utilization point is a challenge and can contribute 25-50% to the final cost of products. In order to study the logistics of delivering biomass to a combined heat and power plant, a discrete-event simulation model is developed and presented in this paper. The developed model includes main activities of the supply chain including: biomass production at the suppliers' location, transportation to a collection yard for temporary storage and preprocessing, and hauling the fuel to the conversion facility.

■ MD-56

Monday, 14:30-16:00
B15-3

OR Applications in Transportation and Logistics

Stream: OR Applications in Industry
Invited session

Chair: *Ahmad I. Jarrah*, Decision Sciences, George Washington University, 2201 G Street NW, Funger 415, 20052, Washington, DC, United States, jarrah@gwu.edu

1 - A Spreadsheet Based Decision Support System For Production and Distribution Planning
Cem Saydam, Business Information Systems and Operations Management, University of North Carolina at Charlotte, 9201 Univ City Blvd, 28223, Charlotte, North Carolina, United States, saydam@uncc.edu, *Elizabeth Sharer*, *Hari Rajagopalan*

In this paper we report the development and implementation of a spreadsheet based decision support system for the largest manufacturer of natural fiber products in North America. We developed a linear programming formulation for the firm's multi-plant, multi-period production and transportation problem, and used an off-the-shelf solver to solve problem instances. The system is implemented on Excel platform and utilizes VBA in Excel for problem generation, solution, and writing the plethora of reports.

2 - Efficient Ship Routing and Scheduling for a Salmon Feed Supplier
Guillermo Durán, University of Buenos Aires, Argentina, gduran@dm.uba.ar, *Andrés Weintraub*, *Javier Marenco*, *Gonzalo Romero*

A decision support system is developed for scheduling the maritime delivery operations of a salmon feed supplier in southern Chile. The problem is formulated as a ship routing problem with heterogeneous fleet, soft time windows, and accessibility and precedence constraints. Good quality solutions are generated using a GRASP approach. In tests comparing the delivery schedules generated by the prototype with the company schedules, the prototype reduced the number of required ship-days by 20% and the nautical miles traveled per tonne of feed delivered by 7.3%.

3 - The Destination-Loader-Door Assignment Problem for Automated Sorting Facilities
Ahmad I. Jarrah, Decision Sciences, George Washington University, 2201 G Street NW, Funger 415, 20052, Washington, DC, United States, jarrah@gwu.edu, *Jonathan F. Bard*

We present a multiobjective MIP model and solution procedure for a problem that arises in configuring package sorting centers that perform multiple automated sorts per day. The 1st objective is to assign destinations to consecutive doors so that the number of changes of destination-to-door assignments from one sort to the next is minimized. The 2nd and 3rd objectives are to minimize the number of loaders who work the doors and to balance the number of packages assigned to each loader. The MIP is strengthened via strong cuts. Complexity analysis and computational results are discussed.

4 - Analysis of the distribution of medicinal drugs in a hospital using discrete event simulation
José Arnaldo B. Montevechi, Production, UNIFEI, 37500903, Itajubá, MG, Brazil, montevechi@unifei.edu.br, *Fernanda Rocha*, *José Antonio de Queiroz*

In a hospital environment setting processes are complex, high risky, high cost and depend on agility in the delivery of medicines to patients, a critical success factor to reduce sequel and improve the patients' recovery chances. Applying Discrete Event Simulation using the IDEF-SIM technique and the ProModel software, this paper analyzes the distribution of medicines in a hospital, evaluates the impact of unplanned downtime of employees and changes in patient demand, and proposes alternative scenarios to improve the system.

■ MD-57

Monday, 14:30-16:00
B15-4

Operations Planning Models and Applications

Stream: IBM Research Applications
Invited session

Chair: *Marco Laumanns*, IBM Research - Zurich, 8803, Rueschlikon, Switzerland, mlm@zurich.ibm.com

1 - Optimizing the Operations of Power Distribution Systems
Martin Mevissen, IBM Research Dublin, IBM Technology Campus, Damastown Industrial Park, Mulhuddart, 15, Dublin, Ireland, martmevi@ie.ibm.com, *Jakub Marecek*

While providing a safe and stable supply of electricity, distribution system operators face the additional challenges of changing demand patterns and increasing integration of uncertain renewable energy sources. We propose a nonconvex MIQP approach based on an AC power flow model to optimize the operations of switchgear in the grid under the combined objective of minimizing number of customers interrupted, minimizing voltage drops and minimizing power losses. We make use of SDP relaxations to find globally optimal solutions to the problem.

2 - Improving Urban Public Transportation: Optimal Bus Stop Locations
Bruno Flach, IBM Research, Brazil, Av. Pasteur, 138/146, Botafogo, 22296-903, Rio de Janeiro, RJ, Brazil, bflach@br.ibm.com, *Pavankumar Murali*, *Milind Naphade*

As part of a project that encompasses a large number of initiatives aimed at providing the population with improved public transportation services, we will describe in this presentation the development of a model that determines the location of stops along bus routes so as optimize two conflicting objectives: demand coverage and the lines service levels. We propose a mixed integer linear programming model that incorporates demographic data, an assessment of the mobility patterns of potential passengers and demand elasticity. Computational results are discussed to illustrate existing tradeoffs.

3 - Transit Schedule Coordination using Opportunistic Sensing
Rahul Nair, IBM Research - Ireland, 15, Dublin, Ireland, rahul.nair@ie.ibm.com, *Fabio Pinelli*, *Francesco Calabrese*

We present a two-stage stochastic program that refines a city-wide, multi-modal transit schedule based on transfer information that is available from opportunistic sources. The model works by perturbing or offsetting the schedule such that the expected value of waiting times at all transfer points in the system is minimized. Probabilistic information on transfers can be gathered from sources such as journey planner requests, mobile phone data, or other opportunistic sources. Using journey planner results for the transit system in Washington, D.C., we demonstrate the potential of the approach.

4 - OR modeling and deployment for a better (OR) world
Hans Schlenker, ILOG Optimization, IBM Deutschland GmbH, Software Group, Hollerithstr. 1, 81829, München, Germany, hans.schlenker@de.ibm.com, *Alex Fleischer*

We claim that the OR community should move away from yet-another-xyz-algorithm, towards more and better modeling. We show you how easy it can be to model real world problems, of real size, and real matter, with a state-of-the-art modeling language: OPL. And, what's next? With ODME you can bring your models (and even algorithms) to life! This can help the OR community grow, not only through brilliant academic papers but also real OR applications. We await your flamy replies.

■ MD-58

Monday, 14:30-16:00
B15-6

Software for OR/MS II - Industry

Stream: OR in Industry and Software for OR (contributed)
Contributed session

Chair: *Bjarni Kristjansson*, Maximal Software, Ltd., Boundary House, Boston Road, W7 2QE, London, United Kingdom, bjarni@maximalsoftware.com
Chair: *Robert Fourer*, AMPL Optimization, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com

1 - A methodology for scheduling an integrated terminal-refinery system under oil supply uncertainty

Fabrício Oliveira, Industrial Engineering, PUC-Rio, Av. Marquês de S. Vicente s/n, Gávea, 22453-900, Rio de Janeiro, Rio de Janeiro, Brazil, fabricio.carlos.oliveira@gmail.com, *Paula Nunes*, *Rosa Blajberg*, *Silvio Hamacher*

We present a methodology for scheduling the oil supply of a system composed by a marine terminal, a refinery, and a pipeline connecting them. In this case, we consider the of the oil tankers arrival as uncertain. The methodology comprises a scenario generation technique and a 2-stage stochastic model. The objective is minimizing operational costs, considering berthing, pumping, and inventory handling. The proposed methodology was evaluated considering a real case study. Results show the benefits of using the proposed approach to obtain optimal schedules while dealing with uncertain oil supply.

2 - A convex relaxation approach for solving a nonlinear refinery planning problem

Tiago Andrade, Industrial Engineering, PUC - RIO, Rio de Janeiro, Rio de janeiro, Brazil, tiago-andrade-2@hotmail.com, *Fabrício Oliveira*, *Gabriela Ribas*, *Paula Nunes*, *Pedro Hespanhol*, *Silvio Hamacher*

This work proposes a heuristic to solve a nonlinear non-convex mathematical programming model, with the objective of maximize the profit of a real oil refinery. We propose an approach based on convex relaxations of the original problem using McCormick's envelopes. In this sense, we first solve a relaxation of the original problem in order to obtain good initial solutions. Without this heuristic, it was not possible to find a feasible solution in six of the seven cases considered. Moreover, in one case, although it was already possible to solve without it, the objective function was improved.

3 - Optimizing Domestic Distribution Network at a Major 3PL Provider from Turkey

M. Can Arslan, R&D Center, Ekol Logistics, Atasehir, 34779, Istanbul, Turkey, mehmetcanarslan@gmail.com

In this study, the domestic distribution network design problem at a major 3PL provider from Turkey is considered. First, a brief introduction of the company and its domestic distribution operations is presented. The solution methodology in optimizing the distribution network is described and the network resulting from the proposed methodology is illustrated. Practical issues related to an industrial implementation of this scale are particularly emphasized. A comparison of the existing and optimized distribution network in terms of the associated performance metrics concludes the study.

4 - A Fuzzy-Based List Scheduling Algorithm for a Parallel Machine Scheduling Problem in an Injection Molding Plant

Ceyhun Araz, Department of Industrial Engineering, Celal Bayar University, Turkey, ceyhun.araz@cbu.edu.tr, *Emrah B. Edis*, *Emrecan Sezen*, *Yahya Barış Özçakır*, *Utku Yapa*, *Alper SaltabaŞ*

This study deals with a scheduling problem of an injection molding plant. The aim is to schedule the job orders by considering the tardiness, setup time and priority issues. The setup times are sequence dependent subject to the color changes of the plastic parts on the machines. In addition, each part has a priority list of compatible dies and each die has a priority list of compatible machines. To solve the problem, a fuzzy-based list scheduling algorithm has been developed on the scheduling platform of an ERP software. The results are given and discussed on the Gantt chart of the platform.

■ MD-59

Monday, 14:30-16:00
B15-5

Data Processing for Model Selection

Stream: Machine Learning and Its Applications
Invited session

Chair: *Michael Khachay*, Ural Branch of RAS, Institute of Mathematics and Mechanics, S.Kovalevskoy, 16, 620990, Ekaterinburg, Russian Federation, mkhachay@imm.uran.ru

1 - Small CVD sample set classification: generative versus discriminative

Anastasia Motrenko, Applied mathematics and management, MIPT, Moscow, Russian Federation, pastt.petrovna@gmail.com

The challenge of the Cardio-Vascular Disease patients classification problem is the small sample size. To make a classification model we combine generative and discriminative classifiers (known from the supervised and non-supervised approaches to Machine Learning). Our goal is to obtain the maximum generalizing ability of the classifier. The quality function is a linear combination of generative and discriminative likelihoods. It includes evaluation of both discrete and continuous joint distribution of random variables. We study the dependence of the combination structure on the sample size.

2 - Computational experimetns with ensemble of logical algorithms

Andrey Ivakhnenko, Moscow Institute of Physics and Technology, Mocsow, Russian Federation, andrej_iv@mail.ru

We present a sofware wich implement the weighted voting logical conjunction rules classification algorithm based on combinatorial theory of machine learning. A framework for the effective computational experiments is based on the calculations on the GPU is developed. The paralellilizm allows us to take much more algorithms in the neighborhood in consideration and better assess its generalization apability. The implemented algorithm is compared to the classical supported algorithms on a large number of problems from the UCI repository.

3 - Fast detection of correlated pairs

Dmytro Fishman, Mathematics and Computer Science, University of Tartu, Estonia, dmytrofishman@gmail.com

The problem of detecting most similar pairs of genes is commonly known in bioinformatics. Generally, it implies enumerating all possible pairs of genes in the dataset and can thus be a very slow process. In this paper we have proposed a much faster solution, which is based on nearest neighbor indexing method. Experiments show that our algorithm finds almost exact answers in nearly linear time. The application of proposed approach will improve quality of research in this area. Dmytro Fishman, Faculty of Mathematics and Computer Science, University of Tartu

4 - Extension of Contract Net Protocol (CNP) with fault tolerance

Djamila Boukredera, Laboratoire LMA, University of bejaia, Route Targa ouzemmour, 06000 , Bejaia, Algeria, boukredera@hotmail.com

This paper addresses the critical challenge of extending the conventional CNP with fault tolerance to handle the agent death exception which may occur during the task performing. This random failure is one major concern regarding system performance. Our approach models the heartbeat mechanism to detect the failure and hence an appropriate behavior can be timely performed by the manager ensuring thus the failure recovery. The extended CNP is developed using stochastic timed petri net and the supporting tool CPN Tools. The model analysis proves that the protocol meets the key properties.

■ MD-62

Monday, 14:30-16:00
R18-1

Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks (COST TD1207)

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Martin Mevissen*, IBM Research Dublin, IBM Technology Campus, Damastown Industrial Park, Mulhuddart, 15, Dublin, Ireland, martmevi@ie.ibm.com
Chair: *Andrea Lodi*, D.E.I.S., University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, andrea.lodi@unibo.it
Chair: *Claudia D'Ambrosio*, LIX, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, dambrosio@lix.polytechnique.fr

1 - Optimizing efficiency of solar plants
Emilio Carrizosa, Estadistica e Investigacion Operativa, Universidad de Sevilla, Matematicas, Reina Mercedes s/n, 41012, Sevilla, Spain, ecarrizosa@us.es, *Carmen Ana Dominguez-Bravo*, *Enrique Fernández-Cara*, *Manuel Quero*

The energy generated by a solar plant is greatly influenced by the number, location and size of the heliostats pointing to the receiver. Efficiency optimization is typically a large-scale optimization problem with nonconvex constraints, and black-box type objective. In the literature several geometric patterns have been proposed to parameterize the feasible set. However, this does not seem to be helpful to address recent challenges such as the design (size) of the heliostats. In this talk we propose heuristics which allow us to cope with both location and design of the heliostats.

2 - Solving Optimization Problems with Separable Convex Objective Functions Arising in Electricity Transmission Networks by Column-and-Row Generation
Ibrahim Muter, Industrial Engineering, Bahcesehir University, Turkey, ibrahim.muter@bahcesehir.edu.tr, *S. Ilker Birbil*

In this study, we consider the transmission switching problem. The transmission cost in the literature is considered to be independent of the location of a generator and a consumer, hence a linear function. However, in the real-life instances, the cost functions that are convex with respect to the increase in flow are used. These functions can be approximated by piecewise linear functions. We posed the transmission switching problems as a origin-destination type problem with separable piecewise linear convex objective. We proposed a column-and-row generation algorithm to solve this problem.

3 - An operation researcher's perspective on electrical distribution networks
Florent Cadoux, Grenoble INP / G2ELab, 38400, Grenoble, France, Florent.Cadoux@g2elab.grenoble-inp.fr

Electrical power distribution has many optimization problems to offer and constitutes a fruitful playground for operation researchers. We will briefly describe the physics of electrical distribution and then list typical objectives, constraints and decision variables. Then we will review some important engineering problems that lend themselves to OR-based solution approaches, and present some of the joint work between operation researchers and electrical engineers that we are currently carrying out in close partnership with the main French distribution system operator, ERDF.

4 - Global solution of mixed-integer quadratic programs through quadratic convex reformulation
Sourour Elloumi, Laboratoire CEDRIC, Conservatoire National des Arts et Métiers, 292 Rue Saint Martin, Paris, France, elloumi@cnam.fr, *Alain Billionnet*, *Amélie Lambert*

We review the quadratic convex reformulation approach for quadratic programs with integer variables. We also show the recent extensions to quadratically constrained programs and to the case of mixed-integer variables. In all these extensions, the global framework is the same: in a preprocessing step, we compute a tight equivalent reformulation of the original quadratic program that we deduce from the solution of its SDP relaxation. The equivalent reformulation is easier to solve because its continuous relaxation is a convex problem. Then, we solve the equivalent reformulation by standard B&B.

■ MD-63

Monday, 14:30-16:00
R18-2

Discrete Problems in Control Theory I

Stream: Operational Research and Control Problems
Invited session

Chair: *Alexander Lazarev*, Institute of Control Sciences, Profsoyuznaya st. 65, 117997 Moscow, Russia, 117997, Moscow, Russian Federation, jobmath@mail.ru

1 - GTSP approach to sequential control problem
Evgeny Ivanko, Institute of Mathematics and Mechanics Ural Branch Russian Academy of Sciences, Russian Federation, viatore@ya.ru

We consider a vehicle complying constraints on the velocity modulus and the turning radius, which is to visit a set of given points at minimum time. A simple example of such an object is a patrol aircraft. This problem is referred to as a sequential control problem and is known to be very hard due to the infinite number of "elementary control problems' needed to be solved. In this work a simple transformation of the original problem into a generalized TSP problem is proposed. This transformation provides a convenient heuristics for the corresponding sequential control problem.

2 - Servicing schedules synthesis for stationary objects in one-dimensional working zone of a mobile-processor
Nadezhda Dunichkina, Volga State Academy of Water Transport, Nesterova str, 5a, 603950, Nizhny Novgorod, Russian Federation, nadezhda.dunichkina@gmail.com, *Dmitry Kogan*, *Yuri Fedosenko*

We consider the servicing strategies synthesis questions for a group of stationary objects located along one-dimensional working zone of a mobile-processor. Every object is associated with early date of servicing start, its duration and individual penalty functions of servicing completion time (there can be one or two characteristics). We consider minimized criteria of total penalty and (or) maximum among individual penalties. For corresponding one-criterion and bi-criteria problems we construct synthesis algorithms for optimal solutions. Computational complexity questions are also discussed.

3 - The problem of gathering and scheduling a freight train
Nail Khusnullin, ICS RAS, Russian Federation, nhusnullin@gmail.com, *Alexander Lazarev*, *Elena Musatova*

A polynomial dynamic programming algorithm was suggested to construct orders delivery schedule for one locomotive in a 3 station circuit. An approach to exact solution was proposed and the steps were represented to gather a freight train and build destination routing in order to minimize the total completion time. A point-to-point and a triangle shapes of railways are considered. Computational results are reported to conrfim the strength of our approach. The complexity of this algorithm is O(n8) operations.

4 - A Simulation Model for Irregular Operations in Airlines
Burak Erkayman, Industrial Engineering, Sakarya University, Sakarya Universitesi Muhendislik fak., Endustri Muh. Bolumu, 54187, Sakarya, Turkey, erkayman@atauni.edu.tr, *Emin Gundogar*, *Ertugrul Duman*, *Omer Fatih Bolukbas*

Airline companies are trying to control all operations through their published flight schedules. Unexpected situations related with aircrafts, passengers, crew and bad weather conditions may make difficult the control of the schedule. Various solutions concerning passengers, crew and aircrafts must be presented in a short period of time. Resuming to the original schedule must be considered as well as solution costs. In this study a simulation approach is offered for having an opinion on the probable results in case of a disruption. Disruption types and applicable scneraios are defined through

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■ MD-64

Monday, 14:30-16:00
R18-3

Defence and Security III

Stream: Defence and Security
Invited session

Chair: *Ana Isabel Barros*, Military Operations, TNO, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - An attrition game on the network
Keiichi Sunaga, Graduate School of Science and Engineering, National Defense Academy, Japan, em51053@nda.ac.jp, *Ryusuke Hohzaki*

Attrition games on the network are important for network security and military affairs. In this study, we deal with a two-person zero-sum game with intruders and defenders. The intruder's side aims to flow the number of intruders being survived as many as possible from a start node to a goal node. The defender's side wants to block the intrusion. Their meeting on arcs makes the attrition of the intruders proportional to the number of the defenders, namely, in accordance with the linear law of Lanchester. We propose a linear programming method to derive an equilibrium point for the game.

2 - Unpredictable Patrolling
Ana Isabel Barros, Military Operations, TNO, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl, *Lanah Evers*

Due to the increase in violence among sports fans it is important to timely monitor possible conflict locations. To this end, patrols can be defined to remotely monitor activities at these locations. Efficient monitoring of all potential conflict locations, requires repeating monitor and a short average response time to reach another location where some abnormal activity is taking place. Finally, these patrols should not be easy to predict and avoid from the point of view of a sport hooligan. In this presentation we will address this problem and provide some computational results.

3 - Open problems on defence situations modelled as games on a lattice
Noemi Zoroa, Estadistica e Investigacion Operativa, University of Murcia, Facultad de Matematicas. Universidad de Murcia.Campus de Espinardo, 30071,Murcia. Spain, 30071, Murcia, Spain, nzoroa@um.es, *M.José Fernández-Sáez*

Different strategic defence situations can be studied from the point of view of game theory, modelling them as two-person zero-sum games on the Cartesian product of two finite sets. Here we present cases where only partial solutions have been obtained, showing the last results and the unsolved problems. These situations include: patrolling a border of an occupied city or territory, espionage and counterespionage problems, avoiding or finding some objects hidden by an enemy, incursions on a protected zone, and so on.

4 - A Spatial Lanchester Model with Heterogeneous Forces
Marcelo Villena, Faculty of Engineering, Universidad Adolfo Ibáñez, DIAGONAL LAS TORRES 2640 PEÑALOLÉN, Santiago, Chile, marcelo.villena@uai.cl

We develop a spatial Lanchester model for combat between heterogeneous forces. In a spatial setting, each different type of military units will have different kill-rates, different speed and mobility capabilities, and their own geographical distribution. This model is far more realistic that the current aggregate Lanchester approach and it allow us to simulate more complex battle situations. There is a variety of spatial problems where this model could be used, e.g.: marketing, spatial retail competition, epidemiology and public health policy, crime combat, among many others.

■ MD-65

Monday, 14:30-16:00
R18-5

Dynamic Game Theory

Stream: Emerging Applications in Game Theory and Management
Invited session

Chair: *Ryusuke Hohzaki*, Department of Computer Science, National Defense Academy, 1-10-20 Hashirimizu, 239-8686, Yokosuka, Kanagawa, Japan, hozaki@cc.nda.ac.jp

1 - Pure strategy Nash equilibria in finite symmetric concave games
Takahiro Watanabe, Graduate School of Social Sciences, Tokyo Metropolitan University, Minamioosawa 1-1, Hachiouji_city, 1920397, Tokyo, Japan, contact_nabe08@nabenavi.net

In this paper, we consider a finite symmetric game with one-dimensional integer interval strategy sets. We show that a pure strategy Nash equilibrium exists if the payoff function is concave with respect to the own strategy and satisfies a pair of symmetrical conditions near the diagonal line of the strategy profile set. This result implies the existence of a symmetric equilibrium in pure strategy under the weak unilateral competitiveness [Kats and Thisse (1992), International Journal of Game Theory, 21:291-299], assuming the concavity of the payoffs on the own strategy sets.

2 - Congestion control of uniform customers by priority assignment
Yasushi Masuda, Faculty of Science and Tech, Keio University, 3-14-1, Hiyoshi, Kohoku, 2238522, Yokohama, Japan, masuda@ae.keio.ac.jp, *Akira Tsuji*

We consider a congestion game theoretic equilibrium of uniform customers in a multiple resource setting. We demonstrate that priority could be an effective method of congestion control in such a system. The idea relies on the fact that the marginal effect of an additional load of priority customers on the waiting time of non-priority customers is larger than that of an additional load of non-priority customers. We see that a proper priority assignment sometimes induces the equilibrium to be the first best. Also we provide a heuristic for improving the priority assignments.

3 - A Security Game and an Air Defense
Ryusuke Hohzaki, Department of Computer Science, National Defense Academy, 1-10-20 Hashirimizu, 239-8686, Yokosuka, Kanagawa, Japan, hozaki@cc.nda.ac.jp

This paper deals with a security game between security guards and an invader in facilities, where guards want to find the invader and the invader desires to reach his destination without being found. Concerning with the game, we define some optimization problems: invasion scheduling, patrol routes and the distribution of searching effort against the invader. We propose some methodologies using dynamic programming and linear programming for these problems based on the game theoretical point of view. We also show some examples of air defense, which our methods could be applied to.

4 - A Search Game with The Private Information on Target Distribution
Kwanshik Joo, Graduate School of Science and Engineering, NATIONAL DEFENSE ACADEMY OF JAPAN, 10-20, Hashirimizu 1, 239-8686, Yokosuka, Kanagawa, Japan, najks629@gmail.com, *Ryusuke Hohzaki*

This paper deals with a search game between a target and a searcher. Although the initial distribution of the target has a big influence on the result of the game, the early studies mostly assumed the distribution as players' common knowledge. In this paper, we consider the initial location of the target as private information and analyze the value of the information by a two-person zero-sum game. We solve the game by a mathematical programming methodology, which could be applied to other search models.

■ MD-66

Monday, 14:30-16:00
R18-4

Visualization in OR

Stream: OR: Visualization and Arts
Invited session

Chair: *Vitaly Podobedov*, Computational Mathematics and Cybernetics, Moscow State University, Vorobievy Gory, MSU, 119992, Moscow, Russian Federation, vetix@or-art.org

1 - A new strategy based on genetic algorithms for solving multiobjective problems interactively
Ernestas Filatovas, Institute of Mathematics and Informatics, Vilnius University, Akademijos st. 4, LT-08663, Vilnius, Lithuania, ernest.filatov@gmail.com

A new strategy is proposed for solving multiobjective optimization problems. Using interactive methods, a decision maker can solve more complex multiobjective optimization problems comparing with other methods. However, this process requires a lot of decision maker's time and the problem of even distribution of the found solutions on the Pareto remains. The evolutionary methods generate a lot of solutions but they give only approximation of the Pareto front. New strategy combines advantages of genetic algorithms, interactive multiobjective optimization methods and visualization techniques.

2 - Assessment of the perceptual map of a group by the Three-way multidimensional scaling coupled to the non-parametric combination
Moacyr Machado Cardoso Junior, Production Department, Aeronautics Institute of Technology - ITA, R Licinio Rodrigues Alves 114, Chácara Jafet, 08730661, Mogi das Cruzes, São Paulo, Brazil, moacyr@ita.br, *Rodrigo Scarpel*

The proposal is to analyze a group Perceptual map obtained via Three-Way Multidimensional Scaling using non-parametric combination technique. It was compared both Liptak and Fisher as combining functions. The present study involved occupational and environmental risk perception assessment. The results showed that both combining Functions behaved well and it was possible to compare the risk perception in all levels in the perceptual map produced

3 - Conceptualization of the Information Flow for the Planning of an Early Warning System
Sema Onurlu, Sintek Muhendislik Ltd Sti, Kazım Karabekir Cad No 4 (1-2), Sariyer, 34457, Istanbul, Turkey, sema.onurlu@sintekmuhendislik.com, *A. Metin Ger*

A study is conducted for the establishment of an early warning system that involve multiple agencies. To form an initial framework a questionnaire is administered to the relevant agencies. Results are used to construct an initial cognitive structure where the taxonomy of the related agencies and the relative information clusters are derived. Data is represented using various maps. This information is elaborated at a participative meeting. Resulting data is analyzed for the expectancy of the participants from the system and the mechanisms to realize the desired information system is discussed.

■ MD-67

Monday, 14:30-16:00
R19-1

Resource Management in Health Care

Stream: Patients Flows Models and Optimization
Invited session

Chair: *Ana Cecilia Zenteno*, Massachusetts Institute of Technology, 100 Main St, E62-385, 02138, Cambridge, Massachusetts, United States, ceciliaz@mit.edu

1 - Resource-Based Patient Prioritization in Mass-Casualty Incidents
Nilay Argon, University of North Carolina, United States, nilay@unc.edu, *Alex Mills*, *Serhan Ziya*

The most widely used standard for mass-casualty triage, START, relies on a fixed-priority ordering among different classes of patients, and does not consider resource limitations or the changes in survival probabilities with respect to time. We construct a fluid model of mass-casualty triage that incorporates these factors and characterize its optimal policy. Using this characterization, we propose a simple policy and show, by means of a realistic simulation model and data from emergency medicine literature, that it outperforms START in all scenarios considered - sometimes substantially.

2 - Inpatient bed capacity management at hospitals
Burhaneddin Sandikci, Booth School of Business, University of Chicago, 5807 South Woodlawn Avenue, 60637, Chicago, IL, United States, burhan@chicagobooth.edu, *Tom Best*, *Don Eisenstein*, *David Meltzer*

Hospitals deal with capacity challenges in various ways. Motivated by the implementation in an urban teaching hospital in US, we consider a novel approach that partitions the inpatient care into focused wings. When forming wings, the hospital faces a tradeoff between forming large wings to take advantage of pooling, and forming specialized wings to take advantage of focusing. We provide an optimization framework to inform the wing formation decisions. Using data from our collaborating hospital and national databases, we report a rich set of numerical results to highlight a number of insights.

3 - Impact of Information Sharing Between Emergency Medical Providers on the Stochastic Properties of Patients' Wait Time.
Masha Shunko, Krannert School of Management, Purdue University, 403 W. State Street, 47906, West Lafayette, IN, United States, mshunko@purdue.edu, *Hung Do*

Emergency medicine in the US is in critical condition and one of the main problems is crowding in emergency departments (ED). One of the methods to decrease ED crowding is using central control of patient traffic to balance the load between the EDs. This problem has been addressed in emergency medicine and OM literature from the average wait time perspective. We contribute to this stream by focusing on the impact of load balancing on the stochastic properties of wait time. We show that under load balancing, the wait time at each ED is stochastically smaller and less variable (in convex order).

4 - Systematic Block Allocation in Large Academic Medical Centers
Ana Cecilia Zenteno, Massachusetts Institute of Technology, 100 Main St, E62-385, 02138, Cambridge, Massachusetts, United States, ceciliaz@mit.edu, *Retsev Levi*, *Timothy Carnes*, *Peter Dunn*, *Bethany Daily*, *Devon Price*

We describe the large-scale implementation of data-driven surgical scheduling strategies at Massachusetts General Hospital (MGH). The strategies are based on a range of simulation and integer optimization techniques. The goals were to smooth the surgical census on the surgical floors and to increase timely access to non-elective patients. The models and analyses provided accurate predictions, supported the changes in the scheduling practices, and delivered rigorous methodologies to monitor and study the changes in the respective performance metrics.

■ MD-69

Monday, 14:30-16:00
R19-3

Solving Transportation Problems in Developing Countries

Stream: OR for Development and Developing Countries
Invited session

Chair: *Sabeur Elkosantini*, ISIMA, 3000, Sfax, Tunisia, Sabeur.Elkosantini@isima.rnu.tn
Chair: *Souhail Dhouib*, Department of Quantitative Methods, University of Gafsa, Route Kaid Mhamed Km 1.5 Rue 4047 N12, 3039, Sfax, Tunisia, souhail.dhouib@gmail.com

1 - Comparison of Slurry Pipelines with Traditional Transportation Options: A Case Study for Turkey's Mines
A. Burcu Altan-Sakarya, Civil Engineering, Middle East Technical University, 06800, Ankara, Turkey, burcuas@metu.edu.tr, *Burhan Yıldız*, *A. Metin Ger*, *Hasan Ozturk*

This study searches for the best transportation option for a case study including three mines and three steel factories in Turkey. A progressive method, slurry pipelines, is compared with two traditional options, transportation by trucks and rail. For the design of slurry pipelines, a non-linear optimization problem is developed. The problem is solved with Genetic Algorithms method for the optimal pipe diameters and transported ore amounts. For other two options, the cost is determined to transport this amount. The methods are compared in terms of cost and environmental effects.

2 - Nonlinear programming solutions for transportation logistics

Joao Lauro D. Faco', Dept. of Computer Science, Universidade Federal do Rio de Janeiro, Av. do PEPE, 1100 / 203, 22620-171, Rio de Janeiro, RJ, Brazil, jldfaco@ufrj.br

Oil & derivatives transportation from port to refinery are modeled by Optimal Control and solved by nonlinear programming methods. A scheduling model to determine: (1) vessel allocations on jetties; (2) transfer operations: vessel to tank, tank to pipeline, and pipeline to refinery is a dynamic system where the controls are transfer operations flows from a source equipment (tank, vessel, pipeline or process unit) to its destination, and equipment contents (volume and properties) are the states. Yes/No decisions are modeled by complementarity constraints allowing a continuous nonlinear model.

3 - Power plant evaluation and site selection: A study for Turkey

Emre Çalışkan, Industrial Engineering, Gazi University, Faculty of Engineering, Gazi University, 06570,, Ankara, Turkey, ecaliskan@gazi.edu.tr, *Erdem Aksakal*, *Metin Dagdeviren*, *Orhan Türkbey*

In developing countries, because of high growth rate of export/import activities in industry, the energy consumption is highly increasing. For keeping the economic growth high in a sustainable environment, the evaluation and building the power plants is one of the most strategic decisions for a government. In this study we will evaluate the power plants under some certain criteria for Turkey with using Multi Criteria Decision Making Methods. Then we will use the obtained results via mathematical model for facility location problem.

4 - Determination and minimization of carbon footprint in automobile industry

Asude Ates, ENVIRONMENTAL ENGINEERING, SAKARYA UNIVERSITY ENGINEERING FACULTY, SAKARYA UNIVERSITY ENGINEERING FACULTY ENVIRONMENTAL ENGINEERING DEPARTMENT ESENTEPE CAMPUS M2 BULDING NO: 2219, 54187, SAKARYA, Turkey, asudeates@hotmail.com, *Hüseyin PehlİIvan*

Human beings have a negative effect to natural environmental system,and global environmental change due to excessive carbon emissions. The main responsible of the global warming is CO2. It is generally accepted that production, processing, transport and consumption account for a relevant portion of the environmental(GHG)emissions associated with any country. The total amount of GHG produced to directly and indirectly support human activities and industrial actions .This research deals with the assessment of the carbon footprint for automobile industry,all activity is calculated and discussed.

■ MD-70

Monday, 14:30-16:00
R19-4

EURO Journal on Computational Optimization

Stream: Journals
Sponsor session

Chair: *Martine Labbé*, computer Science, Université Libre de Bruxelles, CP210/01, Boulevard du Triomphe, 1050, Bruxelles, Belgium, mlabbe@ulb.ac.be

■ MD-71

Monday, 14:30-16:00
R16-1

Logistics in Health and Disaster Response

Stream: Humanitarian Logistics
Invited session

Chair: *Gultekin Kuyzu*, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Caddesi No:43, Sogutozu, 06560, Ankara, Turkey, gkuyzu@etu.edu.tr

1 - Effect of Vulnerability on Locations of Pre-positioning Disaster Response Facilities

Serhan Duran, Industrial Engineering, Middle East Technical University, Orta Dogu Teknik Universitesi, Endustri Muh. Bolumu, 06531, Ankara, Turkey, sduran@metu.edu.tr, *Sinem Konu*

Pre-disaster planning helps reducing arrival time of relief items to affected areas. In this study, an MIP model is proposed to pre-position warehouses and determine amount of relief items to be stored. The effect of vulnerability of the transportation network on location and size decisions are investigated for the expected Istanbul earthquake.

2 - A vulnerability approach to modelling supply chain design

Ozias Ncube, Graduate School of Business Leadership, University of South Africa, P O Box 392, Muckleneuck, 0003, Pretoria, Gauteng, South Africa, ncubeo@unisa.ac.za, *Venkata Yadavalli*

Supply chain design has assumed significant importance recently because of vulnerability of supply chains. This in turn has impacted on supply chain performance, with at times disastrous consequences for the different supply chain players. In this paper, we show how supply chain vulnerability analysis can enhance supply chain design leading to robust supply chains. The approach is illustrated by a simulated example. The results indicate a better supply chain performance when vulnerability assumes a higher priority compared to elevating financial considerations.

3 - The Blood Collection Problem

Gultekin Kuyzu, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Caddesi No:43, Sogutozu, 06560, Ankara, Turkey, gkuyzu@etu.edu.tr, *Ali Ekici*, *Okan Ozener*

In this paper, motivated by the practices in blood supply management, we study a variant of the vehicle routing problem. Considering processing requirements of donated whole blood in order to extract platelets, we analyze the pickup operations from donation centers and develop algorithms to maximize the platelet production.

4 - GIS Integrated Emergency Logistics Coordination System

Samet Yilmaz, Industrial & Systems Eng., Yeditepe University, Turkey, yilmazsamet7@gmail.com, *Onur Demir*, *Linet Ozdamar*

The use of GIS in the highly dynamic environment of post-disaster response is discussed.Response centers have to deal with the coordination of relief distribution and medical evacuation at a large scale level where collected data is inaccurate.A web based data collection visualize updated information on geographical maps facilitates the task.We review GIS applications in the literature and discuss the scope of the ArcGIS Network Optimization Tool.The architecture of a large scale emergency logistics coordination system embedded in ArcGIS is discussed.An off-line demo finalizes the talk.

■ MD-72

Monday, 14:30-16:00
R16-2

Methodology of societal complexity and economy

Stream: Methodology of Social Complexity
Invited session

Chair: *Stephen Taylor*, Champlain Regional College, Retired, 5320 Avenue MacDonald, Apt 207, H3X 2W2, Cote Saint-Luc, Quebec, Canada, steveta@alumni.concordia.ca

1 - A Modified Gravity Model for Mexico - U.S. Migration Data

Duygu Cinar, Industrial and Systems Engineering, Yeditepe University, Resit belgesay sok. Dilek apt., No:29/23 Caddebostan Kadikoy, 34730, Istanbul, Turkey, duygu.cinar@live.com, *Deniz Duman*, *Linet Ozdamar*

In this paper,we theoretically and empirically investigate the determinants of net migration flows into United States from Mexico,by using the modified gravity model based on factors relevant for both countries.These factors are food and clean water availability per capita,the GDP per capita,employment rates,poverty headcount ratio,and percentage of migration prone population in source and destination countries.A multivariate regression model where net migration depends on these factors is constructed.Analysis of prediction errors obtained indicates that the model works with tolerable error.

2 - Corporate foresight and strategic decision making: Dealing with societal complexity

Ulrike Reisach, Information Management Faculty, Neu-Ulm University of Applied Sciences, Centre of Excellence in Corporate Communications, Wileystraße 1, 89231, Neu-Ulm, Bavaria, Germany, ulrike.reisach@hs-neu-ulm.de

Companies deal with societal complexity along their international value added chains. The worldwide diversity of business partners and societal/political/economic systems requires sensibility and adaptability and, at the same time, a strong corporate culture and identity. Strategic foresight and issues management help identifying, anticipating and shaping megatrends. This article explains how decision making is influenced by scenario techniques, internal and external expertise, corporate communications and government affairs networking, and corporate goals and psychology.

3 - Is topological invariance a reasonable assumption for studying social systems too? Methodological remarks on the application of NK simulation modeling

Lucio Biggiero, Department of Industrial Engineering, Information and Economics, University of L'Aquila, Via Giovanni Falcone, 25, 67100, L'Aquila, AQ, Italy, biggiero@ec.univaq.it

During the last decade NK simulation modeling has been used for studying social systems too, but without a clear awareness of the methodological implications deriving from the ontological differences between biological and social systems, and in particular of the higher degree of complexity of these latter. In fact, the NK methodology requires the assumption of topological invariance. In this paper it is argued that, consequently, it is better to apply it only to very small and simple social networks, in order to get general dynamic indications, like in the so-called scenario analyses.

4 - Energy Efficiency and Climate Change

Sudhakara Reddy, Energy and Envt., Indira Gandhi Institute of Development Research, Film City Road, Goregaon (E), 400065, Mumbai, Maharashtra, India, sreddy@igidr.ac.in

This paper develops a new systematic classification and explanation of barriers and drivers to energy efficiency. Using an 'actor oriented approach', the paper tries to identify (a) the drivers and barriers that affect the success or failure of energy efficiency investments and (b) the institutions that are responsible for the emergence of these barriers and drivers. This taxonomy aims to synthesise ideas from three broad perspectives, viz., micro, meso, and macro. The paper develops a systematic framework by looking at the issue from the perspective of different actors.

■ MD-73

Monday, 14:30-16:00
R16-3

OR in Forestry I

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *Concepcion Maroto*, Applied Statistics, Operations Research and Quality, Universitat Politecnica de Valencia, Camino de Vera S/N, 46071, Valencia, Spain, cmaroto@eio.upv.es

1 - Supporting forest management cooperatives in selecting a robust supply chain strategy for wood chips under uncertainty

Christian Trinks, -, Germany, christian.trinks@kit.edu

This work presents a simulation-based approach to support forest management cooperatives in selecting a robust supply chain strategy (SCS) for forest wood chips (FWC). The dynamic model considers epistemic supply chain uncertainties using expert-based scenarios. The performance of the FWC supply chain is measured by the criteria staging quantity, costs and regional value-added. Subsequently, the criteria are aggregated for each scenario to a supply chain performance index (SCPI) applying a survey-based AHP. Finally, the robustness of a SCS is determined by the location and spread of the SCPI.

2 - Decision support system for forest resources allocation and harvesting optimization in multiusers context

Mustapha Ouhimmou, GPA - Logistics and Operations Engineering, École de Technologie Supérieure, 1100, rue Notre Dame Ouest, H3C 1K3, Montréal, québec, Canada, mustapha.ouhimmou@etsmtl.ca, *Samir Haddad*, *Sébastien Lacroix*, *Jean Favreau*

The tactical planning in forest management involves the selection of harvest areas over a horizon of several years and allocates them to mills to fulfill certain demand. Several optimization criteria must be included to achieve sustainable forest management policies. Both government and industry face these questions and need decision support system to enable efficient plans. In this paper, we address this wood allocation problem and we propose simple approaches to weight different targets and spatial aspects (dispersion). Case studies have been conducted to validate the new formulations.

3 - An assessment of methods used in Decision Support Systems for solving forest management problems

Concepcion Maroto, Applied Statistics, Operations Research and Quality, Universitat Politecnica de Valencia, Camino de Vera S/N, 46071, Valencia, Spain, cmaroto@eio.upv.es, *Marina Segura Maroto*, *Duncan Ray*, *Baldomero Segura*

Appropriate approaches to deal with forest management problems using Decision Support Systems (DSSs) depend on their characteristics, such as the spatial context, the temporal and spatial scale, the number of objectives and decision makers/stakeholders, as well as the nature of goods and services. The objective of this paper is to analyse the relationship among these dimensions and the methods to solve forest problems in DSSs.Results have shown a significant relationship between problems and methods, useful to design and apply these DSSs in coming years.

■ MD-74

Monday, 14:30-16:00
R16-4

Teaching OR/MS III

Stream: Teaching OR/MS
Invited session

Chair: *Evelyn Richards*, Forestry, University of New Brunswick, 46 Cameron Court, UNB, E3B2R9, Fredericton, New Brunswick, Canada, Evelyn.Richards@gmail.com

1 - Developing OR application skills with AIMMS: a bridge in OR education
Ovidiu Listes, Paragon Decision Technology, Paragon Decision Technology, Schipholweg 1, 2034 LS, Haarlem, Netherlands, o.listes@aimms.com

We share some experiences in training both academics and OR professionals for developing OR application skills using AIMMS. Whether the users are students moving from theory to practice or professionals who need to acquire skills in a short time, AIMMS can contribute to bridging the gap in OR education. Fast and flexible modeling, powerful solvers and integrated visualization are among the AIMMS features which facilitate learning, create understanding and stimulate further application refinements. While we illustrate these aspects based on several examples, interaction is much appreciated.

2 - Educational Outreach Activities: Playing OR Games!
Paul Harper, School of Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, Wales, United Kingdom, harper@cardiff.ac.uk, *Vincent Knight*, *Louise Orpin*

The UK OR Society's "OR in Schools' taskforce has an ambitious stretch-goal that "every school child knows what OR is'. As well as creating www.learnaboutor.co.uk and an award winning careers video, visits to schools are an essential means of showcasing OR at an appropriate level for the student. The authors (current and past chair of the taskforce, and the society's Education Officer) will present an overview of activities and describe in particular some that introduce students to Game Theory and Epidemiology. These involve fun role play exercises which we will demonstrate.

3 - Production and Operations Management in the Lego-Factory
Evelyn Richards, Forestry, University of New Brunswick, 46 Cameron Court, UNB, E3B2R9, Fredericton, New Brunswick, Canada, Evelyn.Richards@gmail.com

A Lego^{TM} factory was "created' to help students learn to use simulation to design and improve production systems. The projects allowed students to explore relationships between system throughput, inventory, bottlenecks, and variability. Advantages and disadvantages of this approach will be discussed, and compared with student experience using an actual production problem case.

Monday, 16:30-17:30

■ ME-01

Monday, 16:30-17:30
O1-1

Plenary Lecture - Hal Varian

Stream: Invited Lectures - Plenary
Plenary session

Chair: *Marc Sevaux*, UMR 6285 - Lab-STICC - CNRS, Université de Bretagne Sud, Centre de Recherche - BP 92116, 2 rue de Saint Maudé, 56321, Lorient, France, marc.sevaux@univ-ubs.fr

1 - Predicting the Present with Search Engine Data
Hal Varian, School of Information, University of California at Berkeley / GOOGLE, 102 South Hall, 94720-4600, Berkeley, CA, United States, hal@sims.berkeley.edu

Many businesses now have almost real time data available about their operations. This data can be helpful in contemporaneous prediction ("nowcasting") of various economic indicators. We illustrate how one can use Google search data to nowcast economic metrics of interest, and discuss some of the ramifications for research and policy.

Our approach combines three Bayesian techniques: Kalman filtering, spike-and-slab regression, and model averaging. We use Kalman filtering to whiten the time series in question by removing the trend and seasonal behavior. Spike-and-slab regression is a Bayesian method for variable selection that works even in cases where the number of predictors is far larger than the number of observations. Finally, we use Markov Chain Monte Carlo methods to sample from the posterior distribution for our model; the final forecast is an average over thousands of draws from the posterior.

An advantage of the Bayesian approach is that it allows us to specify informative priors that affect the number and type of predictors in a flexible way.

Tuesday, 8:30-10:00

■ TA-03

Tuesday, 8:30-10:00
O1-3

Recent developments from Nonconvex Programming

Stream: Nonconvex Programming: Local and Global Approaches
Invited session

Chair: *Hoai An Le Thi*, Computer Science, University of Lorraine, Ile du Saulcy,, 57 045, Metz, France, hoai-an.le-thi@univ-lorraine.fr

1 - Improving the Normal Boundary Intersection (NBI) Method for Generation of Pareto Frontiers in Nonconvex Multi-objective Optimization Problems
Sauleh Siddiqui, Johns Hopkins University, 3400 N Charles St, 21218, Baltimore, MD, United States, siddiqui@jhu.edu

We provide a modification of the NBI method to obtain a continuous Pareto frontier for a multi-objective optimization (MO) problem "in one go,' i.e., by solving only one single-optimization problem and preserving computational efficiency for nonconvex MO problems. The proposed method can solve nonconvex MO problems with discontinuous Pareto frontiers using significantly fewer optimization problems than the original NBI and other popular gradient-based methods. The MO problem is solved using a quasi-Newton method whose sequence of iterates is used to obtain points on the Pareto frontier.

2 - Quadratic Eigenvalue Complementarity Problem via DC Programming Approaches
Yi-Shuai Niu, Institute for Scientific Computation and Simulation, University of Paris 6 (UPMC), 4 place jussieu, 75005, Paris, France, niuys@insa-rouen.fr, *Joaquim Judice*, *Hoai An Le Thi*, *Tao Pham Dinh*

We discuss the solution of the Quadratic Eigenvalue Complementarity Problem (QEiCP) via DC programming approaches. The QEiCP is stated as a nonconvex polynomial program, and different DC (Difference of convex functions) formulations are introduced for dealing with this program. These DC programs can be solved by a well-known and efficient DC Algorithm. We also propose a new DC Algorithm based on DCA and local DC decomposition which constructs refined local DC decomposition required in each iteration. Some experiments are reported to illustrate the efficiency of these DCAs in practice.

3 - Recent Advances in DC Programming and DCA
Tao Pham Dinh, INSA Rouen, 76131, Rouen, France, pham@insa-rouen.fr, *Hoai An Le Thi*

The talk is about the State of the Art in DC Programming and DCA with recent advances to meet the growing need for nonconvex programming and global optimization, in terms of mathematical modeling as in terms of efficient scalable solution methods based on these theoretical and algorithmic tools. We outline main results on convergence of DCA in DC programming with subanalytic data, exact penalty techniques with/without error bounds in DC programming (including mixed integer DC programming and DC programming with zero-norm), and DCA for general DC programs.

4 - Retrospective trust-region for data estimation
Fabian Bastin, Computing Science and Operations Research, University of Montreal, C.P. 6128, Succ. Centre-Ville, H3C 3J7, Montreal, Quebec, Canada, bastin@iro.umontreal.ca, *Tien Mai Anh*

We consider the restrospective trust-region method in the context of data estimation. It is well known that in nonlinear least-squares of log-likelihood maximization, the outer product of the scores can be used as an efficient estimation of the Hessian under some conditions, but when used in quasi-Newton techniques, the convergence can be poor if these requirements are not met. Capitalizing on Hessian approximation combinations, we exhibit that fast and robust convergence can be achieved, while some interesting properties emerge from the use of a retrospective approach.

■ TA-04

Tuesday, 8:30-10:00
O4-4

Advances in Mathematical Programming

Stream: Mathematical Programming
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Tamás Terlaky*, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

1 - Trace-Penalty Minimization for Large-scale Eigenspace Computation
Yin Zhang, Dept. of CAAM, Rice University, 6100 Main Street, Rice University, 77005, Houston, Texas, United States, yzhang@rice.edu, *Zaiwen Wen*, *Chao Yang*, *Xin Liu*

The Rayleigh-Ritz (RR) procedure is a major bottleneck in computing relatively high-dimensional eigenspaces of large sparse matrices, in part because of its relatively low parallel scalability. In this paper we propose an unconstrained optimization model and establish its equivalence to the eigenvalue problem. This model enables us to greatly reduces the use of the RR procedure and to deploy more parallelizable algorithms using predominately dense matrix-matrix multiplications. Numerical results show that our approach is promising in achieving high parallel scalability.

2 - A simple and original method to obtain the optimal power operating point of the solar cell
Jaleleddine Ben Amor, Masc, Sup com, Manar I, BL.E App 31, 2092, Tunis, tunisia, Tunisia, jaleleddine.benamor@fst.rnu.tn

We present a theoretical and a numerical comparative study of single and double diode models attributed to the photo pile. We adapt the Lagrange methods to solve some optimization programs. So, by a simple method we obtain the optimal power operating point. We note that, throughout this study we obtain the following remarkable properties: The same expression of Lagrange's multiplier and the same frame of the optimal voltage was established in both models. The numerical resolution to obtain the optimal power operating point was made by Matlab.

3 - Inexact BOSVS Algorithm for Ill-Posed Inversion with Application to Parallel Image Reconstruction
Maryam Yashtini, Department of Mathematics, University of Florida, Gainesville, Florida, United States, myashtini@ufl.edu, *William Hager*, *Hongchao Zhang*

This paper proposes an Inexact Bregman operator splitting algorithm with variable stepsize (Inexact BOSVS) for solving non-smooth convex optimization problems that arise in image analysis. The original BOSVS algorithm uses a line search to achieve efficiency, while a proximal parameter is adjusted to ensure global convergence whenever a monotonicity condition is violated. The new Inexact BOSVS uses a simpler line search than that used by BOSVS, and the monotonicity test can be skipped. Numerical experiments are given on partially parallel image reconstruction.

■ TA-05

Tuesday, 8:30-10:00
O4-1

Dynamic Games

Stream: Optimal Control
Invited session

Chair: *Guiomar Martin-Herran*, IMUVA, Universidad de Valladolid, Facultad de Ciencias Economicas y Empresariales, Avda. Valle Esgueva, 6, 47011, Valladolid, Spain, guiomar@eco.uva.es

1 - A noncooperative differential game of a stochastic productive asset

Ricardo Josa-Fombellida, Estadística e Investigación Operativa, Universidad de Valladolid, Facultad de Ciencias, Paseo Prado de la Magdalena, s/n, 47005, Valladolid, Spain, ricar@eio.uva.es, *Juan Pablo Rincon-Zapatero*

We study a dynamic game where players have free access to a productive asset which evolution is a diffusion process with Brownian uncertainty. The game is noncooperative symmetric and the players try to maximize their individual expected utility given the actions taken for the remainder players. We provide rigorous conditions for the existence and uniqueness of Subgame Perfect Nash Equilibria of the game and analyze some of their properties. We also find the equilibrium stochastic Keynes-Ramsey rule.

2 - Pareto-Nash-Stackelberg control problems: mathematical models and principles of solving

Valeriu Ungureanu, Department of Applied Mathematics, State University of Moldova, Gh. Asachi str., 58, ap.38, MD-2009, Chisinau, Moldova, Republic Of, v.a.ungureanu@gmail.com

Optimal control notion is extended and generalized by considering a control of Pareto-Nash-Stackelberg equilibrium type. Equilibrium Principles for a Mixture of Hierarchical and Simultaneous Games are integrated with Control Process by means of best and efficient response mappings, intersection of mappings graphs and multi-level multi-criteria optimization. A direct solution principle is applied to linear mono-valued and set-valued discrete-time PNS control problems. Direct principle is compared with Pontryagin and Bellman principles, which are applied to solve considered problems, too.

3 - Cooperative and non-cooperative trade-offs among design quality and cost-reducing r&d in a supply chain

Juan Carlos Espinoza Garcia, Operations Management, ESSEC Business School, Avenue Bernard Hirsch, B.P. 105, 95021, Cergy Pontoise, France, b00319981@essec.edu, *Fouad El Ouardighi*, *Victoire Denoyel*

In a dynamic model of collaboration between a manufacturer and its supplier: how to allocate each player's resources between improving an existing product and reducing its production cost? To distinguish dynamic from strategic effects, we derive the open-loop, closed-loop, and Markov perfect Nash equilibria with the cooperative solution as a benchmark. The latter strategies contrast with the open loop equilibrium that is close to cooperation. This suggests that strategic aspects are detrimental to the efficiency of the trade-off among cost reduction and quality improvement in a supply chain.

4 - Non-Linear Strategies in Differential Games: A Numerical Investigation

Guiomar Martin-Herran, IMUVA, Universidad de Valladolid, Facultad de Ciencias Economicas y Empresariales, Avda. Valle Esgueva, 6, 47011, Valladolid, Spain, guiomar@eco.uva.es, *Javier de Frutos*

Differential games have been extensively employed to model economic problems in a number of areas including industrial organization, marketing, macroeconomic policy or environmental problems. The choice of type of model is frequently driven by the tractability problem which forces the model to belong to the class of linear-state or linear-quadratic differential games. However, considering models with a more general non-linearity can lead to meaningful richer conclusions extending their applicability. Numerical methods are a powerful tool to investigate non-linear differential games.

■ TA-06

Tuesday, 8:30-10:00
O4-2

Nonsmooth Optimization and its Applications

Stream: Nonsmooth Optimization
Invited session

Chair: *Antonio Fuduli*, Dipartimento di Matematica e Informatica, Universita' della Calabria, Via P. Bucci, CUBO 31B, 87036, Rende, Italy, antonio.fuduli@unical.it

1 - The hyperbolic penalty method on the load profiles clustering

Luiz Antonio Alves de Oliveira, Electrical Power System Department, CEPEL - Electric Energy Research Center, Av. Horacio de Macedo N. 354, 21941-911, RIO DE JANEIRO, RJ, Brazil, laao@cepel.br, *José Francisco Pessanha*, *Adilson Elias Xavier*

The paper proposes to investigate the use of the hyperbolic penalty method in identifying typical daily load profiles, a key information in various stages of the planning and operation of electric power systems. These profiles are used for many applications, such as: calculation of tariffs, evaluation of the energy losses, dispatch of generating units, demand forecasting. In order to show the performance of the hyperbolic penalty method on this clustering problem, the paper presents the results from computational experiments with large data-sets from Brazilian electrical power system.

2 - The Interior Epigraph Directions Method for Nonsmooth and Nonconvex Problems - New Developments

Wilhelm Passarella Freire, Mathematics, Federal University of Juiz de Fora, Campus Universitário - Bairro Martelos. Juiz de Fora - MG, Brasil, 36036-900, Juiz de Fora, Minas Gerais, Brazil, wilhelmfreire@yahoo.com.br, *Regina Burachik*, *C Yalcin Kaya*

The Interior Epigraph Directions (IED) Method has been devised for solving constrained nonsmooth and nonconvex optimization problems. The Nonsmooth Feasible Directions Algorithm (NFDA) and the Deflected Subgradient Algorithm are combined to produce the IED method which considers the dual problem induced by a generalized augmented lagrangian duality scheme and obtains the primal solution by generating a sequence in the interior of the dual epigraph. We propose new strategies for solving the dual problem and compare the new results with the previous ones.

3 - Smooth and non-smooth constrained optimisation using exact and quadratic penalty functions based on RPROP search

Apostolos Kotsialos, School of Engineering and Computing Sciences, Durham University, South Road, DH1 3LE, Durham, United Kingdom, apostolos.kotsialos@durham.ac.uk

The optimisation of a smooth or nonsmooth objective function subject to smooth or nonsmooth constraints is the subject of this paper. We incorporate exact (and quadratic for comparison) penalty terms in the form of weighted absolute values of the constraints into the objective function and solve the resulting nonsmooth unconstrained problem. The Resilient Backpropagation (RPROP) dimension-wise search and step update method is used for solving it. RPROP is a simple search method used in the past for solving fast and efficiently unconstrained and simply bounded large scale nonsmooth problems.

4 - Non-smooth Modeling of Certain Microhardness Problems

Ahmet Sahiner, Mathematics, Suleyman Demirel University, Department of Mathematics, Suleyman Demirel University, East Campus, 32260, ISPARTA, Turkey, ahmetsahiner@sdu.edu.tr

In this study, as a traditional optimization technique Fuzzy logic and as a deterministic optimization technique filled function method are employed in the modeling of certain types of microhardness problems in Physics.

■ TA-07

Tuesday, 8:30-10:00
O4-3

Vector and Set-Valued Optimization IV

Stream: Vector and Set-Valued Optimization
Invited session

Chair: *Elena Molho*, Dipartimento di Scienze Economiche e

Aziendali, Università di Pavia, Via San Felice 5, 27100, Pavia, Italy, molhoe@eco.unipv.it
Chair: *Enrico Miglierina*, Dipartimento di Discipline Matematiche, Finanza Matematica ed Econometria, Università Cattolica del Sacro Cuore, via Necchi 9, 20123, Milano, Italy, enrico.miglierina@unicatt.it

1 - Hierarchical stratification of Pareto sets
Alberto Lovison, Dipartimento di Metodi e Modelli Matematici, Università degli Studi di Padova, 35121, Padova, Italy, lovison@math.unipd.it

In smooth and convex multiobjective optimization problems the set of Pareto optima is diffeomorphic to an m-1 dimensional simplex, where m is the number of objective functions. Furthermore, the vertices of the curved simplex are the optima of the objectives when considered separately, while the k-1 dimensional sub simplexes are the Pareto optimal sets obtained considering jointly subsets of k objective functions. In this talk we will tackle the problem for the general smooth but non convex case, adopting the Smale framework of the Pareto critical set.

2 - A sensitivity result in convex vector-valued optimization
Rita Pini, Dipartimento di Matematica e Applicazioni, Università degli Studi Milano Bicocca, Via Cozzi, 53, 20125, Milano, Italy, rita.pini@unimib.it

We prove a non-global inverse map result for the sum of two maps. Among its implications in terms of sensitivity of parametric generalized equations, we investigate a global condition number for convex vector-valued problems in the Euclidean framework. Indeed, two approaches can be considered, the pointwise approach, and the global one. While the first one focuses on a fixed solution, the global condition number is built as a direct sensitivity measure on the weakly efficient solution map of the perturbed problems.

3 - Variational inequalities in set optimization
Giovanni Paolo Crespi, Economis and Business Management, University of Valle d'Aosta, Loc. Grand Chemin 73/75, 11020, Saint Christophe, Aosta, Italy, g.crespi@univda.it, *Carola Schrage*

Variational inequalities provide necessary and sufficient optimality conditions for scalar and vector optimization problem. Focusing on the notion of infimizers and minimizers for set valued (convex) optimization problems as introduced by Lhone, we develope variational inequalities that provides necessary and sufficient conditions. Inequalities are defined by means of Dini directional derivatives that we introduce both for the set valued function and its scalarization.

4 - A scalarization scheme in set optimization with applications to Tykhonov well-posedness
Elena Molho, Dipartimento di Scienze Economiche e Aziendali, Università di Pavia, Via San Felice 5, 27100, Pavia, Italy, molhoe@eco.unipv.it, *César Gutiérrez*, *Enrico Miglierina*, *Vicente Novo*

We develop a Gerstewitz-type scalarization scheme in set optimization that allows us to avoid the assumption of cone-boundedness. We obtain the equivalence between the well-posedness of the original set optimization problem at a given strict minimizer x* and the classical Tykhonov well-posedness of the scalarized problem, under the assumption that the set F (x*) is cone proper. Finally, we use an existing notion of quasiconvexity for set-valued maps in order to individuate a class of well-posed problems.

■ TA-08

Tuesday, 8:30-10:00
O3-2

Tutorial - Z. Gu

Stream: Invited Lectures - Keynotes and Tutorials
Tutorial session

Chair: *Ariela Sofer*, SEOR, George Mason University, MS4A6 4400 University Drive, 22030, Fairfax, VA, United States, asofer@gmu.edu

1 - Mixed Integer Programming: Algorithms, Computation, Software and Applications
Zonghao Gu, Gurobi Optimization, 4050 Walnut Creek Trail, 30005, alpharetta, Georgia, United States, gu@gurobi.com

Mixed integer programs can be linear, quadratic, quadratically constrained, general convex nonlinear or non-convex nonlinear. We will only focus on linear, quadratic and quadratically constrained problem types, i.e., MILP, MIQP and MIQCP. We will briefly discuss the history of Mixed Integer Programming and review important algorithms, such simplex and the branch-and-cut algorithm. One of our main focus will be on computational aspects of math programming, which are crucial for building and deploying successful optimization applications. This talk will discuss different technologies used in commercial optimization solvers, with an emphasis on understanding the extent to which each contributes to overall algorithmic progress. We will also give computational results to try to characterize the current state of the art, as well as talking about a few software-design considerations, including progress in user interfaces, compute server capabilities, and advanced features, such as callbacks. Finally we will talk about several applications to show the benefits that progress in algorithms, computation and software can bring to real world problems.

■ TA-09

Tuesday, 8:30-10:00
O3-3

Sponsor - OPTIRISK

Stream: Sponsors
Sponsor session

Chair: *Antonino Sgalambro*, Istituto per le Applicazioni del Calcolo "Mauro Picone", National Research Council (CNR), Via dei Taurini 19, 00185, Roma, Italy, a.sgalambro@iac.cnr.it

1 - AMPLDev with SAMPL: modelling tools for Stochastic Programming and Robust Optimisation
Christian Valente, OptiRisk Systems, OptiRisk R&D House, 1 Oxford Road, UB9 4DA, Uxbridge, Middlesex, United Kingdom, christian@optirisk-systems.com

Algebraic modelling languages (AML) are now well established as an important formulation tool used by both practitioners and academics in the field of operational research. Over a number of years OptiRisk Systems have developed tools and software components which support the task of formulating and solving optimisation based decision models. The company's products and services thus cover modellers support, AML extensions and solution algorithms. OptiRisk has recently introduced AMPLDev which is a modern modelling environment, AMPLDev supports modellers in the organisation of their data and models. AMPLDev is multiplatform and robust; it is implemented on the Eclipse framework. OptiRisk has also extended the modelling language (AMPL) which is a well known AML to support SP formulations. The enhanced language constructs we call SAMPL (Stochastic AMPL). This extended AML supports native representation of scenario-based stochastic programming recourse formulations. These SP modeling constructs are in addition to the modeling constructs already supported by the base language. Facilities for representing robust optimisation problems have also been added. The current version of SAMPL provides therefore native representation of: • stochastic programming (SP) with recourse; • chance constraints; • integrated chance constraints; • robust optimisation. We call this "direct representation' of models of such classes, as opposed to deterministic equivalent representation. The direct representation allows the modeller to convey the structure of the model to the solver, which can greatly improve efficiency and scalability.

■ TA-10

Tuesday, 8:30-10:00
G5-1

Telecommunications

Stream: Telecommunications and Network Optimiza-

tion
Invited session

Chair: *Giuliana Carello*, Elettronica, Informazione e Bioingegneria, Politecnico di Milano, via Ponzio 347%, 20133, Milano, Italy, giuliana.carello@polimi.it

1 - Local Search for the Reload Cost Spanning Tree Problem
Mustafa Sahin, The Robert H. Smith School of Business, University of Maryland, 20742, College Park, Maryland, United States, mustafa.sahin@rhsmith.umd.edu, *S. Raghavan*

We discuss the reload cost spanning tree problem (RCSTP) where we try to find the spanning tree with the minimum total reload cost, each node has a demand from every other node, each edge is colored and a reload cost is incurred for every color change. The RCSTP was introduced and shown to be NP-complete by Gamvros et al. (2012). We propose local search heuristics operating in a tree-nontree edge swap neighborhood and how to efficiently conduct search. We present computational results comparing the heuristic solutions with optimal solutions and examine performance for large-scale instances.

2 - Matheuristics for unsplittable multicommodity flow problems
Dorabella Santos, Instituto de Telecomunicações - Pólo de Aveiro, Campus de Santiago, Aveiro, 3810-193, Aveiro, Portugal, dorabella@av.it.pt, *Filipe Alvelos*, *Amaro de Sousa*

We present a hybrid metaheuristic framework which combines column generation techniques and metaheuristics for solving combinatorial optimization problems: SearchCol, which stands for "metaheuristic search by column generation". In this presentation, we apply SearchCol to multicommodity flow problems. We assume single path routing and address two optimization objectives: (i) minimization of the total routing cost; and (ii) minimization of the maximum load of the arcs. We present computational results for both problems and for the different variants of SearchCol.

3 - Energy-aware survivable networks with shared protection mechanism
Sara Mattia, Istituto di Analisi dei Sistemi ed Informatica, Consiglio Nazionale delle Ricerche, viale Manzoni 30, 00185, Roma, Italy, sara.mattia@iasi.cnr.it, *Bernardetta Addis*, *Giuliana Carello*

The problem of optimally managing an energy aware resilient network is considered. Given a set of demands, a primary and backup path must be assigned to each demand. The backup capacity can be shared by backup paths of demands not affected by the same failures. When an edge is active (it is needed by some paths), it consumes energy. As fault conditions are usually quickly resolved, we assume that the energy consumption is due only to the primary paths. The aim is to ensure the routing of the demands, minimizing the energy consumption.

4 - On a Maximum Flow Minimum Reload Cost Problem
Donatella Granata, Istituto per le Applicazioni del Calcolo Mauro Picone, Consiglio Nazionale delle Ricerche, 80131, napoli, Italy, d.granata@na.iac.cnr.it, *Paola Festa*

In this talk, we will describe a special reload cost problem consisting in finding in a di-graph a maximum flow between a source and a sink node, which minimizes the total reload cost, i.e., the sum of the costs to be paid whenever two consecutive arcs belonging to the solution are of different types. We will first state the complexity class to which the problem belongs. Then, we will mathematically formulate it as a mixed-integer linear program and describe a Branch and Price algorithm to optimally solve it. Finally, some preliminary results will be reported and discussed.

■ TA-11

Tuesday, 8:30-10:00
G5-3

Telecommunications, Networks and Social Networks 3

Stream: Telecommunications, Networks and Social Networks (contributed)
Contributed session

Chair: *Carlos Obreque*, Industrial Enginnering, Universidad del Bío-Bío, Concepción, Chile, cobreque@ubiobio.cl

1 - Sanction Effectiveness in Iran: A Network Optimization Approach
Louis Boguchwal, London School of Economics and Political Science, Network Science Center at West Point, United Kingdom, L.Boguchwal@lse.ac.uk

In this project, we apply network flow algorithms to evaluate the effectiveness of existing or additional sanctions for hindering the progress of Iran's nuclear program. We restrict our attention to sanctions that disrupt flows of pertinent resources to appropriate individuals or organizations. This research uses minimum cut methods to provide the key and minimum number of edges in a resource network to cut, such that the nuclear production process is impeded.

2 - A Branch and Cut Method to solve the p-cable trench problem.
Carlos Obreque, Industrial Enginnering, Universidad del Bío-Bío, Concepción, Chile, cobreque@ubiobio.cl, *Vladimir Marianov*, *Oscar Cornejo*, *Gabriel Gutiérrez-Jarpa*

The p-cable trench is a network design problem consisting in locating p facilities and connecting each client with a facility through a cable. Cables must lie in trenches. The objective minimizes cable length and trench digging costs. WiFi systems and forest exploitation are examples of applications. We present a linear integer model and we use valid cuts based on Mixed Integer Rounding in a Branch and Cut procedure to solve it. We provide preliminary computational experience.

3 - A Multi-Objective Nodes Placement Problem for the Next Generation Network Infrastructure
Saoussen Krichen, Institut Superieur de Gestion, 2080, Ariana, Tunisia, saoussen.krichen@isg.rnu.tn, *Ons Abdelkhalek*, *Adel Guitouni*

The Next Generation Networks (NGN) focus on creating a new wireless architecture from heterogeneous components while achieving cost effectiveness and ease of management. In this presentation, we address NGN infrastructure planning given spatial distributions of demand. The problem is modeled as a multi-objective optimization problem. The objective functions include minimization of infrastructure cost and maximization of network performances (e.g., bandwidth, coverage). An evolutionary algorithm is implemented. The empirical results are based on realistic simulated problems

4 - Measuring Digital Divides Among Countries
Chaiho Kim, OMIS Department, Santa Clara University, 500 El Camino Read, 95070, Santa Clara, CA, United States, ckim@scu.edu

Mobile-cellular telephone subscriptions, percent of individuals using the Internet, and fixed telephone subscriptions are three of eleven, called ICT, indices used by International Telecommunication Union to measure information society. Each can also be used as a measure of digital divide. We divide the countries into a number of regional groups and examine whether the relations between these ICT indices and the usual explanatory variables such as GDP-PPP and literacy rates are similar for different regional groups. Economic and Societal implications of our observations will be explored.

■ TA-12

Tuesday, 8:30-10:00
G5-4

Routing with profits

Stream: Transportation and Logistics
Invited session

Chair: *Claudia Archetti*, Department of Quantitative Methods, University of Brescia, Contrada Santa Chiara 50, I-25122, Brescia, Italy, archetti@eco.unibs.it

1 - Reoptimizing the Rural Postman Problem
Claudia Archetti, Department of Quantitative Methods, University of Brescia, Contrada Santa Chiara 50, I-25122, Brescia, Italy, archetti@eco.unibs.it, *Gianfranco Guastaroba*, *M. Grazia Speranza*

Given an instance of the Rural Postman Problem (RPP) together with its optimal solution, we study the problem of finding a good feasible solution after a perturbation of the instance has occurred. We refer to this problem as the reoptimization of the RPP. We consider the case where a new required edge is added or removed. We show that the reoptimization problems are NP-hard and study the worst-case ratios of heuristic algorithms for both problems. Computational tests are made to compare the performance of these algorithms with respect to the Frederickson algorithm running from scratch.

2 - On solving Routing Problems with Time Windows given Dynamic Service Times and Profits
Verena Schmid, Departamento de Ingeniería Industrial, Universidad de los Andes, Bogotá, Colombia, v.schmid@uniandes.edu.co, *Juan Sebastián Gómez Rodríguez*

We present an extension of a routing problem with profits and time windows. We aim at finding profitable tours, which need to be feasible with respect to time windows, while minimizing travel costs minus collected profit. Profits depend on the length of service time. A solution can hence be represented by the sequence of customers to be visited, as well as the length of stay. The proposed algorithm is hybrid. The search for good sequences will be guided by means of Large Neighborhood Search. Any sequence may then be evaluated using Dynamic Programming to determine the optimal length of stay.

3 - Heuristics for the Orienteering Problem with Stochastic Travel and Service Times based on Monte Carlo Sampling
Dennis Weyland, IDSIA, Galleria 2, 6928, Manno - Lugano, Switzerland, dennis@idsia.ch, *Vassilis Papapanagiotou*, *Roberto Montemanni*, *Luca Maria Gambardella*

In this work we investigate a stochastic variant of the Orienteering Problem, the so-called Orienteering Problem with Stochastic Travel and Service Times. As the name suggests, here the travel and service times are modeled in a stochastic way. The goal is to select a subset of customers and to define an order in which these customers are visited, such that the expected profit over the given stochastic input is maximized. We propose a heuristic using an approximation of the objective function based on Monte Carlo sampling. Extensive computational studies reveal the efficiency of our approach.

4 - An Ant Colony Optimization Algorithm for Traveling Salesman Problem
Çağla Cergibozan, Department of Industrial Engineering, Dokuz Eylül University, İzmir, Turkey, cagla.cergibozan@deu.edu.tr, *A. Serdar Tasan*

Traveling salesman problem (TSP) is the problem of creating a Hamiltonian cycle in which each node is visited only once to minimize total distance travelled. Ant colony optimization (ACO) is a metaheuristic approach for solving optimization problems. Aim of this study is to develop an efficient and effective algorithm that can be applicable to real life problems. In the study, an ACO algorithm which utilizes local search heuristics is proposed. The algorithm is applied to well-known TSP datasets and then performance of the approach is evaluated according to results of the computational study.

■ TA-13

Tuesday, 8:30-10:00
G5-5

Flexible public transport

Stream: Traffic
Invited session

Chair: *Pasquale Carotenuto*, Istituto per le Applicazioni del Calcolo "M. Picone", Consiglio Nazionale delle Ricerche, via dei Taurini 19, 00185, Roma, RM, Italy, carotenuto@iac.cnr.it

1 - Apply a heuristics for flexible transport systems to a real case
Leonardo Paradisi, University of Rome "Tor Vergata", Italy, paradisi86@gmail.com, *Pasquale Carotenuto*, *Angélica Lozano*, *Giovanni Storchi*

The demand responsive transport systems (DRTS) aim to satisfy two main objectives: the service flexibility and the costs minimization. They are a good solution for the trade-off between flexibility and efficiency. They require the planning of travel paths (routing) and customers pick-up and drop-off times (scheduling) according to received requests. DRTS may operate according to a static or dynamic mode. The aim of this work is to test on a real case a heuristic for a flexible transport system with different service parameters: fleet size, vehicle capacity, time windows and incoming requests.

2 - Metaheuristic approach for the heterogeneous dial-a-ride problem with multiple depots
Kris Braekers, Research Group Logistics, Hasselt University, Universiteit Hasselt, campus Diepenbeek, Agoralaan gebouw D, 3590, Diepenbeek, Belgium, kris.braekers@uhasselt.be, *An Caris*, *Gerrit K. Janssens*

In this paper a metaheuristic approach for the dial-a-ride problem with heterogeneous users and vehicles (HDARP) is proposed. Several local search operators are embedded in an adaptive threshold accepting framework. Results on several sets of benchmark instances show that our algorithm is competitive with or outperforms current state-of-the-art methods. Finally, a multiple depot version of the HDARP is introduced. This extension allows to investigate possible advantages of creating depots nearby clusters of users or advantages of cooperation among several dial-a-ride service providers.

3 - A genetic algorithm approach for multi objective multi depot vehicle routing & allocation problem
Gokce Ozden, Eskisehir Vocational School,Machinery Programme, Eskisehir Osmangazi University, Organize Sanayi Bol. Antrepo Cad.No:1, 26110, ESKISEHIR, Turkey, gozden@ogu.edu.tr, *Gulcan Gocuklu*, *Burak Urazel*

In this study, a multi objective multi depot vehicle routing allocation problem (MO-MDVRAP) is mathematically modelled by considering current models in the literature. Goal programming is used as a solution method and solvability of the model is shown by computational tests on a fictional scenario. A genetic algorithm (GA) approach is proposed to solve MO-MDVRAP on larger scale and coded using MATLAB. The same model is also solved using GAMS for comparison and the results indicate that GA performs well in terms of efficiency and applicability.

4 - Online Regret Algorithm for dynamic dial a ride problem and its metrics on performance vs costs vs profits.
Athanasios Lois, Department of Mechanical Engineering, University of Thessaly, Athninon & Sekeri, 38222, Volos, Greece, lois@uth.gr, *Athanasios Ziliaskopoulos*

In this paper, an online regret based "dial a ride" algorithm is introduced and its performance evaluated on an actual DRT system. Algorithm's optimization engine is a scheme of signals communication (similar to interrupt controller) between trip dispatcher and the algorithm. It is used to aggressively allocate even small fragments of idle time to the engine. Another contribution is the identification of the critical parameters in the trade-off between gains from continuing to optimize an online system versus the losses from non-served demands due to consumed time from optimization engine.

■ TA-14

Tuesday, 8:30-10:00
G5-6

Metaheuristics applications

Stream: Metaheuristics
Invited session

Chair: *Amirreza Nickkar*, Center for Technology Studies of Sharif University of Technology, Tehran, Tehran, Iran, Islamic Republic Of, amirreza.nickkar@yahoo.com

1 - Electric Load Scheduling using Genetic Algorithms
Carlos Henggeler Antunes, DEEC, University of Coimbra and INESC Coimbra, Rua Antero de Quental 199, 3000-033, Coimbra, Portugal, ch@deec.uc.pt, *Ana Soares*, *Alvaro Gomes*

A genetic algorithm based approach to optimize the scheduling of domestic electric loads is presented. The aim is minimizing the end-user's electricity bill taking into account grid signals, technical issues and user-defined constraints regarding the quality of energy services provided. Constraints include the contracted power level, preferences pertaining to the admissible and/or preferable time periods for operation of each load, comfort thresholds. The load scheduling is done for a given period assuming that a dynamic price structure is known.

2 - An design tool for communication networks in centralized systems of measurement of electricity consumption
Eduardo Martins, Pipca, Unisinos, Brazil, zeca-jv@hotmail.com, *Jose Vicente Canto dos Santos*

Centralized measurement systems are a choice for automating networks of electricity, this is part of the so-called smart grids. In Brazil, a work is being developed to create these networks: the use of an infrastructure measurement, to reducing commercial losses of energy. This work describes a tool, based on Simulating Annealing, to support the design of networks for advanced metering infrastructure using equipment measurement systems, ensuring maximum coverage network, service to all defined customers and minimizing installation costs. Tests performed showed satisfactory results.

3 - Optimal Capacitor Placement to Reduce Active Losses in Distribution Systems via Bioinspired Optimization and Search Space Reduction
Ivo Chaves Silva Junior, Energy, Federal University at Juiz de Fora, Rua José Lourenço Kelmer, s/n - Campus Universitário, 36036-900 , Juiz de Fora, Minas Gerais, Brazil, ivo.junior@ufjf.edu.br, *Bruno Dias*, *Andre Marcato*

The present work presents a hybrid algorithm to solve the optimal capacitor bank placement in electrical power distribution systems. To do so, this algorithm is divided in two steps: (i) Heuristic Step, aiming at reducing the number of candidates bussbars to place capacitor banks; (ii) Bioinspired Search Step, aiming at finding the best placement configuration based on particle swarm optimization. The proposed methodology is tested in two broadly systems used in the literature, presenting some promising results.

4 - Solving the Flight Perturbation Problem Considering Crews Constraints Using Simulated Annealing Algorithm
Amirreza Nickkar, Center for Technology Studies of Sharif University of Technology, Tehran, Tehran, Iran, Islamic Republic Of, amirreza.nickkar@yahoo.com, *Hassan Khaksar*

In this paper the re-assignment of aircraft to the flight with regarding crew's constraints after occurring perturbation conditions in flight network has been considered and a developed model has been offered. The results show that the proposed model is effective in small sizes but not large sizes of flight network and we should use the metaheuristic approaches that in this study simulated annealing approach was proposed. Also the findings show that the proposed algorithm can give a close response to the optimal solution in a reasonable time.

■ TA-15

Tuesday, 8:30-10:00
G5-2

Applications of Metaheuristics

Stream: Metaheuristics (contributed)
Contributed session
Chair: *Patrick Beullens*, School of Mathematics, School of Management, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, Hampshire, United Kingdom, P.Beullens@soton.ac.uk

1 - H.264 video encoder simulator applied in the digital platform of the brazilian tv
Arthur Gomez, University of Vale do Rio dos Sinos, AV unisinos 950, São Leopoldo, Brazil, Av. Joao Satt 25 apt 802A, 91390364, porto alegre, rs, Brazil, atgomezbr@gmail.com, *Iris Linck*, *Marta Villamil*

This paper presents a hybrid metaheuristic simulator applied to the H.264 encoder and decoder of video signals (H.264 codec). The main function of the simulator is to reproduce the dynamics of such behavior in order to find results that can be applied in the H.264 codec of the digital platform of the Brazilian TV. The expected results are the balance and the improvement in compression of video and in the image quality. The simulator was developed by using two metaheuristics, Tabu Search and Genetic Algorithm. The results obtained by the simulator were utilized to configure the H.264 codec.

2 - Stopping rules while searching for optimal solution of facility-location
Xiangli Meng, School of Technology and Business Studies, Dalarna University, Högskolan Dalarna, 79188, Falun, Sweden, xme@du.se, *Kenneth Carling*

Solutions to OR-problems frequently rely on numerical procedures to maximize an objective function with respect to a set of arguments. The maximum is sought iteratively and a criterion, such as the last change in the objective function, is needed to decide when the procedure attains the maximum. However, arbitrarily pre-setting the number of iterations dominates in OR applications. This practise prevails in spite of clever proposals for stopping rules. We implement the proposals on some location problems and illustrate that they provide a simple mean to control the quality in solutions.

3 - Multi-level regression analysis as a tool to design and evaluate heuristic algorithms
An Caris, Research Group Logistics, Hasselt University, Research Foundation Flanders (FWO), Agoralaan gebouw D, 3590, Diepenbeek, Belgium, an.caris@uhasselt.be, *Benoît Depaire*

In this paper we propose an experimental setup and statistical methodology to design and evaluate heuristic algorithms. We apply our approach to various heuristics proposed in literature for the classical VRPTW. First, a multi-level regression analysis is used to determine the algorithms' optimal parameter values and to construct decision rules stating which heuristic elements should be activated for a particular problem instance. Second, the performance of the various algorithms are statistically compared.

4 - Instance-specific parameter tuning by means of evolving fuzzy systems
Jana Ries, Portsmouth Business School, University of Portsmouth, Richmond Building, United Kingdom, jana.ries@port.ac.uk, *Patrick Beullens*, *José-Fernando Camacho-Vallejo*

Instance-specific parameter tuning (IPTS) allows for incorporating structural instance information into the selection of parameter values. One approach is to use a fuzzy inference system that uses instance characteristics and a preference on heuristic performance to determine parameter values. An effective fuzzy design needs to be adjustable to differently structured instances. Two evolving concepts are presented for IPTS designs using decision trees and fuzzy clustering. Results are shown for the TSP using Guided Local Search and the Road pricing problem using a Co-evolutionary algorithm.

■ TA-16

Tuesday, 8:30-10:00
G5-7

Vehicle Routing Problems II

Stream: Routing Problems
Invited session
Chair: *Aristide Mingozzi*, Department of Mathematics, University of Bologna, C.d.L. Scienze dell'Informazione, Via Sacchi, 3, 47023, Cesena, FC, Italy, mingozzi@csr.unibo.it
Chair: *Roberto Roberti*, DEIS, University of Bologna, Via Sacchi, 3, 47521, Cesena, Italy, roberto.roberti6@unibo.it

1 - A new mixed integer linear programming mathematical model for the multi-depot vehicle routing problem with multiple objectives: total cost and load balance
Santiago Nieto Isaza, Ingeniería Industrial, Universidad de la Costa, Cl 58 # 55-66, Barranquilla, Atlántico, Colombia, snieto2@cuc.edu.co, *Alcides Santander*, *Julian Lopez Franco*, *Nilson Herazo*

This work presents a MILP model for the Multiple Depot Vehicle Routing Problem (MDVRP) minimizing two objective functions: Total Cost and Load Imbalance. First, we present the mathematical formulation declaring both objectives as they are defined; then, we explain why this type of formulation cannot be solved; and then, the proposed MILP formulation is presented. Finally, we show experimental results using an e-constraint approach to solve small instances which prove that the proposed model can be solved using standard solvers such as CPLEX®.

2 - An exact algorithm for the multiple-depot vehicle routing problem
Claudio Contardo, Department of management and technology, ESG UQÀM, 315 rue Ste-Catherine, local R-3570, H2X 3X2, Montreal, Québec, Canada, contardo.claudio@uqam.ca

We present an exact algorithm for the multiple-depot vehicle routing problem (MDVRP) based on the sequential solution of a vehicle-flow and a set-partitioning formulation. The former is used to discard variables using reduced cost fixing, while the latter is used to solve the problem exactly. We introduce several families of valid inequalities to strengthen both formulations, including a new family used to forbid cycles of an arbitrary length. We present computational results on instances of the MDVRP and the capacitated vehicle routing problem (CVRP) and discuss avenues of future research.

3 - The multi-trip vehicle routing problem with time windows and release dates
Dominique Feillet, CMP Georges Charpak, Ecole des Mines de Saint-Etienne, 880 avenue de Mimet, F-, 13541 , GARDANNE, France, feillet@emse.fr, *Nabil Absi*, *Diego Cattaruzza*

In this presentation, we introduce the Multi Trip Vehicle Routing Problem with Time Windows and Release Dates. This problem arises in the context of mutualized distribution in cities. Trucks continuously arrive during the day in platforms where goods are unloaded and made available for small vehicles. We focus here on how to optimize routes for these small vehicles. We propose a memetic algorithm, based on the Split procedure popularized by Prins (2004). It is extended to deal with the peculiar characteristics of our problem. Results demonstrate the efficiency of the method.

4 - Compound Neighborhood Structures for Heterogeneous Vehicle Routing Problems
Puca Huachi Penna, Instituto de Computacao, Universidade Federal Fluminense, Rua Passo da Patria 156 - Bloco E - 3o. andar, Sao Domingos, 24210-240 , Niteroi, RJ, Brazil, ppenna@ic.uff.br, *Thibaut Vidal*, *Anand Subramanian*, *Luiz Satoru Ochi*, *Christian Prins*

We investigate some large neighborhoods for Heterogeneous Vehicle Routing Problems (HVRP), combining reallocation and swap moves with a problem-tailored procedure for optimizing customer-to-vehicle assignment decisions. The assignment is either performed exactly by means of a primal-dual algorithm, or heuristically using a limited number of vehicle-type changes. The resulting large neighborhood are integrated into an iterated local search framework and compared. Competitive results are produced for well-known HVRP benchmark instances.

■ TA-17

Tuesday, 8:30-10:00
G5-8

Transportation Planning 1

Stream: Transportation Planning
Invited session

Chair: *Christoph Reiners*, Mercator School of Management, University of Duisburg-Essen, Lotharstr. 65, 47048, Duisburg, Germany, christoph.reiners@uni-due.de

1 - The Vehicle Routing Problem with Time Windows, Collaboration Between Freight Carriers, and a Rolling Planning Horizon
Christoph Reiners, Mercator School of Management, University of Duisburg-Essen, Lotharstr. 65, 47048, Duisburg, Germany, christoph.reiners@uni-due.de, *Alf Kimms*

We describe a framework for the VRPTW to model collaboration between freight carriers. It enables them to exchange orders to decrease the length of the trips and improve capacity utilization. The framework is extended to handle a rolling planning horizon: Carriers can add customer requests, swap them between carriers, and update the current routes. The solution procedure is a Genetic Algorithm which computes the tours using a Constraint Programming model. To deal with the rolling planning horizon, the chromosome must be modified in a special way. Computational studies show promising results.

2 - Permutation-based coordination of schedules of independent resources: The split vehicle routing case
Jörn Schönberger, University of Bremen, 28359, Bremen, Germany, jsb@uni-bremen.de

In split vehicle routing, the fulfillment of a split request involves several vehicles. In some applications all vehicles contributing to a split request must arrive simultaneously at the customer site. Simultaneous means to keep the difference of the last arriving vehicle and of the first arriving vehicle below a given threshold. A genetic algorithm routing framework is presented. It incorporates scheduling procedures for the determination of the coordinated operation starting times which are controlled by adequate vehicle permutations.

3 - A Container Assignment Problem with Pickup and Delivery
Virginie Lurkin, QuantOm, HEC-ULG, Rue Louvrex, 14, 4000, Liège, Belgium, vlurkin@ulg.ac.be, *Michaël Schyns*

We address the problem of allocating containers into predefined positions of a carrier, in this case aircraft, under several realistic structural and safety constraints. The originality of our approach is to allow multi-trips with pickup and delivery at some intermediate locations. The objective is to minimize the economic and environmental costs including the impact of the intermediate operations. We resort to an integer linear model. Numerical experiments have been performed using a standard B
C library. Heuristics are developed to speed up the process.

4 - A branch and price approach for an airport vehicle routing problem
Michaël Schyns, HEC - Management School, University of Liège, LIEGE, Belgium, M.Schyns@ulg.ac.be, *Céline Maquet*

This project has been initiated by a main European freight airport. The goal is to optimize the aircraft refueling process which relies on a given set of trucks. The underlying process can be defined as a vehicle routing problem with capacity and time windows. We resort to a branch and price approach for which we first analyze the impact of different parameters on the performance of the algorithm. Due to the stochastic nature of the demand and time windows in this context, we are also working on a priori (split delivery) and a posteriori (efficient re-optimization) measures.

■ TA-18

Tuesday, 8:30-10:00
G5-9

Stochastic Simulation Models

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

Chair: *Kateryna Pereverza*, Students Science Association, National Technical University of Ukraine, Kyiv, Scherbakova str., 42/44, app. 54, Kyiv, Ukraine, pereverza.kate@gmail.com

1 - An Approximate Dynamic Programming Approach to the Car Rental Revenue Management with the Flexible Capacity

Dong Li, The York Management School, University of York, Freboys Lane, Heslington, YO10 5GD, York, North Yorkshire, United Kingdom, dong.li@york.ac.uk, *Zhan Pang*

Different from airlines or hotels, car rental companies have the flexibility to adjust the local capacity (number of cars) at their rental stations. Cars are transshipped from one station to another to achieve a better supply/demand match on a daily basis. Such a flexibility is often called shuttling in practice. This work studies the car rental revenue management with the flexible capacity due to shuttling. An approximate dynamic programming approach is proposed to derive high quality decisions on not only the booking control, as do airlines and hotels, but also the shuttling movements.

2 - A stochastic simulation model for the maintenance workshop for CODELCO-ANDINA

Pedro Gazmuri, Ingenieria Industrial y de Sistemas, Pontificia Universidad Catolica de Chile, V. Mackenna 4860, Santiago, Chile, pgazmuri@ing.puc.cl, *Pablo Senosiain*, *Pedro Halcartegaray*

CODELCO is the biggest copper company in the world; Andina, one of its divisions, is facing a three-fold expansion in his capacities in the next 30 years. One important aspect of its operation is the maintenance workshop of trucks. A preliminary design, based on average operation, was established. We developed a very detailed simulation model for the workshop and established a new design that can generate an US$$ 46 MM increase in annual revenues.

3 - Waiting time for optical signals

Laszlo Lakatos, Computer Algebra, Eotvos Lorand University, Pazmany Peter s. 1/C, H-1117, Budapest, Hungary, lakatos@inf.elte.hu

We consider a queueing system with FCFS service discipline. The service of a customer can be started at the moment of arrival (if the server is free) or at moments differing from it by the multiples of a given cycle time T (the server is occupied or a waiting queue exists). The waiting time is always the multiple of cycle time. We find the generating functions of number of customers and that of waiting time. The characteristics of service are illustrated by numerical examples. If we measure the waiting time in the number of cycles we have the possibility to optimize it.

4 - Erlang service queues with service interruptions

Parikshit Verma, Transport Planning, CH2MHill Inc., B 1D Sector 10 Noida, Uttar Pradesh, India, 201301, Noida, Uttar Pradesh, India, verma.parikshit@gmail.com, *Manjulata Agarwal*

We study an M/Ek/1 queuing system which may experience interruptions in service due to partial service breakdowns for an exponentially distributed duration. These interruptions are modeled as multiple server failure states in which the server may work providing different rates of service. Expected number of phases in the system and mean waiting time for a customer are evaluated under steady state and their graphs for various sets of values of the parameters are presented. Though closed form solutions are difficult to be obtained explicitly, for some special cases results have been derived.

■ TA-19

Tuesday, 8:30-10:00
G5-10

Routing

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Maria Cortinhal*, Dep. Métodos Quantitativos para Economia e Gestão, ISCTE - IUL / Centro IO, Portugal, ISCTE-IUL/CIO, Av. das Forças Armadas, 1649-026, Lisbon, Portugal, maria.cortinhal@iscte.pt

1 - An algorithm for solving the traveling salesman problem

Luis Moreno, Sistemas, Universidad Nacional de Colombia, Cra. 80 65-223, Bloque M8A of. 207, Medellin, Antioquia, Colombia, lfmoreno@unal.edu.co, *Javier Diaz*

The proposed deterministic algorithm for the TSP solves in a first step an assignment problem and in a second step, if there are still subtours, a sequence of fast integer programming problems connecting the subtours, by addition and removal of edges, in a way that looks for two consecutive neighbor nodes in each subtour: one used as an inbound edge from another subtour, and its neighbor as an outbound edge to another subtour. In this way subtours are kept unbroken while minimizing the sum of distances (that could be negative if the removed edge is longer than the added one) connecting them.

2 - An application showing the impact of the travelling salesman problem based on logistic costs through heuristic hybrid methods

Abdullah Oktay Dundar, Selcuk University, Akoren, KONYA, Turkey, aodundar@selcuk.edu.tr, *Mehmet Akif Sahman*, *Mahmut Tekin*, *Mustafa Servet Kıran*

When the total logistic costs are reviewed, it is seen that 50% arises from Vehicle Operating Costs (VOC). Most firms that aim to reduce their logistic costs concentrate especially on VOC. The travelling salesman problem, one of the methods to reduce VOC, makes important contributions by ensuring the minimization of the distance covered by vehicles. However, VOC is contingent not only upon distance. An ice-cream distribution problem was addressed. It was analyzed using heuristic hybrid methods and distances were optimized. The impacts of these optimizations upon VOC were discussed.

3 - Logistics Optimization-Case Study: Routing Fuel Transportation

Abdelaziz Benantar, Operational research, USTHB University, Algeria, a_benantar@yahoo.fr

This paper studies a variant of the VRPTW where vehicles have several compartments (multi compartment-vehicle routing problem with time windows or MC-VRPTW). Under this scenario, an attention has been paid to vehicles with compartments that allow transportation of several products on the same vehicle, but in different compartments. In this work, a solution method based on tabu search is proposed for solving the MC-VRPTW. The method is evaluated by adding compartments to Solomon's VRPTW instances and using the real-life instances provided by the fuel distribution company.

4 - An adaptive large neighborhood search heuristic for the sectoring-arc routing problem

Maria Cortinhal, Dep. Métodos Quantitativos para Economia e Gestão, ISCTE - IUL / Centro IO, Portugal, ISCTE-IUL/CIO, Av. das Forças Armadas, 1649-026, Lisbon, Portugal, maria.cortinhal@iscte.pt, *Ana Catarina Nunes*, *Cândida Mourão*

The sectoring-arc routing problem involves partitioning one area into sectors, within a time-limit and building arc routing trips per sector, within the vehicles capacity. Among its several real world applications lies the refuse collection. In the refuse collection problem, the aim is to design routes that minimize the total routing cost but taking into account desirable features for the sectors, such as balancing, compactness and contiguity. We propose an adaptive large neighborhood search heuristic. The performance of the algorithm is evaluated over a set of benchmark problems.

■ TA-20

Tuesday, 8:30-10:00
G5-11

Passenger-oriented Planning in Public Transportation

Stream: Optimization in Public Transport
Invited session

Chair: *Marie Schmidt*, Institut für Numerische und Angewandte

Mathematik, Georg-August-Universität Göttingen, Lotzestraße 16-18, 37073, Göttingen, Germany, m.schmidt@math.uni-goettingen.de

1 - Integrated Rolling Stock Planning for Suburban Passenger Trains

Per Thorlacius, Production Development, DSB S-tog, Kalvebod Br. 34, 5., 1560, Copenhagen V, Denmark, pthorlacius@s-tog.dsb.dk

A central issue for operators of passenger trains is providing sufficient number of seats while minimising operating costs. This process must be conducted taking a large number of practical, railway oriented requirements into account. Because of this complexity, a stepwise solution was previously used, the result being the loss of optimality. The talk will present a new, integrated rolling stock planning model in which the many requirements are handled all at the same time. Preliminary results from DSB S-tog, the suburban train operator of the City of Copenhagen will also be presented.

2 - Stop Location with Realistic Vehicle Velocity Function

Jonas Harbering, Institute for Numerical and Applied Mathematics, University of Goettingen, Lotzestrasse 16-18, 37083, Goettingen, Lower Saxony, Germany, jo.harbering@math.uni-goettingen.de, *Anita Schöbel*, *Emilio Carrizosa*

The Stop Location Problem is considered to be the first problem of a sequence of problems in Public Transportation planning. Usually the costs for the operator of constructing new stations or the average traveling time of a passenger are the objectives to be minimized. In the literature the non-realistic assumption of having a constant velocity of vehicles everywhere is usually made. In this talk we present a model which considers more realistic velocity functions, taking the acceleration and deceleration of vehicles into account. We analyze its properties and we develop solution approaches.

3 - An Empirical Study of Algorithms for Solving the Traffic Assignment Problem

Olga Perederieieva, Engineering Science, The University of Auckland, 70 Symonds street, room 325, 1142, Auckland, New Zealand, o.perederieieva@auckland.ac.nz, *Matthias Ehrgott*, *Judith Y. T. Wang*, *Andrea Raith*

The user equilibrium approach to model traffic assignment assumes that all drivers minimise their travel time. Various algorithms developed to solve this problem were reported in the literature. However, according to our knowledge there is no comprehensive empirical study that compares the performance of different approaches on benchmark instances. Thus, the objective of this work is to fill this gap. We provide a literature overview to indicate the most promising methods, study them with respect to different convergence measures and analyse the impact of their main components on performance.

4 - Passenger route choice in case of disruptions

Marie Schmidt, Institut für Numerische und Angewandte Mathematik, Georg-August-Universität Göttingen, Lotzestraße 16-18, 37073, Göttingen, Germany, m.schmidt@math.uni-goettingen.de, *Paul Bouman*, *Leo Kroon*, *Anita Schöbel*

While traveling by train, a passenger learns that he cannot follow his planned route due to a disruption of uncertain duration. Should he wait until the disruption has vanished or should he take a detour path? Depending on the travel time on planned route and detour route, the location of the disruption, and the frequencies of the connections we present a strategy which minimizes the competitive ratio and derive a more general strategy depending only on the ratio of travel times and frequencies. Furthermore, we study the problem from the point of view of robust and stochastic optimization.

■ TA-21

Tuesday, 8:30-10:00
G6-1

Scheduling with material constraints

Stream: Scheduling
Invited session

Chair: *Tamas Kis*, Computer and Automation Research Institute, Kende utca 13-17, 1111, Budapest, Hungary, tamas.kis@sztaki.hu

1 - A single machine scheduling problem with time windows and precedence constraints

Morteza Davari, Decision Sciences and Information Management, KU Leuven, Belgium, morteza.davari@kuleuven.be, *Fabrice Talla Nobibon*, *Roel Leus*, *Erik Demeulemeester*

This paper studies a scheduling problem in a single-machine environment. Each job has a processing time, a release date, a due date, a deadline and a weight representing the penalty per unit-time delay. Moreover, an acyclic graph representing the jobs' precedence relations is given so that each job is executed after all completion times of its predecessors. Our goal is to schedule jobs to minimize the total weighted tardiness penalty. We present a branch and bound algorithm as well as an enhanced successive sublimation dynamic programming algorithm to solve the problem until optimality.

2 - Heuristic approaches for single machine scheduling problems of minimizing total weighted completion time

Pavel Sukhov, Laboratory of Algorithms and Technologies for Networks Analysis, National State University The Highest School of Economics, Turkov street, d.41 , kv. 2, 607605, Bogorodsk, Nizhny Novgorod region, Russian Federation, pavelandreevith@gmail.com, *Mikhail Batsyn*, *Panos Pardalos*

In this talk we discuss three single machine scheduling problems with total weighted completion time as an objective function: the problem with arbitrary release dates and equal processing times, the same problem with strict deadlines, and the problem with arbitrary processing times and release dates. New heuristic approaches for solving these three problems are suggested.

3 - Scheduling of operations in a steelmaking and casting plant

Gabriella Stecco, Department of Engineering and Architecture, University of Trieste, Via A. Valerio, 6/1, 34127, Trieste, Italy, gstecco@units.it, *Maria Pia Fanti*, *Giuliana Rotunno*, *Walter Ukovich*

This contribution considers the problem of scheduling the steelmaking and casting operations of a real integrated plant. The considered system is constituted of continuous casting and ingot casting machines and cranes transport ladles between the machines. Each machine of the process has specific constraints. In addition, the schedule of ladles is considered since the type of steel that a ladle can contain depends on the sequence. The objective is to determine the schedule of operations minimizing the makespan. We present a formulation of the whole process and some test results.

4 - Scheduling of inventory releasing jobs

Márton Drótos, Computing and Automation Research Institute, 1111, Budapest, Hungary, drotos.marton@sztaki.mta.hu, *Tamas Kis*

In this talk we provide new complexity and algorithmic results for scheduling inventory releasing jobs, a new class of single machine scheduling problems proposed recently by Boysen et al. We focus on due-date related criteria, while known results are concerned with inventory levels between fixed delivery points. We will establish NP-hardness results, or provide polynomial or pseudo-polynomial time algorithms for various special cases, as well as an FPTAS for a special case with maximum tardiness.

■ TA-22

Tuesday, 8:30-10:00
G6-2

Simulation in Scheduling

Stream: Scheduling II
Invited session

Chair: *Carlo Meloni*, Dipartimento di Elettrotecnica ed Elettronica, Politecnico di Bari, Via E. Orabona, 4, I-70125, Bari, Italy, meloni@dia.uniroma3.it
Chair: *Gabriella Dellino*, IMT Institute for Advanced Studies Lucca, Piazza San Ponziano 6, 55100, Lucca, Italy, g.dellino@imtlucca.it

1 - A Framework for Dynamic Rescheduling Problems

Marco Pranzo, Dipartimento di Ingegneria dell'Informazione, Università di Siena, Siena, Italy, pranzo@dii.unisi.it, *Rune Larsen*

Academic scheduling problems usually assume deterministic and known in advance data. However this situation is not often met in practice, since data may be subject to uncertainty and it may change over time. We introduce a general rescheduling framework consisting in a Solver and a Controller. The Solver assumes deterministic and static data, whereas the Controller is in charge of triggering the Solver when needed and when possible. Extensive tests, carried out for two well-known scheduling problems (SMWCTP and JSP), show the general applicability of the approach.

2 - Implicit enumeration for shift scheduling in systems with time-varying demand

Inneke Van Nieuwenhuyse, Research Centre for Operations Management, K.U.Leuven, Naamsestraat 69, Office 04.112, 3000, Leuven, Belgium, inneke.vannieuwenhuyse@econ.kuleuven.be, *Mieke Defraeye*

In many service systems (such as call centers or emergency departments), the arrival rate fluctuates on a daily basis. This may induce long waiting times, if the scheduled personnel capacity is not adjusted accordingly. We present a simulation-based search algorithm based on implicit enumeration to determine the min-cost shift schedule in a small-scale M(t)/G/s(t)+G system. Shift constraints and service level constraints (i.e., the probability that a customer experiences an excessive waiting time should be small) are taken into account.

3 - Risk analysis through Monte Carlo simulation in operating room scheduling

Gabriella Dellino, IMT Institute for Advanced Studies Lucca, Piazza San Ponziano 6, 55100, Lucca, Italy, g.dellino@imtlucca.it, *Carlo Meloni*, *Marco Pranzo*

Operating Room scheduling is typically affected by uncertainty on surgery durations. To evaluate the risk of overtime and possible waste of operating time, we propose a model for determining the surgical schedule under stochastic surgery durations, combining Mathematical Programming formulations and Monte Carlo simulations. Results for the operating theatre of a medium-size public hospital in Italy motivate the need for a decision support tool explicitly accounting for stochastic components affecting the planning activity.

4 - Simulation-based Appointment Scheduling with Transportation Constraints

Hanna Ewen, FernUniversität in Hagen, Germany, hanna.ewen@fernuni-hagen.de, *Lars Moench*

This research is motivated by a real-world scheduling problem found in a German Eye Hospital. We are interested in reducing the waiting time of the patients and in increasing the utilization of the operating rooms. We study an integrated appointment scheduling and vehicle routing problem because the eye hospital runs buses to transport the patients to the hospital. A NSGA-II scheme is proposed. Simulation is used to calculate the fitness function taking the availability of the staff and the stochastic surgery times into account. Results of computational experiments are presented.

■ TA-23

Tuesday, 8:30-10:00
G6-3

Non-standard Optimization Methods and Applications 1

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Jaroslav Ramik*, Dept. of Math. Methods in Economics, Silesian University, School of Business, University Sq. 1934/3, 73340, Karvina, Czech Republic, ramik@opf.slu.cz
Chair: *Martin Gavalec*, Department of Information Technologies FIM, University of Hradec Kralove, Rokitanského 62, 50003, Hradec Kralove, Czech Republic, martin.gavalec@uhk.cz

1 - Decision Analysis Module for Excel

Radomir Perzina, Department of Mathematical Methods in Economics, Silesian University, School of Business, University square 1934/3, 73340, Karvina, Czech Republic, perzina@opf.slu.cz, *Jaroslav Ramik*

This presentation introduces a Microsoft Excel add-in called DAME — Decision Analysis Module for Excel. DAME is free, can work with scenarios or multiple decision makers, allows for easy manipulation with data and utilizes capabilities of Microsoft Excel. Decision models can be structured into 3 levels. Various methods for the evaluation of the weights are provided. Multiplicative and additive syntheses are supported. All calculations are instant so users can perform what-if analysis. The software package will be demonstrated on an illustrating example.

2 - On Farkas' Lemma and the Hahn-Banach Theorem

Lenka Plohakova, University of Ostrava, 30. dubna 22, 70200, Ostrava, Czech Republic, lenka.plohakova@osu.cz

First we recall the classical algebraic Hahn-Banach theorem. Then we recall Farkas' lemma within a vector space and a linearly ordered vector space over a linearly ordered field. Using the latter result, we formulate a new version of Dax's theorem of the alternative and then we derive a Hahn-Banach type theorem. Inspired by those results, we derive a Universal Theorem of the Alternative and a yet more general Hahn-Banach type theorem.

3 - Achieving sufficient consistency of preferences in Saaty's matrix: model for evaluation of artistic production of art colleges

Jana Talasova, Dept. of Mathematical Analysis and Applications of Mathematics, Faculty of Science, Palacky University Olomouc, tr. 17. listopadu 1192/12, 771 46, Olomouc, Czech Republic, jana.talasova@seznam.cz, *Jan Stoklasa*, *Vera Jandova*

In this paper the notion of weak consistency of Saaty's matrix is defined. The procedure of setting pair-wise preferences that guarantees this kind of consistency is presented. Several propositions concerning the properties of weakly consistent Saaty's matrices are shown. The proposed method of setting Saaty's matrix of preference intensities was used in the model for determining scores for particular categories of artistic production of Czech art colleges. Based on the total scores achieved by these institutions, a part of the state budget subsidy is being allocated among them.

4 - Consistency and transitivity of pair-wise comparison matrices in AHP

Zuzana Kiszova, Department of mathematical methods in economics, Silesian university in Opava, School of business administration in Karvina, Univerzitni namesti 1934/3, 73340, Karvina, Czech Republic, kiszova@opf.slu.cz, *Jaroslav Ramik*

The contribution is focused on multiplicative and additive reciprocal pairwise comparison matrices as a tool of decision making in the analytic hierarchy process. There are investigated some properties of pairwise comparison matrices such as consistency and transitivity in the article. Advantage of the multiplicative approach is easier computation of priorities. Preference expression is more natural in the additive approach. Illustrative example is provided.

■ TA-24

Tuesday, 8:30-10:00
G6-4

Scheduling in Transport, Healthcare and Production

Stream: Project Management and Scheduling
Invited session

Chair: *Chris Potts*, School of Mathematics, University of Southampton, Highfiled, SO17 1BJ, Southampton, Hampshire, United Kingdom, C.N.Potts@soton.ac.uk

1 - Increasing nodal capacity by redesigning the train timetable
Dimitris Paraskevopoulos, School of Management, University of Bath, Claverton down, BA2 7AY, Bath, United Kingdom, d.paraskevopoulos@bath.ac.uk, *Tolga Bektas*, *Chris Potts*

Railway capacity is an increasingly scarce and valuable commodity, mainly reduced by bottlenecks in stations and junctions. This paper addresses a train scheduling problem that aims at minimising nodal capacity utilisation, and thus maximising reliability and potentially releasing capacity for additional services. The related scheduling problem has been modelled as a rich Job Shop Scheduling problem, and an efficient Tabu search algorithm has been developed to tackle it. Experimentation on a major UK railway line shows the efficiency and effectiveness of the proposed methodology.

2 - On-Line Scheduling of Operating Theatres
Nor Aliza Abd Rahmin, School of Mathematics, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, United Kingdom, naar1v09@soton.ac.uk, *Chris Potts*, *Marion Penn*

Waiting for treatment due to unavailability of an operating theatre can result in both deteriorating health and inconvenience. An operating theatre scheduling problem for emergency and regular patients is considered. We develop a model and design an algorithm to schedule operations for patients, taking into account their urgency, using a heuristic to provide a starting solution and then applying iterated local search. The schedule is updated daily to take account of variations from planned durations and the arrival of emergency patients. The rescheduling of patients may be necessary.

3 - An Iterated Local Search Heuristic for the Single Machine Total Weighted Tardiness Scheduling Problem with Sequence-Dependent Setup Times
Chris Potts, School of Mathematics, University of Southampton, Highfiled, SO17 1BJ, Southampton, Hampshire, United Kingdom, C.N.Potts@soton.ac.uk, *Anand Subramanian*, *Maria Battarra*

The single machine total weighted tardiness scheduling problem is considered, where sequence-dependent setup times are required between jobs. We develop an iterated local search (ILS) approach, where the neighbourhoods are selected from those that are commonly used for single machine scheduling and for the travelling salesman problem. Computational tests comparing the performance of our proposed ILS algorithm with the state-of-the-art metaheuristics from the literature show that ILS generates high-quality solutions with computation times that are comparable to those used by its competitors.

4 - Scheduling on multiple production locations: a case study in knitted fabrics
Louis-Philippe Kerkhove, Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, louisphilippe.kerkhove@ugent.be, *Mario Vanhoucke*

We consider a real-life case of parallel machine scheduling at a Belgian producer of knitted fabrics. Based on the technical setup at this company this paper extends the literature on unrelated parallel machine scheduling by including geographically dispersed production locations. Producing on multiple locations complicates the problem by introducing location-dependent due dates and lateness penalties. We present a new problem formulation and solve the problem using metaheuristic solution techniques, which are shown to outperform currently used planning techniques.

■ TA-26

Tuesday, 8:30-10:00
G9-7

Integer Programming

Stream: Combinatorial Optimization I
Invited session

Chair: *Monique Guignard-Spielberg*, OPIM, University of Pennsylvania, 5th floor, JMHH, 3730 Walnut Street, 191046340, Philadelphia, PA, United States, guignard_monique@yahoo.fr

1 - Iterative relaxation based algorithms for the bi-objective max-min knapsack problem
Saïd Hanafi, ISTV2, LAMIH-SIADE, University of Valenciennes, Le Mont Houy, 59313, Valenciennes, France, said.hanafi@univ-valenciennes.fr, *Raid Mansi*, *Christophe Wilbaut*, *Anraud Freville*

We propose hybrid approaches to solve the max-min knapsack (MNK) problem, when it is formulated as a mixed integer programming problem. Our algorithms combine relaxation techniques and the temporary fixing of variables to reduce iteratively the gap between upper and lower bounds. Several formulations and relaxations can be considered to solve the MNK. We consider in particular a surrogate relaxation, allowing us to deal with a knapsack problem. Reduction techniques and local search can be integrated to strengthen the algorithms. Numerical experiments show the robustness of the approach.

2 - Hybrid column generation for large-size Covering Integer Programs
Laurent Alfandari, ESSEC Business School, Avenue B. Hirsch BP 05105, 95021, Cergy-Pontoise Cedex, France, alfandari@essec.fr, *Anass Nagih*, *Agnès Plateau*, *Sadki Jalila*

We propose a hybrid column generation approach for large-size Covering Integer Programs (CIP) that runs a greedy approximation heuristic at appropriate iterations of the column generation process to complete subsets of columns according to a given coverage threshold. Numerical results on a real-case railway transportation planning problem show that the hybrid scheme improves the three main performance criteria of Column Generation: computational time, convergence in terms of number of iterations, and quality of integer solutions.

3 - Combinatorial Distributions and 0-1 Decision Games: Modeling and Optimization
Lee Papayanopoulos, MSIS, Rutgers University, RBS, 1 Washington Park, 07102, Newark, NJ, United States, lp1@business.rutgers.edu

Distributions are indispensable tools in stochastic analysis but are ignored in other areas. We survey the dual role that the combinatorial omega distribution plays in 0-1 majority decision games. It offers a means to express players' power and provides a guide for such structural issues as the relative density of feasible points in the solution space of an ILP. Actual public sector implementations, both recent and longstanding, exemplify the method. The omega function can be a general conceptual device useful in combinatorial modeling as the mass function is in probabilistic analysis.

4 - Memory-Saving Parallelized RLT3 for solving Quadratic Assignment Problems
Peter Hahn, Electrical and Systems Engineering, University of Pennsylvania, 200 South 33rd Street, 19104-6314, Philadelphia, PA, United States, hahn@seas.upenn.edu, *Amir Roth*, *William Hightower*, *Matthew Saltzman*, *Monique Guignard-Spielberg*

We present a coarse-grain parallel implementation of RLT1/2/3 (Level 1, 2, and 3 Reformulation and Linearization Technique — in that order) bounds calculations for the QAP within a branch-and-bound procedure. For a search tree node of size S, each RLT3 and RLT2 bound calculation iteration is parallelized S ways, with each of S processors performing O(S5) and O(S3) LAP calculations, respectively. Our implementation is aware of memory usage and availability and uses this information to throttle parallelism as appropriate and to manage resources during the branch-and-bound search.

■ TA-27

Tuesday, 8:30-10:00
G9-8

Recent Advances in Mathematical Programming

Stream: Mathematical Programming (contributed)
Contributed session

Chair: *Mirko Vujosevic*, Faculty of Organizational Sciences, University of Belgrade, ul. Jove Ilica 154, 11000, Belgrade, Serbia, mirkov@fon.bg.ac.rs

1 - New Valid Cuts to Improve a Branch and Cut Method for Discrete Bilevel Linear Problems
Renato Mari, Dipartimento di Ingegneria dell'Impresa, University of Rome Tor Vergata, Via del Politecnico, 1, 00133, Rome, Italy, mari@disp.uniroma2.it, *Massimiliano Caramia*

In this paper we focus on discrete bilevel linear problems (DBLP) with all integer variables. As far as we know, in the literature there exists only a branch and cut algorithm for a generic DBLP. Relying on this approach, we propose two new cutting planes exploiting the geometric properties of DBLP. The branch and cut algorithm developed using these cuts always provides a bilevel feasible solution. We introduce necessary and sufficient conditions for finding an optimal solution and we describe two special cases in which these conditions always hold. The proposed cuts are experimentally tested.

2 - Valid Cuts and Improved Formulations for an Optimal Approach to the Knapsack Problem with Mutually Exclusive Constraints
Abdelkader Sbihi, Axe Logistique-Terre-Mer-Risque, Ecole de Management de Normandie, Le Havre, France, 30, rue de Richelieu, 76087, Le Havre Cedex, France, a.sbihi@em-normandie.fr

We propose an optimal method for the knapsack problem with mutually exclusive constraints s.t for any pair of items, only one item is chosen.The approach is based on valid filtering cuts combining feasible solution with polyhedral methods. We introduce two valid cuts to bound the variables sum. We start by a feasible solution, then we construct two valid cuts for any better feasible solution. Finally, we use a B&B combined with a divide and conquer strategy to reduce the wide slack between both valid cuts. We obtained encouraging results compared to those of the literature.

3 - A new hybrid interior-point algorithm for quasi-variational inequalities
Simone Sagratella, Ingegneria informatica automatica e gestionale A. Ruberti, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, sagratella@dis.uniroma1.it, *Francisco Facchinei*, *Christian Kanzow*

We present an hybrid interior-point algorithm for finite-dimensional quasi-variational inequalities (QVIs). We combine the robustness of the potential reduction algorithm and the local quadratic convergence rate of the LP-Newton method. We provide local and global convergence properties along with a comprehensive description of the algorithm, including matrix corrections for singular system cases and crash methods. Heuristics are also considered that allow faster performance. This method has been implemented in C++, which we demonstrate on QVILIB, a large test problem library of QVIs.

4 - An optimization — simulation approach to stochastic linear programming problem
Mirko Vujosevic, Faculty of Organizational Sciences, University of Belgrade, ul. Jove Ilica 154, 11000, Belgrade, Serbia, mirkov@fon.bg.ac.rs

A stochastic linear programming problem with some stochastic parameters in the set of constraints is considered. An iterative optimization-simulation framework is proposed for solving the corresponding chance-constrained model. In the optimization phase, a deterministic problem is stated by fixing stochastic values and it is solved to optimality. In the second phase, the original constraints are checked by simulation. If the simulation results are not satisfactory, deterministic values of stochastic parameters are changed in the direction which will enable a more robust solution.

■ TA-29

Tuesday, 8:30-10:00
G9-3

Stochastic flow lines

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Raik Stolletz*, Chair of Production Management, University of Mannheim, Schloss, 68161, Mannheim, Germany, stolletz@bwl.uni-mannheim.de

1 - The inter-departure-time distribution modeled by Markov-chains
Svenja Lagershausen, Department of Production Management, Leibniz Universitaet Hannover, Koenigsworther Platz 1, 30167, Hannover, Germany, svenja.lagershausen@prod.uni-hannover.de

We present a method to model the inter-departure-time distribution in closed queueing networks with phase-type distributed processing times and finite buffer capacities. The distribution is based on the Markov-chain representation of queueing networks and results in a general phase-type distribution.

2 - A Tight Bound on the Throughput of Queueing Networks with Blocking
Jean-Sébastien Tancrez, Louvain School of Management, Université catholique de Louvain, UCL - LSM, 151, Chaussée de Binche, 7000, Mons, Belgium, js.tancrez@uclouvain.be, *Philippe Chevalier*, *Pierre Semal*

We propose a tight bound on the throughput of fork-join queueing networks with blocking and with general service time distributions. For this, the distributions are first discretized by probability mass fitting. Then, we show that the critical path can be computed with the discretized distributions and that the same sequence of jobs offers a bound on the original throughput. The tightness of the bound is shown on computational experiments (error on the order of one percent). Finally, we discuss the extension to split-and-merge networks and approximate estimations of the throughput.

3 - Solving the Buffer Allocation Problem by Benders Decomposition with initial bounds
Sophie Weiss, Chair of Production Management, University of Mannheim, Germany, weiss@bwl.uni-mannheim.de, *Raik Stolletz*

The Buffer Allocation Problem (BAP) can be modeled as a mixed integer program (MIP) by sampling the effective processing times. Due to the size of the resulting MIP, the computation time with standard solvers becomes prohibitive. We use Benders Decomposition to reduce this time by decomposing the MIP into a master and a subproblem. They are solved iteratively by exchanging information via cuts. Optimality with respect to the original MIP is proven. Different approaches for initial bounds and cuts for the BAP are discussed and numerically evaluated.

4 - Analysis of Assembly/Disassembly Queueing Networks with Blocking After Service and General Service Times
Michael Manitz, Technology and Operations Management, Chair of Production and Supply Chain Management, University of Duisburg/Essen, Mercator School of Management, Lotharstr. 65, 47057, Duisburg, Germany, michael.manitz@uni-due.de

We analyze assembly lines modeled as multi-stage A/D queueing networks with finite buffer capacities between the stations, generally distributed service times, and synchronization constraints at assembly and disassembly stations. Using a decomposition approach, we evaluate the throughput and the variance of the inter-departure times. The two-station subsystems are analyzed as G/G/1/N stopped-arrival queueing

systems. The virtual arrival and service rates, and the coefficients of variation of the arrival process and of the output process are determined using an approximation procedure.

■ TA-30

Tuesday, 8:30-10:00
G9-10

Advances in Discrete and Global Optimization II

Stream: Discrete and Global Optimization
Invited session

Chair: *Duan Li*, Systems Engineering & Engineering Management Dept., The Chinese University of Hong Kong, Shatin, NT, Hong Kong, dli@se.cuhk.edu.hk
Chair: *Boaz Golany*, Industrial Engineering & Management, Technion - Israel Institute of Technology, Technion City, 32000, Haifa, Israel, golany@ie.technion.ac.il

1 - Maximum k-clubs with familiarity and reliability conditions

Filipa Duarte Carvalho, Matematica, ISEG/UTL; CIO, Rua do Quelhas 6, 1200-781, Lisboa, Portugal, filipadc@iseg.utl.pt, *Maria Teresa Almeida*

A k-club is a subset of nodes of a graph that induces a subgraph with diameter at most k. For small values of k, k-clubs represent clusters whose elements can reach each other through a small number of intermediaries. While k-clubs ensure good reachability among members, they neglect important cluster features, namely familiarity among members and capacity to stand up to link failures. In this talk, we propose integer programming models for finding maximum k-clubs with familiarity and reliability constraints and present results obtained with them on sets of randomly generated test graphs.

2 - On the embedding of new classes of balanced binary trees in the hypercube

Kamal Kabyl, Laboratory of Modeling and Optimization of Systems LAMOS, Technology Department, University of Bejaia, Algeria, 06000, Bejaia, Algeria, k_kabyle2000@yahoo.fr, *Abdelhafid Berrachedi*

The hypercube is a structure whose topology is used in different fields such as computer science, combinatorics, code theory, etc.. Thus, the study of embedding trees in the hypercube has received much interest these later years. The problem consists of giving the smallest dimension of the hypercube in which a given tree T is embeddable. We then talk about optimal hypercube and cubical dimension of the tree. In this paper we are interested in defining new classes of balanced binary trees and determine their cubical dimensions

3 - Semi-analytical analysis of lexicographic maximin flows in regular networks

Lubos Buzna, Department of Transportation Networks, University of Zilina, Univerzitna 1, 010 26, Zilina, Slovakia, buzna@frdsa.uniza.sk, *Rui Carvalho*

We analyse a lexicographic minimax approach that distributes network capacity fairly among existing flow demands. The problem can be solved by semi-analytical methods on a nearest neighbour graph with one source and sink pair when transport occurs over shortest paths. For this simple set-up we uncover broad range of bottleneck location patterns. We investigate the drop in the network throughput as the function of the network size. Our results also show that the combination of network topology and routing rules can lead to highly uneven (but fair) distribution of resources.

4 - The Number of Non-Isometric Quadrilaterals Inscribed in a Regular n-gon

Sadek Bouroubi, Faculty of Mathematics, Dept of Operations research, USTHB University, Laboratory L'IFORCE, BP32 Bab Ezzouar 16111, 16111, Algiers, Algeria, bouroubis@yahoo.fr

In the 1938's, Norman Anning asked the question concerning the number of non-isometric triangles inscribed in a regular n-gon. In this work, we take back the same question, but concerning the number of non-isometric convex quadrilaterals inscribed in a regular n-gon then we give its closed formula. On the other hand, we give a connecting formula between the numbers concerning the non-isometric triangles and the non-isometric ordered convex quadrilaterals, which will be considered as a combinatorial interpretation of certain identity of integer partitions.

■ TA-31

Tuesday, 8:30-10:00
G9-11

Retail Supply Chain Planning II

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Michael Sternbeck*, Supply Chain Management and Operations, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt/Donau, Germany, Michael.Sternbeck@ku-eichstaett.de

1 - Supply Chain Models with Preferred Retailer Privy to Supplier's Inventory Information

Hamed Mamani, Dept of Information Systems and Operations Management, University of Washington, Foster School of Business, 98195, Seattle, WA, United States, hmamani@u.washington.edu

We consider a supply chain with one supplier and several retailers. Some of the retailers have preferred status, which provides them with information about the supplier's inventory level. Such a preferred status can be due to strategic behavior of retailers and learning the supplier's replenishment policy or long term relationships between them. Due to such access to information, preferred retailers can be proactive and inflate their orders when supply gets short. We study the dynamics of such supply chains as a Stackelberg game where retailers react after the supplier fixes his strategy.

2 - Asymmetry of information and the role of 3PL in two-node supply chain coordination

Dimitris Zissis, Athens University of Economics and Business, Greece, dzisis@aueb.gr, *George Ioannou*, *Apostolos Burnetas*

We consider a supply chain with one manufacturer operating lot-for-lot and one retailer. Both have set-up costs while material transfers between them are performed by a 3PL provider. The retailer can handle inventory at its own warehouse or use the 3PL's storage facility. The business relationship can be modeled via a game with asymmetric information and the manufacturer's goal is to force the retailer to larger orders via quantity discounts. We devise exact expressions for optimal order quantities and discounts, and evaluate them via sensitivity analysis. The role of 3PL is also examined.

3 - Solving a Fresh Produce Distribution Problem with Multi-Compartment Vehicles and Time-Window Constraints

Tsung-Sheng Chang, Graduate Institute of Logistics Management, National Dong Hwa University, 1, Sec.2, Da-Hsueh Rd., Shou-Feng, 974, Hualien, Taiwan, ts@mail.ndhu.edu.tw, *Shih-Yu Chou*

After being harvested, fresh produce continuously and rapidly deteriorates. Today, cold chain technology is commonly used to extend the shelf life of fresh produce. This research thus tackles the problem of delivering fresh produce from a distribution center to retail stores with each requiring different combinations and quantities of products in a cold chain. The problem involves multi-compartment vehicles and time-window constraints. This research first mathematically models the problem, and then proposes a procedure based on Benders decomposition and column generation to solve the problem.

4 - Assortment rationalization and localization with inexact sales data
Yalcin Akcay, Koc University, 34450, Istanbul, Turkey, yakcay@ku.edu.tr, *Gurhan Kok*

We study the SKU rationalization problem of a producer that has seasonal products and performs SKU rationalization as part of preseason planning. SKU rationalization is expected to create assortments that are easier to manage and more efficient, leading to less stockouts of the products that are kept in the assortment. For sales points in various geographical regions, representing different consumer characteristics, we estimate the consumers' substitution rates using a big data set consisting of transactions between the producer and sellers and develop a tool to make SKU reduction decisions.

■ TA-32

Tuesday, 8:30-10:00
G8-1

Logistics

Stream: Supply Chain Optimization
Invited session

Chair: *Luca Bertazzi*, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, bertazzi@eco.unibs.it

1 - Humanitarian Supply Chain Design: Pre and Post Disaster Decision Making
Michal Tzur, Industrial Engineering, Tel Aviv University, Tel Aviv University, Ramat Aviv, 69978, Tel Aviv, Israel, tzur@eng.tau.ac.il, *Reut Noham*

Humanitarian logistics is an emerging field that addresses humanitarian relief operations such as disaster preparedness and response. Existing models address network design and resource allocation challenges for pre and post-disaster situations, respectively. However, they adopt a global optimization approach, which may not be attainable, due to the actual decision making process. We develop models that account for practical considerations and demonstrate that network design decisions are sensitive to post-disaster decisions, therefore it is critical to model post-disaster decisions correctly.

2 - A Comprehensive Annual Delivery Program (ADP) Formulation for Upstream LNG Supply Chain
Fatih Mutlu, Qatar University, 2713, Doha, Qatar, fatihmutlu@qu.edu.qa

Scheduling a cost effective Annual Delivery Program (ADP) for the Liquefied Natural Gas (LNG) producers is a challenging problem, especially when the number of customers and the number of LNG carrying vessels are large. Moreover, due to high operational costs in the LNG delivery business, savings of millions of dollars, can be achieved through effective ADPs. We present a comprehensive formulation for a practical ADP problem faced by large LNG exporters. Our formulation provides more flexibility and we develop efficient solution methodologies.

3 - Exact Solution of the Mixed Capacitated General Routing Problem
Demetrio Laganà, Department of Mechanical, Energy and Management Engineering, University of Calabria, Ponte Pietro Bucci, 41/C, 87036, Rende, Italy, demetrio.lagana@unical.it, *Claudia Bode*, *Stefan Irnich*, *Francesca Vocaturo*

The mixed capacitated general routing problem (MCGRP) is defined over a mixed graph where a subset of vertices and links are required. The problem consists of determining a set of routes servicing all the required elements and providing a minimum total cost. We present a two-index formulation for the MCGRP. The solution approach refers to a branch-and-cut scheme where the main ingredient is a lower bounding routine which also provides strong surrogate cuts. Finally, we report computational experiments over benchmark instances.

4 - Customer Differentiation via Pipeline Stock Flexibility
Guangyuan Yang, Econometric Institute, Erasmus University Rotterdam, Netherlands, gyang@ese.eur.nl, *Adriana F. Gabor*, *Sven Axsäter*

In response to different response time guarantee requirements, service providers can offer differentiated services. However, conventional customer differentiation methods often lead to high holding costs and have some practical drawbacks. We therefore propose to use pipeline stock flexibility as a differentiation option. Our analytical results evaluate exactly the effect of pipeline stock flexibility on service levels for different classes of customers. Comparing with conventional methods, we provide insights concerning which method should be used under different conditions.

■ TA-33

Tuesday, 8:30-10:00
G8-3

Reverse logistics

Stream: Production and the Link with Supply Chains
Invited session

Chair: *Amin Chaabane*, Departement of Automated Manufacturing Engineering, École de Technologie Supérieure, 1100, Notre Dame Street Ouest, H3C1K3, Montreal, Quebec, Canada, amin.chaabane@etsmtl.ca
Chair: *Alice Yalaoui*, ROSAS, UTT, 12 rue Marie Curie, 10010, Troyes, France, alice.yalaoui@utt.fr

1 - Strategic Closed-Loop Supply Chain Planning With Carbon Market Trading
Amin Chaabane, Departement of Automated Manufacturing Engineering, École de Technologie Supérieure, 1100, Notre Dame Street Ouest, H3C1K3, Montreal, Quebec, Canada, amin.chaabane@etsmtl.ca

In this research, we propose a multiechelon multicommodity Closed-loop supply chain palnning model with a trading price of carbon credits. The company might either incur costs if the carbon cap, assigned by environmental regulation, is lower than the total emissions, or gain profit if the carbon cap is higher than the total emissions. A numerical study is presented which demonstrates the impact of different carbon prices on cost and closed-loop supply chain planning.

2 - Sustainable Supply Chain Modelling with System Dynamics Approach in terms of SCOR framework
Olga Nazarenko, National Technical University of Ukraine "Kyiv Polytechnic Institute", Mayakovskogo avenue 17v, apt.72, 02225, Kyiv, Ukraine, onazzzaro@gmail.com

Supply Chain was considered taking into account the following features: dynamics; stochasticity; discrete continuity, nonlinearity. Among the existing imitation methods we chose the concept of system dynamics applied using Powersim tool. SCOR helps to manage a common set of business problems through a standardized language, standardized metrics, and common business practices that accelerate business development and improve performance. The created system dynamics model powered by Powersim resulted in a useful tool, which supports decision making while managing sustainable supply chain.

3 - Optimization of a real world Disassembly Problem
Sukran Seker, Industrial Engineering Department, Yildiz Technical University, Barboros Street Yildiz Technical University Industrial Engineering Department 343409 Besiktas, Istanbul, Turkey, sukranseker@yahoo.com, *Mesut Özgürler*

Disassembly has gained much attention in both research and industry. Disassembly is a process which take back components and materials from end-of-life products for remanufacturing. Effective disasembly system provides an increase in the recovery of end-of-life product. Disassembly planning or sequencing: deals with the problem of determining the best order in which to disassemble joints and remove parts. This paper presents an optimization method for analyzing disassembly manufacturing systems. That proposed study model is a reference for many future works.

4 - Stochastic modelling of manufacturing systems characterized by production dependent multiple failure rates: application to reverse logistics
Pierre Dejax, Industrial Engineering and Automatic Control, LUNAM-Ecole des Mines de Nantes-IRCCyN, La Chantrerie, 4, rue Alfred Kastler, BP 20722, 44307, Nantes cedex 3, France, pierre.dejax@mines-nantes.fr, *Annie Francie Kouedeu*, *Jean-Pierre Kenne*, *Vladimir Poloski*, *Victor Songmene*

We consider the problem of minimizing a cost function which penalizes backlog and the inventory in a production system consisting of parallel machines producing a single part-type and subject to non-homogeneous Markov process with failure rates functions of the production rate. A stochastic optimization model of the problem is developed using two decision variables: production rates of the machines; and one state variable: the stock level, together with specific assumptions. An application is presented for a manufacturing/remanufacturing system as well as a numerical example and extensions.

■ TA-34

Tuesday, 8:30-10:00
G8-4

Demand Management: Demand fulfillment 2

Stream: Supply Chain Planning
Invited session

Chair: *Joachim Arts*, School of Industrial Engineering, Eindhoven University of Technology, PO box 513, 5600MB, Eindhoven, Netherlands, j.j.arts@tue.nl

1 - Optimal stock allocation for production-inventory systems with multiple impatient customer classes
Yasar Levent Kocaga, Sy Syms School of Business, Yeshiva University, United States, kocaga@yu.edu, *Yen-Ming Lee*

We address the production-inventory control of a single product make-to-stock system that serves multiple impatient customer classes. We assume Poisson arrivals and exponential production and patience times, and establish that the threshold inventory rationing policy, which is optimal without abandonments, is still optimal under certain conditions including a requirement on the order of abandonment rates. We also show that the inventory rationing policy need not be optimal if the aforementioned condition is not satisfied and via numerical examples illustrate that it can be suboptimal.

2 - Equilibrium analyses of supply chains by allocation games
Petr Fiala, Dept. of Econometrics, University of Economics Prague, W.Churchill Sq. 4, 13067, Prague 3, Czech Republic, pfiala@vse.cz

A supply chain is a complex and dynamic supply and demand network of agents, activities, resources, technology and information involved in moving a product or service from supplier to customer. The paper analyzes allocation decisions in supply chains. Equilibrium search in supply chains is a very important problem. Game theory has become a useful instrument in the analysis of supply chains with multiple agents, often with conflicting objectives. Allocation games are used for modeling of supply chains. Allocation rules for equilibrium in network games are proposed.

3 - Optimal and heuristic repairable stocking and expediting in a fluctuating demand environment
Joachim Arts, School of Industrial Engineering, Eindhoven University of Technology, PO box 513, 5600MB, Eindhoven, Netherlands, j.j.arts@tue.nl, *Rob Basten*, *Geert-Jan van Houtum*

We consider a single stock point for repairable items that are used to maintain capital assets. Demand for repairables fluctuates as modeled by a Markov modulated Poisson process and the repair shop offers the possibility to expedite repair of parts at increased cost. For a fixed turn-around-stock of repairables, we characterize the optimal expediting policy for general lead time structures. We show that the joint stocking and repair expediting problem is convex. We compare optimal solutions with naive heuristics and find gaps of 12% on average and up to 64% in some cases.

■ TA-35

Tuesday, 8:30-10:00
G8-2

Make-to-Order and Make-to-Stock Manufacturing Systems

Stream: Manufacturing and Warehousing
Invited session

Chair: *Hubert Missbauer*, Information Systems, Production and Logistics Management, University of Innsbruck, Universitätsstrasse 15, 6020, Innsbruck, Austria, hubert.missbauer@uibk.ac.at

1 - Comparison of two optimization based order release mechanisms in workload control: A simulation study of a MTO manufacturer
Stefan Haeussler, Information Systems, Production and Logistics Management, University of Innsbruck, Universitaetsstrasse 15, 6020, Innsbruck, Austria, stefan.haeussler@uibk.ac.at, *Peter Puergstaller*, *Hubert Missbauer*

An important goal in manufacturing planning and control systems are short and predictable flow times. One approach to address this problem is the workload control concept. It is based on the idea to control lead times by controlling order releases and thus the level of work-in-process and output. We compare the performance of two multi-period optimization models for order release planning (Input/Output Control model with fixed lead times and a clearing function) using a simulation study. Preliminary results indicate that the clearing function largely outperforms the Input/Output Control model.

2 - The impact of foreknowledge of demand in case of optimization based order release mechanisms in workload control: A simulation study based on a make to order manufacturer
Christina Stampfer, Information Systems, Production and Logistics Management, University of Innsbruck, 6020, Innsbruck, Austria, christina.stampfer@uibk.ac.at, *Stefan Haeussler*, *Hubert Missbauer*

We investigate the problem of planning future order releases in hierarchical production control systems. Due to demand uncertainty, we consider multi-period production planning models in a rolling horizon environment, where only the first-period decision is implemented. A simulation study of a production planning model for a multistage production inventory system is used in order to analyze the sensitivity of two optimization based order release planning models (Input/Output Control with fixed lead times and a clearing function model) with respect to the impact of foreknowledge of demand.

3 - Planning in hybrid make-to-stock and make-to-order production systems
Bart Beemsterboer, Faculty of Economics and Business, Rijksuniversiteit Groningen, Nettelbosje 2, 9745 BS, Groningen, Netherlands, b.j.beemsterboer@rug.nl

Many firms produce on both a make-to-stock (MTS) and a make-to-order (MTO) basis. Although many production planning and scheduling methods exist for either type of system, these methods are based on different performance measures and cannot easily be combined. We develop a planning model for such a hybrid system and derive insights into the decision when to produce to stock, produce to order or leave a production facility idle.

4 - Control of make-to-stock manufacturing lines with convex operating costs
Felix Papier, Operations Management Department, ESSEC Business School, Av. Bernard Hirsch, BP 50105, 95021, Cergy-Pontoise Cedex, France, papier@essec.fr

We study control of a pre-emptive tandem queue with operating costs that are convex in the number of servers. Our research is motivated by manufacturing control systems that smoothen energy consumption over time to reduce expensive and emissions-intensive peak loads. Since the optimal policy is complex and not necessarily of threshold-type, we develop a heuristic control policy. We compare the performance of our policy with the performance of other manufacturing policies. For the case of 2 servers, we derive analytic properties and an exact method for performance evaluation.

■ TA-36

Tuesday, 8:30-10:00
G7-1

Preference Learning IV

Stream: Preference Learning
Invited session

Chair: *Willem Waegeman*, NGDATA, Dok-Noord 7, 9000, Ghent, Belgium, willem.waegeman@ugent.be

1 - Learning the parameters of a multiple criteria sorting method from large sets of assignemnt examples
Olivier Sobrie, Université de Mons, rue de houdain, 9, 7000, Mons, Belgium, olivier.sobrie@gmail.com, *Vincent Mousseau*, *Marc Pirlot*

In decision analysis sorting procedures aim at assigning alternatives to ordered categories. We consider the MR-Sort procedure derived from ELECTRE-TRI. This procedure contains multiple parameters not easy to be elicited by a human. Learning the parameters of such a model on basis of assignment examples with standard solver requires the use of binary variables making it unusable for large problems. We propose a metaheuristic to solve such problems. Our researches include experimental results. With this metaheuristic we want to address problems encountered in the field of Preference Learning.

2 - Robust Ordinal Regression and SMAA in Multiple Criteria Hierarchy Process for the Choquet Integral
Salvatore Corrente, Economics and business, University of Catania, Corso Italia 55, 95129, Catania, Italy, Italy, salvatore.corrente@unict.it, *Silvia Angilella*, *Salvatore Greco*, *Roman Slowinski*

Interaction among criteria and hierarchical structure of criteria are two important issues of Multiple Criteria Decision Aiding. Interaction among criteria is often dealt with fuzzy integrals, especially the Choquet integral. To handle the hierarchy of criteria, we apply a recently proposed methodology called Multiple Criteria Hierarchy Process. Besides, in order to explore the set of all values of preference model parameters compatible with preference information provided by the Decision Maker, we propose to use Robust Ordinal Regression and Stochastic Multiobjective Acceptability Analysis.

3 - Label Ranking with Intensity of Preference
Massimo Gurrieri, University of Mons, Rue du Houdain 9, 7000, Mons, Belgium, Massimo.Gurrieri@umons.ac.be, *Philippe Fortemps*, *Xavier Siebert*

This work focuses on label ranking where the preference relation is expressed by a degree of intensity. In this scenario, the input preference information is a graded pairwise comparison among labels, verifying the Max-max transitivity. The label ranker is based on a decision-rule preference model induced from a rough approximation of the graded preference relation. The set of decision rules, when applied to a new set of instances, provides a graded preference relation which can be exploited by a lexicographic net flow score procedure to obtain a final ranking.

4 - New developments of Interactive Multiobjective Optimization using Dominance-based Rough Set Approach
Salvatore Greco, Deapartment of Economics and Quantitative Methods, University of Catania, Corso Italia 55, 95129, Catania, Italy, salgreco@unict.it, *Benedetto Matarazzo*, *Roman Slowinski*

We presents new developments in application of Dominance-based Rough Set Approach (DRSA) in Interactive Multiobjective Optimization. In an iterative cycle, the procedure proposes to the Decision Maker (DM) a sample of feasible solutions. The DM indicates relatively good solutions in the sample. DRSA is using this information to induce a preference model expressed in terms of "if..., then ..." decision rules. The DM selects some of these rules that best reflect his/her preferences. They define new constraints to be added to the optimization problem, cutting-off non-interesting solutions.

■ TA-37

Tuesday, 8:30-10:00
G7-4

Multicriteria Decision Making and Its Applications II

Stream: Multicriteria Decision Making
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Douwe Postmus*, Epidemiology, University Medical Center Groningen, Netherlands, d.postmus@umcg.nl

1 - A stochastic decision model to deploy a new weapon system
Ahmet Kandakoglu, Scientific Decision Support Department, Turkish Air Force Command, Bakanliklar, 06100, Ankara, Turkey, akandakoglu@hvkk.tsk.tr

This study presents a decision model based on the Stochastic Multicriteria Acceptability Analysis (SMAA) method to deploy a new weapon system in the defense planning process. SMAA is a recent method that allows the representation of different kinds of uncertain, imprecise and partially missing information in a consistent way. It assigns probability distributions to the criteria scores and order or intervals to the criteria weights, and then applies Monte-Carlo simulation to make an evaluation. A deployment location selection problem for a new fighter aircraft is given as an illustrative case.

2 - A formal model for home care services planning
Ilker Guclu, Industrial Engineering, Bogazici University, Boğaziçi Üniversitesi, Bebek, 34342, Istanbul, Turkey, ilker.guclu@boun.edu.tr, *Ali Tamer Unal*

Due to various operational characteristics, home care organizations differ significantly from traditional institutionalized health care providers, such as hospitals. In this study, we first propose a formal object model where we define the entities involved in a health care system including home care as an option, and their relations in an aggregate level. Later we demonstrate that, the proposed formal model can be used to develop mathematical programming models that represent aggregate planning problems from various perspectives, such as patients, institutions and system resources.

3 - Multi-criteria decision analysis to focus the translational research conducted within medical-need-driven public-private partnerships
Douwe Postmus, Epidemiology, University Medical Center Groningen, Netherlands, d.postmus@umcg.nl, *Gimon de Graaf*, *Erik Buskens*

To increase the rate at which biomedical discoveries are translated into new medical technologies, governments increasingly device funding schemes that require academia and industry to join forces. Focusing

the translational research conducted within such public-private partnerships is however not straightforward as we encountered within a consortium aimed at reducing the burden of type 2 diabetes. We here present a detailed account of how we applied SMAA-O to assist in deciding where in the prevention and treatment of diabetes the potential for introducing a new medical test would be highest.

4 - Preference incorporation in multiobjective evolutionary optimization : the nsga-theseus method
Eduardo Fernandez, FACULTY OF ENGINEERING, AUTONOMOUS UNIVERSITY OF SINALOA, Mexico, eddyf@uas.edu.mx, *Jorge Navarro*, *Rafael Olmedo*, *Julia Sanchez*

In this work, we present a new idea to incorporate preferences into a Multi-Objective Evolutionary Algorithm. We propose the use of THESEUS multi-criteria sorting method combined with the NSGA2.Based on certain preference information provided by the Decision Maker, the THESEUS method is used to sort the solutions in the first NSGA2 nondominated front as Good, Acceptable, Not good, Bad. In each iteration the first front is separated in several fronts according to the previous classification. The algorithm is similar to NSGA2, considering the ordered classes as new fronts.

■ TA-39

Tuesday, 8:30-10:00
G7-3

Analytic Hierarchy Process 4

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Tihomir Hunjak*, Faculty of organization and informatics, University of Zagreb, Pavlinska 2, 42000, Varazdin, Croatia, tihomir.hunjak@foi.hr

1 - Comparison of GIS-based Evaluations of Shopping Mall Location Selection by Analytic Hierarchy Process
Ceren Erdin Gundogdu, Business Administration, Yildiz Technical Univercity, Barboros Bulvari Besiktas, 34349, İstanbul, Turkey, ceren_erdin@yahoo.com

We have previously analyzed the GIS (Geographic Information System) method in terms of location selection of shopping malls both at the country (Turkey) level and the Geographical Regions level. Modules within the ArcMap structure under the ArcInfo license of ESRI were used in the analyses and ArcCatalog software was used for data management purposes. Results obtained from assessments done previously with the GIS method were analyzed using AHP and in this context, it was aimed to compare the two methods on the level of geographical regions with regard to common criteria.

2 - Location Selection for a Supermarket with AHP and Set Covering Model
Esra Avdan, Industrial Engineering, Pamukkale University, 20070, Denizli, Turkey, eavdan@yahoo.com, *Aliye Ayca Supciller*, *Nilsu Abalı*

Location selection is among the most important elements of retail management strategies. In this study, set covering model and Analytic Hierarchy Process (AHP) are applied to select the location of a supermarket. The criteria are derived from the literature. The weights of the criteria are determined with AHP and the location is selected with the use of set covering model. Finally, the results of the solutions are presented.

3 - Assessing healthcare service quality using an integrated ahp and fuzzy topsis method
Hafize Yılmaz, Industrial Engineering, Halic University, Sıracevizler Cd. No:29 Bomonti Şişli, İstanbul, Turkey, hafizeyilmaz@halic.edu.tr, *Gökhan Erdir*, *Kenan Özden*, *Sait Gül*

Quality in healthcare systems has a special importance since it is directly related to human life. Thus managers in healthcare services must guarantee not only a predetermined service quality but also continuous performance improvements for meeting patients' expectations. However it is difficult to measure the service quality because of the nature of the system. In this study, we propose a fuzzy MADM method for assessing and comparing healthcare service quality. We utilize AHP to obtain the importance of the assessment criteria and fuzzy logic to deal with TOPSIS under imprecise environment.

4 - AHP Model for Measuring Value for Money of Architectural Design
Tihomir Hunjak, The Faculty of Organization and Informatics, Varazdin, Croatia, thunjak@foi.hr, *Vjeran Strahonja*

In this paper a procedure for selecting the best preliminary design project is described. The two-step procedure was implemented: (s1) the development of the projects selection model that is based on value drivers for good design; (s2) the creation of the AHP model for the assessment and prioritization of selected projects and its implementation in making the final decision. The proposed model contains the criteria necessary for assessing whether the projects meet the requirements of all stakeholders, particularly those of end-users while minimizing the environmental impact.

■ TA-40

Tuesday, 8:30-10:00
Y12-1

DEA Theory I

Stream: DEA and Performance Measurement
Invited session

Chair: *Pekka Korhonen*, Economics and Management Science, Helsinki School of Economics, Runeberginkatu 22-24, 100, Helsinki, Finland, korhonen@hkkk.fi

1 - Applying Non-Singular Linear Transformations on Decision Variables in Data Envelopment Analysis
Abolfazl Keshvari, Aalto University School of Economics, Finland, abolfazl.keshvari@aalto.fi, *Pekka Korhonen*

We study properties of non-singular linear transformations in DEA. Transformation of decision variables occurs in the modeling stage when the decision maker chooses variables among a set of variables representing similar information about DMUs. We show that in case the transformation is non-singular and defined accordingly, the same information will produce the same efficiency scores, even if the chosen variables are different. In case the transformation of variables is ignored by the decision maker, the result of the DEA problem is not consistent with the available information in the dataset.

2 - Interval Scale Data Analysis: Performance Measurement and Target Setting
Akram Dehnokhalaji, Aalto University, Kharazmi University, Finland, Akram.Dehnokhalaji@aalto.fi, *Pekka Korhonen*, *Murat Koksalan*, *Nasim Nasrabadi*, *Jyrki Wallenius*

We develop an approach to measure the efficiency score of DMUs, when variables are measured on an interval-scale data, Since DEA cannot produce meaningful scores. We build a mixed-integer programming model to categorize units into two classes and define an efficiency measure based on this classification. We identify target units for each unit under evaluation. A positive linear transformation is allowed for interval-scale variables, implying that our efficiency measure is invariant under such a transformation.

3 - Fuzzy Efficiency without Convexity
Tomas Balezentis, Lithuanian Institute of Agrarian Economics, Lithuania, tomas@laei.lt, *Jens Leth Hougaard*

In this paper we develop a fuzzy version of the crisp FDH-method for measuring technical efficiency for samples of similar production units. Our approach builds directly upon the definition of Farrell's indexes of technical efficiency used in crisp FDH. Therefore we do not require the use of fuzzy programming techniques but only utilize ranking probabilities of intervals as well as a related definition of dominance between pairs of intervals. We illustrate the approach using a data set of 200 Lithuanian family farms for the period of 2004-2009.

4 - On Singular Linear Transformations in Data Envelopment Analysis
Pekka Korhonen, Aalto University School of Economics, 00100, Helsinki, Finland, pekka.korhonen@aalto.fi, *Abolfazl Keshvari*

Linear aggregation and elimination of decision variables are common techniques for reducing dimensions in a Data Envelopment Analysis. We discuss how dimension reduction techniques are represented as singular transformations. Not all singular linear transformations are feasible. We discuss the principles necessary for a proper transformation and propose a method based on those principles. Numerical examples are used to illustrating the presentation.

■ TA-41

Tuesday, 8:30-10:00
Y12-5

DEA Aplications X

Stream: DEA and Performance Measurement II
Invited session

Chair: *Charles Vincent*, Area: Operations, Logistics and Technology, CENTRUM Católica, Graduate School of Business, Pontificia Universidad Católica del Perú,, Jr. Daniel Alomia Robles 125-129Los Alamos de Monterrico, Santiago de Surco, 33, Surco, Lima, Peru, v.chals@gmail.com

1 - Modeling multiple outputs and joint production in stochastic semi-nonparametric envelopment of data
Timo Kuosmanen, Department of Information and Service Economy - Quantitative Methods, Aalto University - School of Business, P.O. Box 21220, FI-00076 , AALTO, Finland, timo.kuosmanen@aalto.fi, *Andrew Johnson*

Stochastic semi-nonparametric envelopment of data (StoNED: Kuosmanen & Kortelainen 2012, J. Prod. Anal.) combines an axiomatic, nonparametric frontier with stochastic, probabilistic modeling of inefficiency and noise. Thus far StoNED restricts to the single output setting. To model joint production, we extend StoNED to the general multi-input multi-output setting. We define the radial and directional distance functions such that distance to frontier consists of an asymmetric inefficiency term and a stochastic noise term. We apply multi-output StoNED to Finnish electricity distribution firms.

2 - Combining stochastic DEA with Bayesian analysis to obtain statistical properties of the efficiency scores
Panagiotis Mitropoulos, Business Planning & Information Systems, Technological Educational Institute of Patras, Patras, Greece, pmitro@upatras.gr, *ichael Talias*, *Ioannis Mitropoulos*

In order to incorporate statistical properties in a DEA analysis we propose a combined application of a Chance Constraint DEA (CCDEA) model that integrated with a stochastic mechanism from Bayesian techniques. First we make use of Bayesian techniques on the data set to generate a statistical model and to simulate a large number of alternative data sets that can be observed as realizations. Second, we solve the CCDEA problem for each of the alternative samples, compute efficiency measures, and use the sampling distribution of these measures as an approximation to the finite sample distribution.

3 - Performing Longitudinal Data Envelopment Analysis With Missing Data — An Evaluation Of Multiple Methods
Rico Merkert, Institute of Transport and Logistics Studies (ITLS), The University of Sydney Business School, St James Campus C13, 2006, Sydney, NSW, Australia, rico.merkert@sydney.edu.au, *John Rose*

Applying DEA becomes difficult when input/output data is missing. Whilst existing literature focuses on cross-sectional data, this paper evaluates multiple approaches (e.g., seemingly unrelated regressions) to estimate missing panel data. The longitudinal focus aims to improve DEA satisfaction, as prospects of deleting entire DMUs when only one year of data is missing makes estimation of data valuable. We estimate simulated missing data from panel data sets collected from Norwegian and Italian airports and compare the computed DEA results (various models) with those for the complete data sets.

4 - Regional Competitiveness Index based on Multi-objective Data Envelopment Analysis: The case of Peru
Charles Vincent, Area: Operations, Logistics and Technology, CENTRUM Católica, Graduate School of Business, Pontificia Universidad Católica del Perú,, Jr. Daniel Alomia Robles 125-129Los Alamos de Monterrico, Santiago de Surco, 33, Surco, Lima, Peru, v.chals@gmail.com

The primary goal of this paper is to develop a regional competitiveness index for Peru, which has been captured through five pillars, namely Economics, Government, People, Infrastructure, and Business that are described by a variety of observable qualitative and/or quantitative variables (indicators) in accordance with the IMDs competitiveness model. In this study covering 25 provinces in Peru, the multi-objective data envelopment analysis model was employed to analyze the data collected and the model adequacy has been verified.

■ TA-42

Tuesday, 8:30-10:00
Y12-3

Inequality Averse Decisions

Stream: Decision Processes
Invited session

Chair: *Nikolaos Argyris*, Department of Statistics, University of Warwick, Gibbet Hill Road, CV4 7AL, Coventry, United Kingdom, N.Argyris@warwick.ac.uk

1 - Equitable dominance and resource allocation
Nikolaos Argyris, Department of Statistics, University of Warwick, Gibbet Hill Road, CV4 7AL, Coventry, United Kingdom, N.Argyris@warwick.ac.uk

We consider the problem of a central planner choosing among different distributions of resources across different parties. An equitable preference ordering is constructed. This combines structural assumptions relating to efficiency and inequality-aversion with explicit preference data from a survey, past policies, or the planner's paternalistic views. The set of all such functions that rationalise the preference ordering has a succinct polyhedral characterisation. This is then used to derive an equitable dominance relation as well as compute the subset of equitably efficient distributions.

2 - Balance Concerns in Allocation Problems
Ozlem Karsu, Management, London School of Economics, Houghton Street, WC2A 2AE, LONDON, United Kingdom, ozlemkarsu@yahoo.co.uk, *Alec Morton*

We consider input allocation problems where inputs are allocated to different parties such as activities, projects or departments. In such problems one of the main goals is achieving a desired balance in the allocation over the parties. We propose a two dimensional framework for trading balance off against efficiency. We define and categorize reference point based balance indicators and propose formulations and solution algorithms which provide insight into resource allocation problems.

3 - Assigning agents to a line
Lars Peter Østerdal, Department of Business and Economics, University of Southern Denmark, Denmark, lpro@sam.sdu.dk, *Jens Hougaard*, *Juan D. Moreno-Ternero*

We consider the problem of assigning agents to slots on a line, where only one agent can be served at a slot and each agent prefers to be served as close as possible to his target. Our focus is on utilitarian methods, i.e., those that minimize the total gap between targets and assigned slots. In particular, we consider probabilistic assignment of agents to slots, and propose a utilitarian modification of the classic random priority method to solve this class of problems. We also provide some logical relations in our setting among standard axioms in the literature on assignment problems.

■ TA-43

Tuesday, 8:30-10:00
Y12-2

Mathematical Economics and Nonlinear Equilibrium

Stream: Game Theoretical Network Models
Invited session

Chair: *Alexander Zaslavski*, Technion, 32000, Haifa, Israel, ajzasl@techunix.technion.ac.il

1 - Nonlinear Eqilibrium vs.Linear Programming for resource allocation problems.
Roman Polyak, Science and Technology II, George Mason University, Fairfax, 22030 , Virginia, United States, rpolyak@gmu.edu

The nonlinear equilibrium (NE)can be viewed as a new paradigm for resource allocation problems (RAP). We show the fundamental difference between NE and LP calculations for RAP. Finding NE is equivalent to solving a particular VI. We consider two method for solving the VI, which are pricing mechanisms for establishing NE. Convergence, global Q-linear rate as well as complexity bound for both methods was established. We will compare them with well known complexity bounds for LP.

2 - The Market Triple
Stanislaw Walukiewicz, Systems Research Institute, Polish Academy of Sciences, ul. Newelska 6, 01-447, Warsaw, Poland, Stanislaw.Walukiewicz@ibspan.waw.pl

It is a well known fact that at market equilibrium supply equals demand except for instance in North Korea and Cuba. The above should be examined from a contemporary perspective (here and now) as well as all the relevant terms. Basic terms such as value and market are redefined from this perspective and the organizer element is added. Thus a linear creation of demand and supply is expanded into a two-dimensional structure which provides the definition of a market triple. There are countless markets in the world around us, but only six market triples. Quite unique is the research market.

3 - Pareto-optimal solutions and Nash equilibria in infinite-horizon multiobjective optimal control problems
Naila Hayek, Economics, University Paris 2, 171 rue de la Pompe, 75116, Paris, France, naila.hayek@u-paris2.fr

We study multiobjective optimal control problems in the discrete-time case and infinite-horizon framework. We provide necessary conditions and sufficient conditions of Pareto-optimality and overtaking Pareto-optimality in general problems. We look for Markov-Nash equilibria in a differential game arising in a management problem of competition between two Internet service providers.

■ TA-44

Tuesday, 8:30-10:00
Y12-4

Mathematical Economics

Stream: Dynamical Systems and Game Theory
Invited session

Chair: *Alberto Pinto*, Mathematics, University of Porto, Portugal, aapinto1@gmail.com
Chair: *Bruno M.P. M. Oliveira*, FCNAUP, R. Dr. Roberto Frias, 4200-465, Porto, Portugal, bmpmo@fcna.up.pt

1 - Efficiency vs strategy-proofness in matching markets with interval order preferences
Sofya Kiselgof, DeCAn, NRU Higher School of Economics, Russian Federation, skiselgof@gmail.com

We analyze an extension of the classical Gale-Shapley many-to-one matching model: each college admits at most q students, while each student gets one seat. Preferences of the colleges are considered to be the interval orders. We construct two stable mechanisms. First mechanism is based on Erdil-Ergin Stable Improvement Cycles; it always constructs an applicant-efficient stable matching, but is not strategy-proof for applicants. Second mechanism is strategy-proof; it uses a tie-breaking procedure, that reduces a chance of obtaining inefficient matching in comparison to a random tie-breaking.

2 - On licensing agreement with a rival firm in a differentiated Cournot market
Masashi Umezawa, School of Management, Tokyo University of Science, 500 Shimokiyoku, 346-8512, Kuki, Saitama, Japan, umezawa@rs.tus.ac.jp, *Tatsuya Kitagawa*, *Yasushi Masuda*

We study an optimal licensing scheme for a patent holder of a new product facing with a potential rival who may invest in the technology innovation and enter the market of the new product. Alternative forms of licensing schemes considered are fixed fee and royalty. We investigate the joint impact of the substitutability of goods, the cost of technology innovation, and the market size on the optimal licensing scheme. Our conclusion is consistent with the empirical findings by Vishwasrao (2007) that licensing contracts are more likely to be royalty based when sales are high.

3 - Utilizing market sizing information to increase robustness and prediction accuracy of price elasticity models
Rohan Mascarenhas, Global Analytics, Hewlett Packard, 1b lumbini apts, rest house road, 560001, Bangalore, Karnataka, India, rohan.mascarenhas@hp.com

Managers often have to make pricing decisions when planning promotions, price drops etc and Price elasticity is at the heart of these decisions. In declining markets there can be situations where even after a price drop, sales volumes remain the same or decline resulting in a skewed elasticity coefficient. Including market sizing information in the model along with other traditional indicators can account for these conditions and increase the robustness and predictability of the model. Using this methodology we improved the predictability of the elasticity model by 10-15% for different SKUs.

4 - On the desirability of tax coordination when countries compete in taxes and infrastructures
Yutao Han, crea, university of Luxembourg, 162a, avenue de la Fiencerie, 1511, Luxembourg, Luxembourg, Luxembourg, yutao.han@uni.lu

In our paper we show that when countries compete in taxes and infrastructures, tax coordination does not necessarily create the welfare effects observed under pure tax competition. Our model shows that imposing a uniform tax rate is Pareto-inferior to the non cooperative equilibrium when countries compete in taxes and infrastructures. If a minimum tax rate is set, the low tax country will never be better off. Finally the paper shows that the potential social welfare gains from tax harmonization crucially depend on how heterogeneous the competing countries are.

■ TA-45

Tuesday, 8:30-10:00
Y10-3

Mathematical Models in Macro- and Microeconomics 4

Stream: Mathematical Models in Macro- and Microeconomics
Invited session

Chair: *Alexander Vasin*, Operations Research, Lomonosov Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su

1 - Spatial Econometric Approach to Regional Economic Growth Modelling
Andrea Furková, Faculty of Economic Informatics, Department of Operations Research and Econometrics, University of Economics, Dolnozemská cesta 1/b, 85235, Bratislava, Slovakia, Slovakia, furkova@euba.sk, *Michaela Chocholatá*, *Kvetoslava Surmanová*

The impact on the regional economic growth process of factors such as location, spillover effects from neighbouring regions or access to natural resources can be captured and quantified by modern spatial econometric techniques. Spatial econometric models consider the possibility of geographic interaction between the economies of neighbouring regions via incorporating contiguity matrix. The aim of our research is to exploit information about spatial structure to estimate the effects of cooperation or competition between regions and their influence on economic growth of regions.

2 - Multisector monopolistic competition model
Stanislav Radionov, Economics, Higher School of Economics, Moscow, Russian Federation, stradionov@gmail.com, *Igor Pospelov*

We present a natural extension of the well-known Dixit-Stiglitz monopolistic competition model with continuum of industries. We study the properties of this model, prove inefficiency of equilibrium for a broad class of utility functions and find a form of the utility function which allows us to obtain efficient equilibrium. We also study effects of economic growth and growth of the economically active population.

3 - Positively-homogeneous Konus-Divisia indices and their applications
Nikolay Klemashev, Computational Mathematics and Cybernetics, Moscow State University, Russian Federation, niko.klemashev@gmail.com, *Alexander Shananin*

This paper is devoted to the estimation of the power of nonparametric tests of the consistency of observed data on consumption and prices with one of the two axioms. These are Generalized Axiom of Revealed Preference (GARP) and Homogeneous Axiom of Revealed Preference (HARP). Our approach differs from existing ones in both the way of estimating the power of the tests and the alternative hypothesis. We show that the power of HARP test is very close to one, while that for GARP test is less and in many cases much less than one. We also study the applicability of these tests to forecasting.

4 - An Asset Value Game with Balancing Strategy
Jun Kiniwa, Applied Economics, University of Hyogo, 8-2-1 Gakuen nishi-machi, 651-2197, Kobe, Hyogo, Japan, kiniwa@econ.u-hyogo.ac.jp, *Takeshi Koide*, *Hiroaki Sandoh*

A minority game (MG) consists of an odd population of agents who make bids whether to buy or sell. Previously, we presented an asset value game (AG), in which each agent uses a mean acquisition cost. Since the AG ignores the imbalance of money and assets, some agents iterate buy operations with little money; others iterate sell operations with few assets. We present an agent with balancing strategy who sells his abundant assets as much as possible, despite loss. It gives him a chance of further investment. We show that some guaranteed operations are allowed and investigate simulations.

■ TA-46

Tuesday, 8:30-10:00
Y10-1

Game-theoretical applications in sustainable supply chains

Stream: Game-theoretical Models in Operations Research
Invited session

Chair: *Gokce Esenduran*, Ohio State University, 43210, Columbus, United States, esenduran_1@fisher.osu.edu

1 - Optimale Reverse Supply Chain Structures for Consumer Returns under Information Asymmetry
Paolo Letizia, Management of Technology and Innovation, ERASMUS UNIVERSITY, 3062 PA, Rotterdam, Netherlands, letizia@rsm.nl

Both manufacturers and retailers consider consumer returns a nuisance and a source of reduced profits. However, they neither collaborate nor communicate in order to identify causes of and possible solutions to the problem of consumer returns, and as a consequence they have asymmetric information about the possible return rates of the product to the store. We find that this information asymmetry causes an inefficient allocation of the responsibility for recovering the value of the returned units.

2 - Extracting Maximum Value from Consumer Returns
Cerag Pince, The Kuehne Logistics University, 20457 , Hamburg, Germany, Cerag.Pince@the-klu.org

We consider a consumer electronics OEM selling a new product, receiving consumer returns (requiring mild refurbishing) and facing future warranty demand to replace failed products. After refurbishing, the returns can be used to meet warranty demand or sold as refurbished product. We investigate the optimal strategy for the OEM maximizing its profit and identify the optimal prices (and quantities) for new and refurbished products as well as the optimal quantity to be refurbished and earmarked to satisfy warranty demand.

3 - Deposit System vs. Authorized Institution
Oznur Ozdemir Akyildirim, Faculty of Administrative Sciences and Economics - Business Administration, Akdeniz University, 07058, Antalya, Turkey, oozdemirak@akdeniz.edu.tr

We examine two collection systems mainly for packaging materials: a deposit system in which each producer collects its own packaging materials and a collective system where a nonprofit authorized institution (AI) undertakes the responsibility on behalf of producers. The AI delegates the collection task to collection firms via a reverse auction and helps to increase recycling yield by consumer education. Collection firms are paid by the AI and also get some revenue from selling collected materials to recyclers. In a numerical analysis we compare the two systems from different perspectives.

4 - Increased Remanufacturing through Take-Back Legislation and Competition
Gokce Esenduran, Ohio State University, 43210, Columbus, United States, esenduran_1@fisher.osu.edu, *Eda Kemahlioglu-Ziya*, *Jayashankar Swaminathan*

We consider an original equipment manufacturer (OEM) in a market regulated with take-back regulation that holds the OEM responsible for taking back used products and ensuring that they are properly treated. In this setting, we model the competition between an OEM and an independent remanufacturer as a Stackelberg game where the OEM is the leader. We find that in the presence of competition, regulation may cause a decrease in remanufacturing levels. Further, the same level of regulation may induce higher remanufacturing levels in the presence of competition than in its absence.

■ TA-47

Tuesday, 8:30-10:00
Y10-2

RM and Technology Markets

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Ilan Lobel*, Stern School of Business, NYU, 10012, New York, United States, ilobel@stern.nyu.edu
Chair: *Hamid Nazerzadeh*, Marshall School of Business, University of Southern California, 90089, Los Angeles, United States, hamidnz@marshall.usc.edu

1 - Pricing and Sharing for Cloud Services
Peter Key, Microsoft Research, 21 Station Road, CB1 2FB, Cambridge, United Kingdom, Peter.Key@microsoft.com

We consider problems of resource allocation, utility sharing and pricing for Cloud Services. New challenges arising from the interplay between scheduling, pricing and fairness, and from service heterogeneity . We outline the problems and the discuss two different models that provide contrasting insights: first, we consider a simple model of pricing that enables us to characterise the trade-off between fixed pricing and a hybrid scheme that adds auction—based pricing. Secondly, we discuss how the Shapley value can be used to capture utility sharing and motivate a fair pricing scheme.

2 - Optimizing Product Launches in the Presence of Strategic Customers
Ilan Lobel, Stern School of Business, NYU, 10012, New York, United States, ilobel@stern.nyu.edu

A technology firm launches newer generations of a given product over time. At every period, the firm decides whether to release a new version of the product that captures the current technology level, at the expense of a fixed launch cost. Consumers are forward-looking and purchase newer models only when that maximizes their own future discounted surpluses. We characterize the optimal policies for both when the firm launches products on-the-go and when it preannounces its launches. Joint work with Jigar Patel, Gustavo Vulcano and Jiawei Zhang.

3 - Real-Time Optimization of Personalized Assortments
Hamid Nazerzadeh, Marshall School of Business, University of Southern California, 90089, Los Angeles, United States, hamidnz@marshall.usc.edu, *Paat Rusmevichientong*, *Negin Golrezaei*

Motivated by the availability of real-time data on customer characteristics, we consider the problem of personalizing the assortment of products to each arriving customer. We propose a family of index-based policies with performance guarantee. These algorithms effectively coordinate the real-time assortment decisions with the backend supply chain constraints.

4 - Dynamic Pricing with Linear Price Correction
Qi Chen, Technology and Operations, University of Michigan, Ross School of Business, 701 Tappan Avenue, Room 0402, 48109, Ann Arbor, Michigan, United States, georgeqc@umich.edu, *Izak Duenyas*, *Stefanus Jasin*

We study a dynamic pricing problem where the seller with a finite amount of inventories sells the products during a finite selling season with uncertain price-sensitive demand. Two common concerns with dynamic pricing are the expensive optimization and the frequency of price adjustments which have led many sellers to still continue using a form of static pricing policy. To address these concerns, we propose a pricing heuristic which only requires solving a convex optimization once and then automatically adjusts the price over time.

■ TA-48

Tuesday, 8:30-10:00
Y11-1

Financial Modelling II

Stream: Simulation Methods in Finance
Invited session

Chair: *Özge Sezgin Alp*, Accounting and Financial Management, Baskent University, Baskent University Faculty of Faculty of Commercial Sciences, Department of Accounting and Financial Management Baglica Kampusu Eskisehir Yolu 20. km Baglica, 06530, Ankara, Turkey, osezgin@baskent.edu.tr

1 - The Effect of Executive Stock Option Grants on Investment and Financing Decisions
Kyoko Yagi, Department of Management Science and Engineering, Akita Prefectural University, 84-4 Ebinokuchi Tsuchiya, 015-0055, Yurihonjo, Akita, Japan, yagi@akita-pu.ac.jp, *Ryuta Takashima*

In this paper we consider the capital structure and the investment strategies of a firm with stock option grants as managerial compensation in real options framework. We propose a theoretical model regarding the managerial compensation of firms with stock options grants. We focus on pay-performance sensitivity, that is, the sensitivity of changes in CEO wealth to changes in shareholder one, and discuss about the stock option grants and the capital structure on investment and the some consistencies of results in our theoretical model with empirical evidences.

2 - Behaviour of Options written on Optimal CPPI Portfolios
Özge Sezgin Alp, Accounting and Financial Management, Baskent University, Baskent University Faculty of Faculty of Commercial Sciences, Department of Accounting and Financial Management Baglica Kampusu Eskisehir Yolu 20. km Baglica, 06530, Ankara, Turkey, osezgin@baskent.edu.tr, *Aysegul Iscanoglu Cekic*

The Constant Proportion Portfolio Insurance(CPPI) is a dynamically adjusted portfolio strategy designed for guaranteing a certain amount of money until a specific maturity time. In this study we derive the closed form formula for options written on CPPI portfolios. We then examine the hedging properties of the CPPI options with some proposed optimal strategies. We finally employ a simulation study for highly risky markets.

3 - Perpetual Game Call Options for Jump Diffusion Processes
Atsuo Suzuki, Meijo University, NIjigaoka 4-3-3, Kani, Gifu, 5090261, Japan, atsuo@urban.meijo-u.ac.jp, *Katsushige Sawaki*

In this paper, we deal with perpetual game call options with jumps. Game option is a contact that the seller and the buyer have the rights to cancel and to exercise it at any time, respectively. We give the optimal boundaries for the seller and buyer and present the value function of perpetual game call option for double exponential jump diffusion processes. The pricing of this option can be formulated as a coupled optimal stopping problem which is analyzed as Dynkin game.

4 - Investments and Environmental Liability Law
Heinz Eckart Klingelhöfer, Managerial Accounting and Finance, Tshwane University of Technology, Building 12, Room 117, Private Bag X680, 0001, Pretoria, Gauteng, South Africa, KlingelhoeferHE@TUT.ac.za

According to the "polluter pays" principle, environmental liability law allows for internalisation of pollution cost. To adjust, an approach to valuing investments in environmental protection and to examining the price determinants is presented.The latter depend on several (corrected) NPVs and interdependencies arising from program changes. Though we can confirm well-established results of environmental economics for single investments, tightening laws may have counterproductive and unexpected effects on environmental protection. However, they can be interpreted economically comprehensibly.

■ TA-49

Tuesday, 8:30-10:00
Y11-2

Dynamic stochastic portfolio optimization and Hamilton-Jacobi-Bellman equations

Stream: Actuarial Sciences and Stochastic Calculus
Invited session

Chair: *Daniel Sevcovic*, Department of Applied Mathematics and Statistics, Comenius University, Mlynska dolina, 84248, Bratislava, Slovakia, sevcovic@fmph.uniba.sk

1 - Dynamic Stochastic Portfolio Optimization via Hamilton-Jacobi-Bellman equation
Sona Kilianova, Department of Applied Mathematics and Statistics, Comenius University, KAMS - FMFI UK, Mlynska dolina, 84248, Bratislava, Slovakia, sona.kilianova@fmph.uniba.sk

We formulate a Hamilton-Jacobi-Bellman equation as a model for dynamic stochastic portfolio optimization. We show that the nonlinear HJB equation can be transformed to a simpler quasi-linear PDE. We discuss interpretation of the transformation function as a function representing risk aversion. As a by-product of the transformation, we obtain a parametric quadratic programming problem. We illustrate the behavior of its value function and discuss interesting information it provides to the investor. We illustrate a practical example of the German DAX 30 Index portfolio optimization.

2 - Robust dynamic stochastic portfolio optimization
Maria Trnovska, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Mlynska dolina, 84248, Bratislava, Slovakia, trnovska@pc2.iam.fmph.uniba.sk

We consider a problem of dynamic stochastic portfolio optimization modeled by the Hamilton-Jacobi-Bellman equation. Using the Riccati transformation a quadratic programming problem with a vector of expected asset returns and a covariance matrix of returns is obtained. Since the problem can be sensitive to the input data, we consider the vector of mean returns and covariance matrix belonging to either convex or discrete uncertainty sets. It leads to a robust optimization problem that can be solved as a conic programming problem. Qualitative properties of the value function are analyzed.

3 - Analysis of the Hamilton-Jacobi-Bellman equation arising in the optimal portfolio selection
Daniel Sevcovic, Department of Applied Mathematics and Statistics, Comenius University, Mlynska dolina, 84248, Bratislava, Slovakia, sevcovic@fmph.uniba.sk

In this talk we shall investigate qualitative and quantitative properties of solutions to the Hamilton-Jacobi-Bellman equation arising from a problem of dynamic stochastic optimal portfolio selection. Applying the Riccati transformation we show how the fully nonlinear Hamilton-Jacobi-Bellman equation can be transformed into a quasi-linear parabolic equation whose solution can be interpreted as the relative risk aversion. We also propose a stable fully implicit iterative numerical scheme for solving the transformed equation.

2 - From 1849 back to 1788: reconciling the Faustmann formula with the principle of maximum sustainable yield
Fritz Helmedag, Economics, Technical University of Chemnitz, Chair VWL II, Thueringer Weg 7, 09107, Chemnitz, Germany, f.helmedag@wirtschaft.tu-chemnitz.de

In 1849, Martin Faustmann published an article where he calculated the claim on one's insurance if fallow woodland has been definitely destroyed. Though Faustmann assumed a given cutting time of an even aged plantation, his contribution is a standard reference in forest economics. Nowadays, the rotation period associated with the highest compensation for the damaged soil is deemed the correct felling instruction. Yet, the Faustmann approach can be extended to a 'normal' cultivation characterised by a permanent harvest based on a 'synchronised' structure of the stumpage.

3 - On long term forest valuation subject to survival risk
Thomas Burkhardt, Campus Koblenz, IfM, Universitaet Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, tburkha@uni-koblenz.de

Forests are considered as long term investments, which are subject to survival risks. Survival is modeled in a completely general way by a survival function on a stand level. It is shown that this implies a Markov aging process and an age class structure which corresponds to the normalized survival function. The implications for optimal forest management (rotation) and valuation are explored. It is shown that neglecting survival risks in forest valuation will result in substantial overvaluations.

4 - Evaluation of capabilities of the option pricing models for market uncertainty associated with mining investments
Masoud Soleymani Shishvan, RWTH Aachen, 52062, Aachen, Germany, soleymani@bbk3.rwth-aachen.de, *Christian Niemann-Delius*

According to multiple market uncertainties associated with mining investments, as well as upside potentials of managerial flexibility to respond to future information, the adequacy of traditional project evaluation tools based on discounted cash flow analysis may be debatable. This paper presents a multi criteria ranking system for selection between alternative option pricing models for handling complex uncertainties which involved with mining operations. The results shows that a Monte Carlo based option model is preferred due to the stochastic nature and more realistic outcomes.

■ TA-50

Tuesday, 8:30-10:00
Y11-3

Long term investments in forestry and in resource related industries

Stream: Long Term Financial Decisions
Invited session

Chair: *Thomas Burkhardt*, Campus Koblenz, IfM, Universitaet Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, tburkha@uni-koblenz.de

1 - Risk-sensitive planning in forest enterprises with non-linear programming
Fabian Härtl, Institute of Forest Management, Technische Universität München, Hans-Carl-von-Carlowitz-Platz 2, 85354, Freising, Bavaria, Germany, haertl@forst.wzw.tum.de

YAFO is a planning-support tool focusing on the forest enterprise level. Based on stand data, it derives management scenarios that are optimized with respect to financial considerations and ecological constraints, and predicts timber stocks, harvest amounts and financial returns. It calculates financially optimized management plans by means of the net present value development of single stands. The objective can also consider risks due to calamities and timber price fluctuations, evaluated by Monte Carlo simulation. Non-linear programming is used as a solution technique.

■ TA-51

Tuesday, 8:30-10:00
Y11-4

Financial Modeling 1

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *Gonzalo Cortazar*, Ingenieria Industrial y de Sistemas, Pontificia Universidad Catolica de Chile, Vicuna Mackenna 4860, Santiago, Chile, gcortaza@ing.puc.cl

1 - Fair Pricing of International Indices
Gonzalo Cortazar, Ingenieria Industrial y de Sistemas, Pontificia Universidad Catolica de Chile, Vicuna Mackenna 4860, Santiago, Chile, gcortaza@ing.puc.cl, *Juan-Pablo Araujo*, *Juan-Pablo Gonzalez*

We address how to obtain a fair price for an international index when there are no market prices for a given day because of a national holiday. Current practice uses the last observed price inducing stale prices and short-term arbitrage opportunities. We assume returns are a linear function of a common set of latent factors. Estimations use the Kalman filter and Maximum Likelihood. We estimate models with one to three factors using 43 international indices between 2007 and 2011. We compare model errors with those using the last observed price obtaining error reductions between 10 and 50%.

2 - A fast calibrating volatility model for option pricing
Suren Islyaev, Mathematical Sciences, Brunel University, Brunel University,Kingston Lane, Uxbridge, Middlesex, UB8 3PH, London, United Kingdom, suren.islyaev@brunel.ac.uk, *Paresh Date*

We propose a new volatility model, where the volatility has a deterministic term structure modified by a scalar random variable (rather than a random process). Closed-form approximation can be derived for European option price using higher order Greeks. The model calibration procedure is very simple and can be implemented on a spreadsheet. On real option data sets, we show that our model achieves accuracy comparable with established models (e.g. Heston and Bates models), at a fraction of the computational cost. Our model is potentially very useful in high frequency derivative trading.

3 - Dynamic investment behavior of financially constrained firms in a duopoly
Michi Nishihara, Graduate School of Economics, Osaka University, 1-7, Machikaneyama, Toyonaka, 560-0043, Osaka, Japan, nishihara@econ.osaka-u.ac.jp, *Takashi Shibata*

We study the effects of leverage and financing constraints in a duopoly. We show that the first mover issues a debt with lower coupon than that of the follower. Then, we observe the LIFO scenario, i.e., the follower exits from the market first. The accessibility to debt, like in a monopoly, increases firm value and speeds up investment compared with the unlevered case. In many cases, financing constraints reduce the first-mover advantage, mitigating the preemptive competition and increasing the preemption threshold and firm value above those of a duopoly without financing constraints.

4 - Financialization of Commodity Markets or Financial Crisis: The High Dependence among Commodity and Stock Markets
Mehmet Fatih Öztek, Economics, Middle East Technical University, Turkey, oztek@metu.edu.tr, *Nadir Ocal*

This paper examines effects of financialization of commodity market on correlation between agricultural commodity and stock market indices. We search for increasing trend in correlation and analyze factors explaining the structure of correlation. Results show that high correlation between indices are not new phenomenon and cannot be attributed to recent financial crisis. It is also found that correlation shifts to higher levels during turbulence periods. It is seems that high levels of correlation may return back to low levels if the markets become calm.

■ TA-52

Tuesday, 8:30-10:00
B13-1

Energy forecasting I

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Fernando Luiz Cyrino Oliveira*, Electric Engineering, Pontifical Catholic University of Rio de Janeiro, Brazil, fcyrino@ele.puc-rio.br

1 - Forecasting energy consumption of buildings using performance indicators
Evangelos Spiliotis, School of Electrical and Computer Engineering, National Technical University of Athens, Agiou Andreou 13, 17122, Athens, Greece, vangspiliot@gmail.com, *Achilleas Raptis*, *Nikoletta Zampeta Legaki*, *Vassilios Assimakopoulos*

This paper deals with the problem of efficient electrical energy consumption forecasting in energy-intensive buildings such as hotels, hospitals, restaurants and supermarkets through a range of energy performance indicators. Defining the most representative indicators per energy sector of the building (HVAC, kitchen, refrigerators, lighting, etc.), an energy assessment of the buildings is taken place. Finally, time series forecasting methods are applied at energy performance indicators time series, in order to predict and evaluate future energy performance of the buildings.

2 - Modeling electrical energy operations of buildings to forecast and achieve energy efficiency
Nikolaos Gkolemis, School of Electrical and Computer Engineering, National Tecnhical University of Athens, SKLAVOUNOU 12, 18539, PIRAEUS, ATTIKI, Greece, nikos_golemis@yahoo.gr, *Nikoletta Zampeta Legaki*, *Vassilios Assimakopoulos*, *Evangelos Spiliotis*

The purpose of this paper is to achieve energy efficiency in commercial buildings, applying different scenarios of energy conservation measures (ECM's) while maintaining their customer service level. Using real business data and the respective energy indicators, it is feasible to depict and simulate most of the operational and electrical usages of the building. Subsequently, a theoretical parameterized model is described and the implementation of various ECM's is evaluated through energy and operational simulation software for buildings in order to minimize and forecast energy consumption.

3 - Forecasting by genetic algorithm the short-term electricity demand of major cities in turkey
Mesut Kumru, Doğuş University, Turkey, mkumru@dogus.edu.tr, *Pınar Yıldız Kumru*

Short-term electricity demand is affected from several factors that are working days, weekends, feasts, festivals, and temperatures. Contribution of these factors to demand is analyzed and modeled with genetic algorithms. The variation of daily total demand under the actual weather temperature and calendar events is determined for major cities. A multi-variable model is constructed for the demand function. The results are compared with those of various time series models based on the mean absolute percentage errors. Findings indicate the superiority of the GA approach.

4 - New Approach for Stochastic Scenarios Trees Construction Applied to Energy Planning
Fernando Luiz Cyrino Oliveira, Electric Engineering, Pontifical Catholic University of Rio de Janeiro, Brazil, fcyrino@ele.puc-rio.br, *Reinaldo Souza*

This paper proposes a new methodological approach for generating synthetic series to build scenarios trees used in stochastic optimization models. This formulation is thoroughly used in the medium-term energy planning in Brazil. Departing from a periodic stochastic model, the methodology combines the well-known nonparametric technique Bootstrap and a Monte Carlo simulation procedure in the construction of probabilistic scenarios trees that are used in the Forward and Backward simulations of the optimization procedure via a Stochastic Dual Dynamic Programming.

■ TA-53

Tuesday, 8:30-10:00
B13-2

Flexible Electricity Demand Modeling

Stream: Stochastic Modeling in Energy Planning
Invited session

Chair: *Tal Raviv*, Department of Industrial Engineering, Tel Aviv University, 69978, Tel Aviv, Israel, talraviv@eng.tau.ac.il

1 - Optimal Control of Battery Switch Station
Tal Raviv, Department of Industrial Engineering, Tel Aviv University, 69978, Tel Aviv, Israel, talraviv@eng.tau.ac.il, *Gil Einy*

This study addresses the optimal control of battery switch stations (BSSs) for Electric Vehicles (EVs). A BSS can be used to switch batteries in order to extend the range of EVs. Its operation poses a challenging closed loop inventory and scheduling problem. There is an interesting trade-off between the electricity costs and the need to meet the stochastic demand. We introduce two heuristics methods to solve this problem: One is based on mathematical programming and the other on dynamic programming. The applicability of both methods is demonstrated via extensive numerical experiment.

2 - A Model-Based Online Mechanism for Demand Side Flexibility in the Smart Grid
Christoph Flath, Information Systems and Marketing, KIT, Englerstr. 14, 76131, Karlsruhe, Baden Württemberg, Germany, flath@kit.edu, *Philipp Stroehle*

Future power systems dominated by fluctuating renewable energy sources call for a more flexible and responsive demand side. Our work investigates the design and efficiency of a model-based online mechanism which ensures truthful revelation of load flexibility potentials. We generalize previous work on uniform demand levels by generalizing to multi-unit demand. A special focus lies on mitigating the exposure problem which arises in such multi-unit demand settings.

3 - Envelope Modeling for Renewable Energy Intermittency and Capacity
Xiaoyue Jiang, Tulane Energy Institute, United States, xjiang@tulane.edu, *Geoffrey Parker*, *Ekundayo Shittu*

Electricity systems can be viewed as a supply chain system with zero-tolerance of delay and limited storage resources. Inspired by Network Calculus theory, we characterize electricity supply and demand by upper and lower-envelopes and their Legendre conjugates, which quantify the variability across different time scales and reveal the tradeoff between capacity and its corresponding Quality-of-Service (QoS) performance; the latter can be further interpreted through storage. The proposed methods are applied to real data from the California Independent System Operator (CAISO).

4 - Risk-aware Coupon Incentive-based Demand Response in Smart Distribution Grid
Le Xie, Electrical and Computer Engineering, Texas A&M University, 3128 TAMU, 77843, College Station, TX, United States, lxie@ece.tamu.edu, *Evdokia Nikolova*

We introduce a novel coupon incentive-based demand response (CIDR) program, built on the advanced computational and communication infrastructure in smart distribution grid, to induce flexibility from millions of retail-level customers on a voluntary basis. In CIDR, retail consumers' flexibility is extracted while their base load consumption is not exposed to wholesale real-time price fluctuations. We assess the potential from such voluntary-based CIDR in limiting the operating risks of power systems.

■ TA-54

Tuesday, 8:30-10:00
B14-1

Mathematical Modelling in Environmental Management and Charging Operations of Electric Vehicles

Stream: Energy, Environment and Climate
Invited session

Chair: *Nikita Zhivotovskiy*, Faculty of Control and Applied Mathematics, Moscow Institute of Physics and Technology, Russian Federation, nikita.zhivotovskiy@phystech.edu
Chair: *Monica Clemente*, Department of Engineering and Architecture, University of Trieste, Via Valerio 6, 34127, Trieste, Italy, monica.clemente@phd.units.it

1 - I-O waste management for mobile phones
H. Ziya Ulukan, Industrial engineering, University of Galatasaray, 80840, Istanbul, Turkey, zulukan@gsu.edu.tr, *Müjde Erol Genevois*

Electrical and Electronic Equipments (EEE) are developing very fast and the management of their waste becomes critical. Input-output model developed by Leontief can be a useful tool for analyzing waste management problem for EEE. We focus on the recycling of mobile phones and the recovery of valuable metals and its contribution to the economy by using dynamic Leontief model and monetary input-output table. We propose an extension of the standard model with recycling using the balance equations which take into account the input and output coefficients and the capital coefficients of recycling.

2 - Developing a strategy for collection and recycling of E-Wast in Turkey
Burak Topcu, Industrial Engineering, Yıldız Technical University, Yıldız Teknik Üniversitesi Yıldız Yerleşkesi A628, Beşiktaş, 34330, İstanbul, Turkey, buraktopcu@hotmail.com, *Vildan Ozkir*, *Tugba Efendigil*, *Nihan çetin Demirel*, *Tufan Demirel*, *Muhammet Deveci*

In this paper we analyze the analytical basis of forecasting method of e-waste quantity produced in Turkey. We propose a fuzzy regression model which includes demographic, economic and technological trends variables as effective reasons of e-waste production. Moreover, we designed an optimal and profitable collection network method of each kind of electronic waste devices to supply practically applicable collection and recycling strategies for municipalities and government. A case study of one fuzzy regression model for Istanbul is presented.

3 - A Lot-Sizing based algorithm for demand side management and optimal electric vehicle charging
Matteo Seminaroti, Department of Computer, Control, and Management Engineering, University of Roma "La Sapienza', Via Ariosto 25, 00185, Rome, Italy, matteo.seminaroti@gmail.com, *Silvia Canale*, *Alessandro Di Giorgio*, *Francesco Liberati*, *Antonio Sassano*

We study the problem of charging a fleet of Electric Vehicles (EVs) in public parking stations. We formulate an optimization problem according to the Model Predictive Control strategy and model the charging control parameters as binary variables subject to demand and capacity constraints. The objective function takes into account both the overall charging cost of the EVs and the error between charging profile and a given power reference. We present a lot sizing based approach to solve the optimization problem and compare exact and heuristic solution algorithms in real world charging scenarios.

4 - Management of Charging Operations of a Large Fleet of Electric Vehicles
Monica Clemente, Department of Engineering and Architecture, University of Trieste, Via Valerio 6, 34127, Trieste, Italy, monica.clemente@phd.units.it, *Noemi Augenti*, *Valentina Boschian*, *Maria Pia Fanti*, *Giorgio Iacobellis*, *Giovanni Lucci*, *Agostino Marcello Mangini*, *Walter Ukovich*

This contribution refers to the integration of Electric Vehicles (EVs) with the power distribution system. To this aim, a management approach for controlled charging of a large population of EVs is presented. More precisely, two interdependent assignment problems are formulated in order to minimize the grid power losses and to guarantee a reasonable level of service for the drivers. In particular, the first problem assigns EVs to charging stations minimizing charging costs and drivers' waiting time on the basis of energy prices and charging rates determined by the second assignment model.

■ TA-55

Tuesday, 8:30-10:00
B14-2

Supply Chain Design in the Forest Industry I

Stream: Biomass-based Supply Chains
Invited session

Chair: *Eldon Gunn*, Industrial Engineering, Dalhousie University, 5269 Morris St., B3J 2X4, Halifax, Nova Scotia, Canada, eldon.gunn@dal.ca
Chair: *Corinne MacDonald*, Industrial Engineering, Dalhousie University, 5269 Morris St, B3H 4R2, Halifax, NS, Canada, corinne.macdonald@dal.ca

1 - Carbon-based Supply Chain Design in the Forest Sector
Sophie D'Amours, Universite Laval, FORAC-CIRRELT, G1V 0A6, Quebec, Canada, Sophie.Damours@gmc.ulaval.ca

This presentation will discuss carbon-based supply chain design within the forest sector. It will review challenging issues related to the integration of long term forest planning and strategic industry decisions using a number of case studies. These issues include dealing with divergent and alternative processes and their impact on carbon accounting as well as understanding the contribution of Life Cycle Assessment to carbon-based supply chain design. The presentation will highlight the recent development of SilviLab a web-based application supporting long term spatial forest planning.

2 - Modelling for Optimization of Wood Value Chains.
Arto Usenius, Industrial systems, VTT Technical Research Centre of Finland, Metallimiehenkuja 6, 02044, Espoo, Finland, arto.usenius@vtt.fi

Optimization of wood value chains is challenging due to huge number of operation alternatives. Models are needed to support planning and realization of harvesting, manufacturing and sales. VTT has developed WoodCIM® software system primary for sawmills to optimize activities throughout value chains. Models describe geometrical and quality features of stems and logs, sawn timber products, conversion from wood raw material to final products taking into account profitability issues. Simulation approach is used to determine operation options and linear programming for maximizing profitability.

3 - Considerations in the design of the integrated forest industry supply chain
Corinne MacDonald, Industrial Engineering, Dalhousie University, 5269 Morris St, B3H 4R2, Halifax, NS, Canada, corinne.macdonald@dal.ca, *Eldon Gunn*

This paper discusses a mixed integer model developed to study the implications of inserting capacity to process biomass into energy and biochemicals into a system that is already using forest biomass in the production of sawlogs and pulpwood in Nova Scotia Canada.A single period model considers specific capacity and configuration decisions and deals with the supply chain from harvesting, transport to and between mills and delivery of final product to market.

4 - Sawmill Manufacturing Planning, Scheduling and Control: Moving Towards Lean
Eldon Gunn, Industrial Engineering, Dalhousie University, 5269 Morris St., B3J 2X4, Halifax, Nova Scotia, Canada, eldon.gunn@dal.ca, *Corinne MacDonald*

Sawmills production is characterized by disassembly, with logs broken into many products. Automation and variable yields limit the control methods that can be used to match production to demand. Efficient utilization of capacity dominates planning and scheduling activities. Integer programming and simulation are used to optimize capacity and inventory, while responding to customers, Simple cyclic policies are unlikely to be effective, even with constant demands and yields. Our models facilitate both the planning and scheduling of this complex environment.

■ TA-56

Tuesday, 8:30-10:00
B15-3

MIP Software

Stream: Software for OR/MS
Invited session

Chair: *Hans Mittelmann*, School of Math&Stats, Arizona State University, Box 871804, 85287-1804, Tempe, AZ, United States, mittelmann@asu.edu

1 - Recent advances in CPLEX MIP solver
Andrea Tramontani, IBM Italy Research & Development, Via Martin Luther King 38/2, 40132, Bologna, Italy, andrea.tramontani@it.ibm.com

We will present some of the new features and ingredients that have been added to IBM ILOG CPLEX Optimization Studio and will give benchmark results that demonstrate the performance improvements in the recent CPLEX versions.

2 - Recent advances in Xpress presolve
Michael Perregaard, FICO, FICO House, International Square, Starley Way, B37 7GN, Birmingham, United Kingdom, MichaelPerregaard@fico.com

The ability to reduce and tighten MIP problems significantly by the application of simple rules often makes the differences between a solvable and an unsolved problem. We will here present some of the recent presolve techniques applied by the Xpress MIP solver.

3 - Performance of Optimization Software - An Update
Hans Mittelmann, School of Math&Stats, Arizona State University, Box 871804, 85287-1804, Tempe, AZ, United States, mittelmann@asu.edu

We report on the current status of our benchmarking effort for both discrete and continuous optimization software.

4 - Improving Strong Branching by Domain Propagation
Gerald Gamrath, Zuse-Institute Berlin, Takustr. 7, 14195, Berlin, Germany, gamrath@zib.de

Deciding how to branch is one of the most important decisions any branch-and-bound based MIP solver has to take. An important component of most state-of-the-art branching rules is strong branching, which predicts the dual bounds of potential child nodes by solving auxiliary LPs. In this talk, we describe how these predictions can be improved by including domain propagation into strong branching. We present computational experiments which show that this reduces the strong branching effort and helps to decrease both the number of branch-and-bound nodes and the overall solving time.

■ TA-57

Tuesday, 8:30-10:00
B15-4

Channel and Outsourcing

Stream: Operations/Marketing Interface
Invited session

Chair: *Jun Ru*, University at Buffalo, 326D Jacobs Management Center, 14260, Buffalo, NY, United States, junru@buffalo.edu

1 - Business Process Outsourcing: Managing Service Quality
Samar Mukhopadhyay, GSB, SungKyunKwan University, 53 Myungryun-dong 3-ga, Jongno gu, 110 745, Seoul, Korea, Republic Of, samar@skku.edu

OEM's resort to Business Process Outsourcing to profit from several operational advantages, but they have to relinquish the control over service quality. In case of multiple suppliers, the possible differential quality can be a source of irritant for the OEM's customers. We propose that the allocation of volume to each supplier can be a motivator for quality improvement. This will also equalize the equilibrium service quality. Optimum volume allocation policies for the OEM and quality improvement strategies for the suppliers, including an asymmetric information case are obtained.

2 - Multi-channel Allocation of Marketing Budget for a New Product Introduction in Segmented Market
Vahideh Sadat Abedi, Steven G. Mihaylo College of Business and Economics, California State University Fullerton, 92831, Fullerton, California, United States, vabedi@fullerton.edu, *Oded Berman*, *Dmitry Krass*

We consider a firm introducing a new product and investigate its resource allocation marketing strategies between multiple channels over time under a limited budget. A heterogeneous population segmented into multiple markets is served. Demand evolves over time similar to the Generalized Bass model but its response to the firm's marketing decisions at any time is left in a general form. We provide a solution method for the general problem. For the case in which multiple local and one mass channels are available we derive further insights on the structure of the resource allocation.

3 - Product (Mis)Fit Information and Strategic Channel Decisions in Store Brand Context

Arcan Nalca, School of Business, Queen's University, Canada, arcan.nalca@business.queensu.ca

In this work, we consider the uncertainty in customer tastes prior to the launch of a new product owned by a manufacturer. Following the launch, the retailer — through its customer contact - generates private information about the valued product features. Should the retailer use this knowledge to gain competitive advantage for its own brands? Are there any incentives in play to share information with the manufacturer? What are the implications of store brand introduction and uncertain customer tastes on the trade relationship between the retailer and the manufacturer?

4 - Flexible Products for Dynamic Needs

Karthik Ramachandran, Georgia Institute of Technology, 800 W Peachtree NW, 30308, Atlanta, GA, United States, karthik.r@gatech.edu, *Aydin Alptekinoglu*

We address a product design dilemma in the face of dynamic consumer needs that change randomly over time. Is it better from a firm's perspective to offer multiple custom products (a set of dumbbells each with a specific weight) or one flexible product (a weight-adjustable dumbbell)? Each of the design alternatives has its own advantage. Whereas a firm could charge a premium for the flexible product's versatility, only custom products will encourage consumers to purchase more than one unit. We identify the optimal product design based on consumer needs and product characteristics.

■ TA-58

Tuesday, 8:30-10:00
B15-6

Expanding the Scope of Little's Law

Stream: New Frontiers for Little's Law
Invited session

Chair: *Maria Luisa Ceprini*, MIT Sloan School of Management, 100 Main Street, Room 062-534, 02142, Cambridge, Massachusetts, United States, mceprini@mit.edu
Chair: *John D C Little*, MIT Sloan School, Mass. Inst. of Tech., Room E62-534, 100 Main St, 02142, Cambridge, MA, United States, jlittle@mit.edu

1 - New Applications of Little's Law

John D C Little, MIT Sloan School, Mass. Inst. of Tech., Room E62-534, 100 Main St, 02142, Cambridge, MA, United States, jlittle@mit.edu

In writing the 2011 paper "Little's Law as Viewed on its 50th Anniversary,' I sought concrete examples of Little's Law (LL) use in practice. There are many applications, but finding them was more difficult than expected. Since LL is not new, the application itself must be new and interesting. Academics have published a few. People in industry have many more but little incentive to write them up. Earlier this year I ran a course and, with the help of the students, ferreted out some new ones. This talk will report several and seek generalizations about them.

2 - A Real Application of Little's Law

Donatello Apelusion Gassi, Sloan, MIT, 77 Massachusetts av., 02139, Cambridge, MA, United States, dgassi@ieee.org, *John Carrier*

A case study shows the application of Little's Law in a US manufacturing firm to find production improvements. Little's Law parameters are estimated from the firm's financial statements. The value of Lambda is estimated from the Cost of Goods Sold (COGS), L from the inventory costs and W by applying Little's Law. In the case study, a large average delay time to the customer (W) is caused by the production of unprofitable SKUs (stock keeping units). A drastic reduction of SKUs decreases costs and also delays, leading the firm to profitability.

3 - A First Step Towards A Theory Of Manufacturing

Mike George, Institute of Lean Six Sigma Research, 3605 Beverly Drive, 75205, Dallas, Texas, United States, mike@entropy2718.com, *Dinesh Rajan*

In this paper, we study the interplay between Little's Law from queueing theory, Ohno's axioms of Toyota manufacturing, and leverage them to improve the performance of manufacturing processes. We identify the work-in-process (WIP) as a key variable that captures the efficiency of the manufacturing process. Specifically, we quantify the effects that set-up time, machine downtime, and defects have on the WIP and in defining the next steps toward a theory of manufacturing cost reduction

4 - The Generalized Little's Law and an Asset Picking System to Model and Maintain a Customized Investment Portfolio: A Working Prototype

Maria Luisa Ceprini, MIT Sloan School of Management, 100 Main Street, Room 062-534, 02142, Cambridge, Massachusetts, United States, mceprini@mit.edu, *John D C Little*

Generalized Little's Law (GLL), advanced version of Little's Law (LL), can weight investments ($) calculating averages in $/time; investment over a time interval and time investment stays in a portfolio. We have created a sophisticate asset picking system (APS) that selects type and number of shares for each investment. Changes can be accepted/rejected by the adviser or customer. Events, like recession, can negatively impact some investment' classes making them unappealing. GLL-APS customizes portfolios for customers. Now a working prototype, later, an assessed and calibrated model.

■ TA-59

Tuesday, 8:30-10:00
B15-5

Multimedia Data Processing

Stream: Machine Learning and Its Applications
Invited session

Chair: *Ivan Reyer*, Dorodnicyn Computing Centre of RAS, ul. Vavilova d. 42, k. 267, 119333, Moscow, Russian Federation, reyer@forecsys.ru

1 - Special data structure for Temporal databases

Karol Matiasko, Informatics, University of Zilina, Faculty of management science and informatics, Univerzitná 8215/1, 01026, Žilina, Slovakia, Slovakia, karol.matiasko@fri.uniza.sk, *Michal Kvet*, *Monika Vajsová*

Data processing requires keeping actual, but also historical data in the database. Conventional tables store only actual valid objects. However, temporal tables (mostly modelled using uni-temporal and bi-temporal tables) describe the whole states of the object during its existence, even after logical delete. This paper deals with the problems and offers methods, structures and operations to provide easy access to historical data. The aim is to simplify the process of historical data manipulation so the user does not need to use special techniques to obtain data at any timepoint.

2 - Learning Models of Activities Involving Interacting Objects

Cristina Manfredotti, LIP 6, University PMC, Paris 6, 4 place Jussieu, 75252, paris, France, cristina.manfredotti@gmail.com, *Kim Steenstrup Pedersen*, *Howard Hamilton*, *Sandra Zilles*

Many practical problems including activity recognition and multi target tracking require models of activities involving interacting objects, these models are usually unknown and have to be learnt directly from sensor data. We propose a multi-layer learning framework which makes use of hierarchical abstraction to learn models for activities of interacting objects from time sequences of data concerning the individual objects. Experiments in the sea navigation domain yielded learned models that were then successfully applied to activity recognition, activity simulation and multitarget tracking.

3 - Modification of Voronoi diagram in OD matrices estimation
Nikita Ivkin, Faculty of Management and Applied Mathematics, Moscow Institute of Physics and Technology (State University), Institutskiy Pereulok, 9, 141700, Dolgoprudny, Moscow Region, Russian Federation, ivkinnikita@gmail.com

Our research is estimation of Moscow origin-destination matrix using cell phones data. We've got a log, that consist of events like client A made some action using GSM station B in time T. Each station is represented by its position and angle range of broadcast. Thus to locate each client with base station we need to create a partition of initial region, according to assumption that client has used nearest station that broadcast in direction of client. Such partition is a modification of well-known Voronoi diagram. Here we provide efficient algorithm for creating such partition.

4 - Continuous boundary-skeleton model of a segmented image
Ivan Reyer, Dorodnicyn Computing Centre of RAS, ul. Vavilova d. 42, k. 267, 119333, Moscow, Russian Federation, reyer@forecsys.ru, *Ksenia Zhukova*

A boundary-skeleton model of a segmented image consisting of a set of nonoverlapping polygonal figures is suggested. Each polygon from the set approximates a homogeneous raster region within the image, with polygons of two neighbour regions having common fragments of boundary. The model also includes marked skeletons of polygons describing changes of skeletal representation and significance estimations for boundary convexities corresponding to polygon vertices. To obtain the set of polygons a modified algorithm for approximation of a binary image with polygons of minimal perimeter is used.

■ TA-60

Tuesday, 8:30-10:00
B15-7

Data Mining in Early Warning Systems 1

Stream: Data Mining in Early Warning Systems
Invited session

Chair: *Inci Batmaz*, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr

1 - Comparison of Parametric and Nonparametric Statistical Models for Predicting Interest Rate
Inci Batmaz, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr, *Elcin Kartal Koc*, *Ceyda Yazici*

Predicting daily interest rates for time deposit accounts is a very critical issue for a bank management. The aim of the study is to develop models that predicts these rates by considering previous rates set by the bank authorities as well as demographic and banking products ownership information of the customers. The statistical models, MLR, MARS, RT and ANN, are used for this purpose. The data is provided by one of the biggest Turkish banks collected from different regions of the country. The results indicate that ANN and MARS methods provide better performance models then the others.

2 - An application of binary quantile regression in credit scoring
Dries Benoit, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, dries.benoit@ugent.be, *Vera Miguéis*, *Dirk Van den Poel*

This paper proposes a model for evaluating credit risk based on binary quantile regression, using Bayesian estimation. This paper points out the distinct advantages of the latter approach: that is (i) the method provides accurate predictions of which customers may default in the future, (ii) the approach provides detailed insight into the effects of the explanatory variables on the probability of default, and (iii) the methodology is ideally suited to build a segmentation scheme of the customers in terms of risk of default and the corresponding uncertainty about the prediction.

3 - Methods of classification in predicting important events in energy markets.
Vadym Omelchenko, Faculty of Mathematics and Physics, The Charles University in Prague and UTIA, Ke Karlovu 3, 121 16 Praha 2, The Czech Republic, UTIA: Pod Vodarenskou vezi 4 CZ-182 08, Praha 8, The Czech Republic, 121 16 , Prague, Czech Republic, vadim224@yahoo.com

Coupling of European markets has caused that the prices in many electricity markets are derived from German prices except for instances of decoupling which usually last for a few hours. We found out that methods of classification can predict important events in local market which can be consequently used in trading. Our methodologies include classification and time series analysis. For classification, random forests. We estimate parameters by Newton and interior points methods. Our methods yield prediction with more than 99.99% precision. The results are demonstrated on Nord Pool market.

4 - Short - Term Electricity Load Forecasting via Nonparametric Prediction Methods
Elçin Ergin, Industrial Engineering, Middle East Technical University, Turkey, elcin_ergin@yahoo.com, *Mustafa Murat Arat*, *Cem Iyigun*, *Inci Batmaz*

Short-term load forecasting, which is crucial for planning the daily operation of an electric power system, has attracted a great deal of attention from both practice and the academia. Several techniques have been tried out in order to improve the accuracy of forecasting. In this paper, Artificial Neural Networks, Support Vector Regression and Double Seasonal Exponential Smoothing methods are compared through an application with 12 weeks of the hourly electricity load data to forecast one hour ahead. Implementation of the methods is discussed and the numerical results are presented.

■ TA-62

Tuesday, 8:30-10:00
R18-1

MINLP emerging methods and applications I

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Sonia Cafieri*, Lab. MAIAA, Dept. de Mathematiques et Informatique, Ecole Nationale d'Aviation Civile, 7 Ave. Edouard Belin, 31055, Toulouse, France, sonia.cafieri@enac.fr

1 - Aircraft conflict avoidance by Mixed-Integer Nonlinear Optimization models combining turn and velocity change maneuvers
Laureano Fernando Escudero, Dept. de Estadística e Investigación Operativa, Universidad Rey Juan Carlos, c/Tulipan, S/n, 28933, Mostoles (Madreid), Spain, laureano.escudero@urjc.es, *Antonio Alonso-Ayuso*, *Sonia Cafieri*, *F. Javier Martin-Campo*

Aircraft conflict detection and resolution is crucial in Air Traffic Management to guarantee air traffic safety. When aircraft sharing the same airspace are too close to each other according to their predicted trajectories, separation maneuvers have to be performed to avoid risks of collision. We propose new mixed-integer nonlinear optimization models combining turn-changes and velocity-changes separation maneuvers. Each aircraft is allowed to perform only one type of maneuver, at time instants which are decision variables of the problem. The pros and cons of the models are also discussed.

2 - On the aircraft conflict detection and resolution by turn-change maneuvers
F. Javier Martin-Campo, Statistics and Operations Research II, University Complutense of Madrid, Campus de Somosaguas, Edificio 1, Despacho N227, 28223, Pozuelo de Alarcón (Madrid), Spain, javier.martin.campo@ccee.ucm.es, *Antonio Alonso-Ayuso*, *Laureano Fernando Escudero*

The aircraft conflict detection and resolution problem is solved by using turn-change maneuvers to provide a new configuration for a set of aircraft, such that every conflict situation is solved. An exact mixed integer nonlinear optimization (MINLO) model and an approximate approach by sequentially solving integer linear optimization models are presented. Computational experience is reported by comparing the response time required to solve the MINLO model by a state-of-the-art engine and the approximate approach as well as the quality of the solution obtained by both approaches.

3 - A comparative study of techniques for solving simulation based upstream petroleum production problems

Andrew Conn, IBM TJ Watson Research Center, 10598, New York, United States, arconn@us.ibm.com, *Sheri Shamlou*, *Stine Ursin-Holm*, *Vidar Gunnerud*

We compare state-of-the art optimization methods for upstream operational petroleum production using mixed integer (nonlinear and linear) models. Capacities, pressure considerations and multiphase flow are accounted for. Formulations and corresponding algorithms are implemented and tested. Techniques include the relevant simulators directly, both treating the entire production system as a black box and using decomposition by including structural constraints. We also consider approximating the underlying simulator data nonlinearly and piecewise linearly. So overall four approaches are compared.

4 - Reformulations of a MINLP model for a bipartite modularity maximization heuristic

Alberto Costa, Singapore University of Technology and Design, Singapore, costa@lix.polytechnique.fr, *Pierre Hansen*

We propose a locally optimal hierarchical divisive heuristic for bipartite modularity maximization: starting from an initial partition with one cluster containing all the vertices, each cluster is recursively divided into two clusters by maximizing the bipartite modularity. The division process stops when it does not improve the bipartite modularity anymore. The problem of the optimal division of a cluster into two clusters can be formulated as a MINLP, but it is difficult to solve. Hence, we propose some reformulations, obtaining MILP and MIQP models that can be solved more efficiently.

■ TA-63

Tuesday, 8:30-10:00
R18-2

Discrete Problems in Control Theory II

Stream: Operational Research and Control Problems
Invited session

Chair: *Evgeny Gafarov*, Institute of Control Sciences of the Russian Academy of Sciences, Profsoyuznaya 65, 117997, Moscow, Russian Federation, axel73@mail.ru

1 - On Combining Linear and Discrete Optimization in Localization Problems

Alexander Kuvichko, Gasfield, Gubkin Russian State University of Oil and Gas, 723, 65 Leninskiy avenue, bld. 1, 119991, Moscow, Moscow, Russian Federation, a.m.kuvichko@gmail.com, *Alexander Ermolaev*

This paper describes optimization problems with special constraints like problems of localization (automatic classification). Differences between such problems and general localization problems complicate the use of well-known optimization methods. A solution might be obtained with the use of reduced search in a set of sub-optimal solutions of a general transportation problem (a non-square assignment problem). To make the search more effective and to reduce the number of sub-optimal feasible candidates, heuristic methods, simulated annealing and genetic algorithms might be used.

2 - Schedule Synthesis in System with Refillable Limited Volume Storage Component

Anastasia Kuimova, Department of Computer Sciences, Control Systems and Telecommunications, Volga State Academy of Water Transport, 5a Nesterova St., 603950, Nizhni Novgorod, Russian Federation, anastasia.kuimova@gmail.com, *Dmitry Kogan*, *Yuri Fedosenko*

We consider the problems of synthesizing the strategies for vehicles flow servicing at a single service processor with the refillable limited volume storage component. Regarding the storage component, the vehicles are divided into two types: consumers and suppliers. Each vehicle attributes include the capacity, the arrival time, the processing time, the due date and the penalty function. The problems are formulated subject to two independent criteria and the storage component restriction. We develop exact and metaheuristic algorithms and discuss the problems of their computational complexity.

3 - Verification method of the theoretical models of the cognitive maps and the task statements of dynamic analysis based on them

Zinaida Avdeeva, lab. Cognitive modeling and situation control, Institute of Control Science of Russian Academy of Sciences, Profsouznaya st., 65, 117997, Moscow, Russian Federation, zinaida.avdeeva@gmail.com, *Nina Abramova*, *Artem Fedotov*

Verification method of a theoretical models of maps and task statements of dynamic analysis aims to identify incompleteness, ambiguities and inconsistency in a formal cognitive maps. The method is based on the formalization of a author's description of these models and the statements in terms of the general parametric maps model. Capability of the proposed method to expose significant theoretical errors is demonstrated. However, experiments show personal dependence of its efficiency on stereotypes and paradigms. This implies the need for psychological support based on modern cognitive science.

■ TA-64

Tuesday, 8:30-10:00
R18-3

Defence and Security IV

Stream: Defence and Security
Invited session

Chair: *Ana Isabel Barros*, Military Operations, TNO, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - Long-term defence planning vs. short-term requirements: A risk-based perspective

Havard Fridheim, Analysis Division, Norwegian Defence Research Establishment, PO BOX 25, NO-2027, Kjeller, Norway, havard.fridheim@ffi.no, *Gunn Alice Birkemo*, *Frode Rutledal*

Scenarios are widely used to analyse capability needs for long-term defence structure development. Such analyses can be consequence driven, where the defence structure is primarily designed to meet the most challenging of the relevant scenarios. While this can be a beneficial approach for long-term planning, the resulting structure may end up less relevant for more likely, but still challenging scenarios. Based on Norwegian experiences, we will discuss how considerations of risk and uncertainty can help address the tensions between the long-term planning process and short-term requirements.

2 - Modelling and analysis of spatial security risk factors

Leandro Teixeira, Center of Operations Research, University of Lisbon, Av. do Lago 317 1e, 2765-421, Cascais, Lisboa, Portugal, fc41423@alunos.fc.ul.pt, *Antonio Rodrigues*

We adress the problem of locating surveillance resources in port areas, against possible asymmetrical threats originating from the waterside. Apart from cost concerns, the problem amounts to maximizing the defense system expected effectiveness so to minimize the worse value of the residual security risk in the area of interest. Therefore, it is essential to estimate a spatial security risk index, and compute risk maps describing the geographical distribution of risk. We illustrate and discuss the factors that contribute to the evaluation of that index.

3 - Risk Management Problems in Defense and Aerospace Industry Projects
Busra Atamer, Industrial Engineering, Middle East Technical University, Ankara, Turkey, busra.atamer@metu.edu.tr, *Sedef Meral*, *Cemal Oguzsoy*

Defense and aerospace industry projects have complicated and long-standing project planning, design, prototyping and manufacturing processes. In such a complex project manufacturing environment, a minor change carried out in one process with a myopic view, may have major impacts on the overall project plan. In this study we consider several risk management problems when changes occur in the successive processes of defense and aerospace projects. We aim to develop modelling approaches to minimize the overall cost brought by change decisions to the project by using robust optimization techniques.

4 - Statistical assessment of cyber threats in cloud computing environment
Alla Kammerdiner, Industrial Engineering, New Mexico State University, PO Box 30001, MSC 4230, 88003, Las Cruces, New Mexico, United States, alla@nmsu.edu

Cloud computing is quickly gaining popularity by offering a convenience of service and infrastructure through a network. With the advantages, cloud computing environment raises new challenges in terms of cyber threat vulnerability of data. This work investigates the changes in cyber protection needed to address the information security issues in cloud computing. Several directions for cyber threat assessment in mobile and uncertain environment are outlined. These heavily computational methods utilize a combination of approaches in statistical inference and discrete optimization.

■ TA-65

Tuesday, 8:30-10:00
R18-5

Finance

Stream: Emerging Applications in Portfolio Selection and Management Science
Invited session

Chair: *Panagiotis Xidonas*, Electrical & Computer Engineering, National Technical University of Athens, 9 Heroon Polytechneiou Str., 15780, Athens, Greece, pxid@epu.ntua.gr

1 - Revisiting the determinants of mutual fund performance
Amparo Soler-Dominguez, Universitat Jaume I, Spain, amparo.soler@uji.es, *Emili Tortosa-Ausina*, *Juan Carlos Matallin-Saez*

This study is focusing on both fund and manager characteristics in order to understand their influence on the efficiency achieved. We apply a two-stage approach, considering partial frontier estimators to assess performance in the first stage, and regression quantiles for isolating the determinants of efficiency in the second stage. Our analysis provides some arguments as a guide for selecting both funds as well as some managerial features.

2 - Testing serial dependence in the stock markets of the G7 countries, Portugal, Spain and Greece
Paulo Ferreira, CEFAGE-UÉ, Portugal, pjsf@uevora.pt, *Andreia Dionisio*

This paper utilizes several tests to analyze serial dependence in financial data. In an attempt to provide a better explanation of the behavior of financial markets, we utilized tests that make use of mutual information and developed a detrended fluctuation analysis (DFA). We concluded for the absence of linear autocorrelation. However, with other tests, we found nonlinear serial dependence that affects the rates of return. Results of mutual information and global correlation based tests confirmed such results. With DFA, we found out that most return rates series have long-range dependence.

3 - Impact of the global financial crisis on the credit and liquidity risk in the banks operating in Poland
Anna Matuszyk, Finance and Banking Collegium, Warsaw School of Economics, Niepodleglosci 162, 02-554, Warsaw, Poland, amatuszyk@matuszyk.com, *Agnieszka K. Nowak*

The purpose of this analysis was to show the extent, to which the global financial crisis affected the Polish banking sector. To achieve this, five banks operating in Poland were selected in order to evaluate the management of credit and liquidity risk in 2007-2010. The project was mainly focused on the evaluation of the regulatory changes implemented and proposed after the subprime crisis in the credit and liquidity risk area as these two types of risks were mostly felt by the banks.

4 - Mixed Effects Models of Loss Given Default
Xiao Yao, University of Edinburgh Business School, University of Edinburgh, China, X.YAO-2@sms.ed.ac.uk, *Jonathan Crook*, *Galina Andreeva*

In the Basel II Internal Rating Based (IRB) approach, banks have to predict the loss given default (LGD) for a portfolio. This paper applies mixed effects models to estimate the LGD of corporate bonds and makes the following contributions: First, an improved linear mixed effects model is developed. Second, a mixed effects inflated beta regression is proposed. Third, in the mixed effects models the random effects are applied to each obligor,seniority and default year level respectively. We find that the linear mixed effects models with obligor specific random effects give the best predictions.

■ TA-66

Tuesday, 8:30-10:00
R18-4

Sustainable Management for Resources, Conservation and Recycling I

Stream: Optimization for Sustainable Development
Invited session

Chair: *Sadia Samar Ali*, Operations Management, Fortune Institute of International Business , New Delhi - 110057, India, Plot No.5 Rao Tula Ram Marg, Opp Army R&R Hospital, Vasant Vihar, New Delhi - 110057, 201009, New Delhi, India, sadiasamarali@gmail.com

1 - Recycling Procurement Strategies with Variable Yield Suppliers
Burak Eksioglu, Industrial and Systems Engineering, Mississippi State University, 117 Red Oak Lane, 39759, Starkville, MS, United States, beksioglu@ise.msstate.edu

Companies are no longer judged on financial performance alone, but rather on their Triple-Bottom Line which accounts for social and environmental measures as well. This led companies to address issues surrounding sustainability of their operations. Following suit, academic literature increasingly focused on the topic of sustainability. While many articles have focused on the design of reverse logistics systems and product remanufacturing, recycling remains largely unexplored. We model a single-period scenario where each supplier sells product with a known yield distribution at market pricing.

2 - Optimization Model for the Cut, Lift, Drag, Transportation and Delivery of sugar cane
Marcela María Morales Chávez, Risaralda, Universidad Libre Seccional Pereira, Cr 19 No. 22-44 Piso 2. Barrio La Pradera. Dosquebradas. Risaralda, Colombia, mmorales@unilibrepereira.edu.co

Presents a Mixed Integer Programming model to optimize the operation CATE (Cut, Lift, Drag, Transportation and Delivery of sugar cane), minimizing the costs associated with crop type, transport sugar cane, the resources assigned to CATE's tasks. It also involves the cost of idle resources of the tasks of cutting and lifting related to the plant personnel front and harvest personnel required to operate the assigned equipment. Finally the opportunity cost of unmet demand is also considered. The results were simulated and observed a decrease in cost of 11.03% with respect to real scenarios.

3 - The dynamic multi-depot vehicle routing problem with pick-up and deliveries
Yiyo Kuo, Industrial Engineering and Management, Ming Chi University of Technology, 84 Gungjuan Rd. Taishan Dist., 24301, New Taipei City, Taiwan, yiyo@mail.mcut.edu.tw

This paper considers the multi-depot vehicle routing problem which deals with two kinds of dynamic request. The first one is repair request which there is an urgent broken product need to be sent form the retail store to a depot for repair. All vehicles can provide the service immediately. The second one is sale request which there is a retail store need a product for sale immediately. The product can be sent form a depot to the store only when the vehicles have returned to depot for up load the product. A heuristic is proposed for solving the problem.

4 - A Robust Optimisation Model for Wastewater Systems Design
Maria Cunha, Civil Engineering, University of Coimbra, Polo 2, 3030-290, Coimbra, Portugal, mccunha@dec.uc.pt, *João Zeferino*, *Antonio Antunes*

This paper presents a robust optimisation model for regional wastewater systems design under uncertainty. It is a scenario based model aimed at determining a configuration for the wastewater systems (the sewer network and the location, type, and size of pump stations and treatment plants) that will perform well under all possible scenarios but are not necessarily optimal in any of them. The model is solved through a simulated annealing algorithm enhanced with a local improvement procedure. The application of the model is illustrated through a case study in the Una River Basin region, Brazil.

■ TA-68

Tuesday, 8:30-10:00
R19-2

Dynamic Programming and its Applications 1

Stream: Discrete Optimal Control
Invited session

Chair: *Yukihiro Maruyama*, General Economics, Nagasaki University, 4-2-1, Katafuchi, 850-8506, Nagasaki, Japan, maruyama@nagasaki-u.ac.jp

1 - Mutually Dependent Decision Processes and Their Application to the Egg Drop
Toshiharu Fujita, Graduate School of Engineering, Kyushu Institute of Technology, 1-1 Sensui-cho, Tobata-ku, 804-8550, Kitakyushu, Japan, fujita@mns.kyutech.ac.jp

In this paper, we introduce mutually dependent decision processes. In this framework, there are n processes (n > 1) and each stage reward depends on the optimal values of other processes. We give a formulation of this type of problem and derive a system of recursive equations by using dynamic programming. Moreover we apply our result to an extended model of 'The Egg Drop' introduced by S. Wagon.

2 - Strong representation of a non-deterministic discrete decision process by a non-deterministic monotone sequential decision process
Yukihiro Maruyama, General Economics, Nagasaki University, 4-2-1, Katafuchi, 850-8506, Nagasaki, Japan, maruyama@nagasaki-u.ac.jp

This paper introduces a new sequential decision process, namely non-deterministic monotone sequential decision process(nd-msdp);Ibaraki(1978) has yet introduced the process, but it is somewhat different from our definition. The nd-msdp admits a functional equations in non-deterministic dynamic programming studied by Lew(2001). Assuming that the original discrete optimization problem is given in the form of a non-deterministic discrete decision process (nd-ddp), we will show the relation between nd-ddp and nd-msdp by using the automata theory.

3 - Two Golden Duals — Complementary and Shift —
Yutaka Kimura, Systems Science and Technology, Akita Prefectural University, 84-4, Tsuchiya-Ebinokuchi, 0150055, Yuri-honjo, Akita, Japan, yutaka@akita-pu.ac.jp, *Seiichi Iwamoto*, *Toshiharu Fujita*

We consider two pairs of primal quadratic optimization problem and its dual problem. It is shown that optimal value and optimal solution of the two pairs are characterized by the Golden number.One pair has a Golden complementary duality, which consists of : (i)Golden optimal value, (ii)Golden solutions, and (iii)Golden complementarity between primal and dual optimal solutions. The other has a Golden shift duality, which consists of : (i)Golden optimal value, (ii)Golden solutions, and (iii)Golden shift between both optimal solutions.

4 - Bellman's Allocation Process - Conjugate Dual -
Takayuki Ueno, Department of Economics, University of Nagasaki, 123 Kawashimo-cho, Sasebo-city, Nagasaki 858-8580, 858-8580, Japan, ueno@sun.ac.jp, *Seiichi Iwamoto*

We consider the multi-stage allocation process in Chap.1, Bellman's DP from a viewpoint of duality. The (primal) process maximizes a total reward on finite-stage. The objective function is a rather complicated composite function, which contains linear terms. However we dare to convert them to constraints. Then the primal process is reduced to a maximization under linear constraints. Further by applying conjugate function/maximum transform, we transform the constrained maximization problem into a minimization one. This is a dual process. We derive Bellman equation for the dual process.

■ TA-69

Tuesday, 8:30-10:00
R19-3

OR for Development and Developing Countries 1

Stream: OR for Development and Developing Countries
Invited session

Chair: *Subhash Datta*, Centre for Inclusive Growth and Sustainable Development, M-134, SF, SouthCity I, 122007, GURGAON, Haryana, India, subhash.datta@gmail.com

1 - Integrated Energy Planning at the Block Level
Subhash Datta, Centre for Inclusive Growth and Sustainable Development, M-134, SF, SouthCity I, 122007, GURGAON, Haryana, India, subhash.datta@gmail.com

The rural development strategy must include development of energy saving technologies. The present paper investigates the energy use in a representative block in India to find out whether the local sources of energy would be able to sustain the kind of rural development envisaged. An allocation (LP) model is formulated so as to satisfy the energy demands from the available energy sources in the best possible way. The model emphasizes the use of local and renewable sources of energy.

2 - The Role of Geographic Information Systems in the Energy Sector in India
Badri Toppur, Operations Management, Great Lakes Institute of Management, Off ECR, Manamai Village, 603102, Chennai, Tamil Nadu, India, badri.t@greatlakes.edu.in

Fossil fuel energy providers dominate the energy sector. Private companies in India have reportedly been more successful in discovering oil and gas reserves in Indian territory. A play is a combination of geologic factors that make the hydrocarbon deposit or layer possible. This project paper showcases the use in India of scientific principles for locating plays, based upon base maps and thematic maps and a geographic information system (GIS). The GIS allows queries of information in the database so that identification can be made of suitable plays for drilling.

3 - Economic Sentiment Indicator and Business Survey Liquidity Measure in Forecasting Changes in Industrial Production- the Case of Croatia
Mirjana Cizmesija, Faculty of Economics & Business, University of Zagreb, J.F.Kennedy Square 6, 10000, Zagreb, Croatia, mcizmesija@efzg.hr, *Natasa Erjavec*, *Vlasta Bahovec*

ESI is a composite leading indicator of the economy as a whole. It is derived (as per The Joint Harmonised EU Programme of Business and Consumer Survey, BCS) from fifteen variables. Business survey liquidity measure (BSLM) is a variable added in Croatia's BCS. It is not ESI component. The aim of this paper is to investigate the relationship among ESI, BSLM and Croatia's industrial production. Various econometric models were defined using the quarterly data (2005-2012). The results showed that BSLM can be a proxy of ESI in forecasting changes in Croatia's industrial production.

4 - Application of DEA to Define the Revenues of Brazilian Power Transmission Companies
Tiago Soares, Advisory of Economic Regulation, FURNAS, Rua Real Grandeza 219, 22281-031 , Rio de Janeiro, Rio de Janeiro, Brazil, aragaotiago@gmail.com, *Rajiv Banker*, *Ana Lopes*

The Brazilian Regulatory Agency (ANEEL) uses, since 2009, Data Envelopment Analysis - DEA to reach the efficiency of 8 electricity transmission companies, regarding to their operating costs. This efficient operation cost is an important part of the revenue of these companies. ANEEL implemented in 2012 a new DEA model that produced an average efficiency around 51%, which was additionally adjusted by the quality of service, impacting negatively the revenues to be received by those companies. Therefore, the aim of this paper is to bring the ANEEL's model for discussion by academic community.

■ TA-71

Tuesday, 8:30-10:00
R16-1

Health Care Management (Health Systems)

Stream: Health Care Management
Invited session

Chair: *Marion Rauner*, Dept. Innovation and Technology Management, University of Vienna, Bruennerstr. 72, A-1210, Vienna, Austria, marion.rauner@univie.ac.at

1 - Benchmarking Rescue Departments of the Austrian Red Cross Using Data Envelopment Analysis
Marion Rauner, Dept. Innovation and Technology Management, University of Vienna, Bruennerstr. 72, A-1210, Vienna, Austria, marion.rauner@univie.ac.at, *Doris Lauss*, *Margit Sommersguter-Reichmann*

We performed a Data Envelopment Analysis (DEA) and a Malmquist Index Analysis for benchmarking rescue departments of the Austrian Red Cross. Suitable input and output variables were selected by correlation analysis. We disclosed a high rate for efficient rescue departments but also some oversupply in other regions. The reduction of several input variables is not possible because the health care supply has to be guaranteed. In addition, several variables can only be changed by particular units (e.g., working hours) or by whole numbers (e.g., ambulances).

2 - Location-Allocation Problem for Blood Service Facility in Thailand
Pornpimol Chaiwuttisak, Operational Research, University of Southampton, Building 54 Mathematics, University of Southampton, Highfield, Southampton, Hamsphire, United Kingdom, molchaiwuttisak@hotmail.com, *Honora Smith*, *Yue Wu*

In Thailand, the amount of blood collected is still not enough to meet demand. An increased number of fixed collection sites are proposed to make easy access for donors. In addition, some sites can prepare and store blood that hospitals can receive directly. Selecting sites for either blood collection from volunteers or blood distribution to hospitals is studied within a limited budget. We present integer programming model based on the Maximum Covering model and p-median model. Computational results on a real-life case study are reported, which are of practical importance to executives.

3 - How OR Simulation Models have helped the Welsh Government maximise the use of existing health related data in order to aid decision making.
Tracey England, Mathematics, Cardiff University, Senghennydd Road, CF24 4YG, Cardiff, United Kingdom, smatje@cf.ac.uk, *Paul Harper*, *Janet Williams*

In October 2011, the Welsh Government recruited four Research Fellows to investigate how existing data could be used more effectively. The role of the Operational Research fellow was to identify areas within the Welsh Government where simulation could be used to make use of existing data, or develop models to aid decision making. Two demonstration projects were developed. The first was a service evaluation of the teledermatology service offered to dermatology patients in rural Wales. The second, a simulation model to represent how women in Wales access midwifery care during their pregnancy.

4 - Service Line Management in US Heatlhcare
Sandra Potthoff, School of Public Health, University of Minnesota, Mayo Mail Code 510, 420 Delaware Street SE, 55455, Minneapolis, MN, United States, potth001@umn.edu, *Diwakar Gupta*

US healthcare systems are developing service line management structures to coordinate patient care across the continuum. Designed to care for populations of patients with similar care needs, there are challenges in managing processes horizontally across the traditional vertical silos of hospitals, clinics, and post-acute care. This change is similar to manufacturing's shift from factory management to supply chain management. We will present the challenges in healthcare service line management and the implications for operations research modeling approaches to address those challenges.

■ TA-72

Tuesday, 8:30-10:00
R16-2

OR Models in Health

Stream: OR in Health & Life Sciences (contributed)
Contributed session

Chair: *Salvador Sandoval*, Métodos Cuantitativos, Universidad de Guadalajara, Sierra Mojada 1102, 044340, Guadalajara, Jalisco, Mexico, salvsanb@cucea.udg.mx

1 - FDI, Corruption and Pollution Quota
Salvador Sandoval, Métodos Cuantitativos, Universidad de Guadalajara, Sierra Mojada 1102, 044340, Guadalajara, Jalisco, Mexico, salvsanb@cucea.udg.mx

This work develops a model of environmental economics with corruption, to determine the optimal institutional level that should allow the government to achieve economic balance of the country under an oligopolistic pattern of FDI. Besides, we calculate the optimal pollution quota, the values of which are derived from a series of strategic environmental policies that aim to maximize the welfare of the domestic country, involving both consumers, producers, government, as well as the dishonest agents working in the public sector. The model includes such variables in a function of social welfare.

2 - Improving Emergency Department Patient Flow: a job shop scheduling approach
Ruth Luscombe, Mathematical Sciences School, Queensland University of Technology, Gardens Point Campus, GPO Box 2434, 4001, Brisbane, Queensland, Australia, ruth.luscombe@student.qut.edu.au, *Erhan Kozan*

In Australia alone the number of Emergency Department (ED) patients has increased by over 30% in the last 10 years indicating a strong need to improve operational efficiency. The aim of this paper is to improve ED patient flow through the reduction of in-process delays. A job-shop scheduling approach with a tardiness objective is developed for the allocation and sequencing of ED resources to patients and tasks. The formulation combines binary integer programming and constraint programming. A numerical investigation demonstrates the efficiency of this approach.

3 - An optimization approach for generating sequential Bayesian designs

Jose M Lainez, Purdue University, 480 Stadium Mall Dr., 47907, WEST LAFAYETTE, IN, United States, jlainez@purdue.edu, *Linas Mockus*, *Seza Orcun*, *Poching DeLaurentis*, *Gary Blau*, *Gintaras V. Reklaitis*

Approaches for the optimal Design of Experiments (DoE) have been proposed in the literature (e.g. D, E, G optimality). However, most of them are developed for linear models and typically don't incorporate available prior knowledge. In this work, we address the sequential DoE for cases in which prior knowledge (e.g. captured by a multimodal probability distribution) is used and the model may be a set of differential equations. The benefits and limitations of the proposed approach are demonstrated using population pharmacokinetics case studies. The results are compared to traditional approaches.

■ TA-73

Tuesday, 8:30-10:00
R16-3

Modeling livestock diseases

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *Anna Stygar*, Economic Research, MTT Agrifood Research Finland, Latokartanonkaari 9, 00790, Helsinki, Finland, anna.stygar@mtt.fi

1 - Evaluation of the risk of the spread and the economic impact of Classical Swine Fever and Foot-and-Mouth Disease by using the epidemiological model Be-FAST.

Benjamin Ivorra, Matematica Aplicada, Universidad Complutense de Madrid, Plaza de ciencias, 3, 28040, Madrid, Spain, Spain, ivorra@mat.ucm.es, *Beatriz Martinez-Lopez*, *Eduardo Fernandez Carrion*, *Angel Manuel Ramos*, *Jose Manuel Sanchez-Vizcaino*

Classical Swine Fever and Foot-and-Mouth are viral diseases of animals that cause severe restrictions on the agricultural products in the affected areas. The knowledge of their spread patterns would help to implement specific measures for controlling future outbreaks. Here, we first describe a hybrid model, called Be-FAST, based on the combination of an Individual-Based model for between-farm spread with a Susceptible-Infected model for within-farm spread, to simulate the disease spread and its economic impact in a region. Then, three examples are detailed considering Spain, Bulgaria and Peru.

2 - Monto carlo simulation for economic evaluation of surveillance systems for livestock disease

Xuezhen Guo, Business Economics Group, Wagenignen University, Hollandseweg 1, WAGENINGEN, 6700EW, wageningen, Netherlands, xuezhen.guo@wur.nl, *G.D.H. (Frits) Claassen*, *Alfons Oude Lansink*, *Helmut Saatkamp*

We present a general Monte Carlo simulation model for comprehensive economic and technical evaluation of surveillance systems for life stock diseases. To stress the applicability of the model we take surveillance of classical swine fever (CSF) as an example. Alternative surveillance setups are compared for two virulent CSF strains. The findings are that rendering information with PCR tests is most effective for surveillance of moderately virulent CSF and serological surveillance on sow farms or in slaughterhouses could significantly improve the surveillance performances for low virulent CSF.

3 - Modeling the control of Actinobacillus pleuropneumoniae infections in fattening pig production.

Anna Stygar, Economic Research, MTT Agrifood Research Finland, Latokartanonkaari 9, 00790, Helsinki, Finland, anna.stygar@mtt.fi, *Jarkko Niemi*, *Claudio Oliviero*, *Tapio Laurila*, *Mari Heinonen*

We present a stochastic dynamic programming model to control actinobacillosis, which is an infectious respiratory disease caused by Actinobacillus pleuropneumoniae in a fattening pig unit. We modeled the problem in a framework where management decisions regarding feeding and slaughter timing are optimized simultaneously with disease prevention and treatment decisions. To characterise the evolution of a disease over time a stochastic compartmental model was developed. An optimal delivery and disease control policy was solved by maximizing the value of facility per fattening pig space unit.

Tuesday, 10:30-12h00

■ TB-03

Tuesday, 10:30-12h00
O1-3

Nonconvex Programming approaches for Machine Learning and Data Mining

Stream: Nonconvex Programming: Local and Global Approaches
Invited session

Chair: *Adilson Elias Xavier*, Systems Engineering and Computer Sciences Department, Federal University of Rio de Janeiro, P.O. Box 68511, Ilha do Fundão - Centro Tecnologia - H319, 21941-972, Rio de Janeiro, RJ, Brazil, adilson@cos.ufrj.br

1 - Nonlinear Eigenproblems and Tight Relaxations of Constrained Fractional Set Programs
Matthias Hein, Saarland University, Campus E1 1, 66123, Saarbruecken, Germany, hein@math.uni-sb.de

Many problems in machine learning have natural formulations as nonlinear eigenproblems. I present our recent line of research in this area. This includes the efficient computation of nonlinear eigenvectors via a generalization of the inverse power method and a general result showing that the class of constrained fractional set programs such as balanced graph cuts allow for tight relaxations into nonlinear eigenproblems. In the case of the Cheeger cut this corresponds to the second eigenvector of the p-graph Laplacian for p=1.

2 - An improved Branch and Bound algorithm for an optimal feature subset selection problem from robust statistics
Salvador Flores, Center for Mathematical Modeling, Universidad de Chile., Av Blanco Encalada 2120, Santiago, Chile, sflores@dim.uchile.cl

We present a Branch and Bound algorithm for computing the Least Trimmed Squares estimator for performing strongly robust linear regression. The main novelty of our approach is the use of lower bounds obtained from a second order cone programming relaxation of the mixed-integer nonlinear programming problem that defines the estimator, which allows pruning at top levels of the enumeration tree. Numerical results show the gains in computing time, notably when the number of explicative variables is close to the number of cases

3 - Fitting Subspaces to Data using the L1 Norm
José Dulá, School of Business, Virginia Commonwealth University, Richmond, United States, jdula@vcu.edu, *Paul Brooks*

The general formulation to find the L1 best-fit subspace for a point set is a complex non-linear, non-convex, non-smooth optimization problem. It has a remarkably simple solution when the subspace is a hyperplane. Other subspaces do not conform as easily. The next challenge is when the subspace is a line. This problem has been studied in the case when the point set is in three dimensions. We present theoretical and computational results for the general dimensional case. Some simple approaches may be optimal or can be used as accelerators.

4 - Solving Very Large Problems by the Accelerated Hyperbolic Smoothing Clustering Method
Adilson Elias Xavier, Systems Engineering and Computer Sciences Department, Federal University of Rio de Janeiro, P.O. Box 68511, Ilha do Fundão - Centro Tecnologia - H319, 21941-972, Rio de Janeiro, RJ, Brazil, adilson@cos.ufrj.br, *Vinicius Layter Xavier*

This paper considers the solution of the minimum sum-of-squares clustering problem by using the Accelerated Hyperbolic Smoothing Clustering Method. Computational experiments were performed with synthetic very large instances with 5000000 observations in spaces with up to dimensions. The obtained results show a high level performance of the algorithm according to the different criteria of consistency, robustness and efficiency.

■ TB-04

Tuesday, 10:30-12h00
O4-4

Optimization for Lot Sizing and Facility Location Problems

Stream: Mathematical Programming
Invited session

Chair: *Juan José Salazar González*, Estadística e Investigación Operativa, Universidad de La Laguna (Tenerife), Av. Astrofísico Francisco Sánchez, s/n, Facultad de Matemáticas, 38271, La Laguna, Tenerife, Spain, jjsalaza@ull.es
Chair: *Florian Potra*, Mathematics & Statistics, University of Maryland, MD 21250 , Baltimore, United States, potra@umbc.edu

1 - Lot Sizing with Piecewise Concave Production Costs
M. Selim Akturk, Industrial Engineering Dept., Bilkent University, 06800, Ankara, Turkey, akturk@bilkent.edu.tr, *Esra Koca*, *Hande Yaman*

We consider the lot-sizing problem with piecewise concave production costs and concave holding costs. Computational complexity of this problem was an open question. We develop a dynamic programming (DP) algorithm and show that the problem is polynomially solvable when the breakpoints of the production cost function are time invariant and the number of breakpoints is fixed. We computationally test the DP and compare it with an MIP solver. We propose a DP based heuristic algorithm for large instances and use a cut-and-branch algorithm to compute better bounds by the MIP formulation.

2 - Solving the Capacitated Lot Sizing and Scheduling Problem with Parallel Machines using Reduced Variable Neighborhood Search and Variable Neighborhood Descent Heuristics
Sel Ozcan, Department of Industrial Engineering, Yasar University, Yasar University Selcuk Yasar Kampusu Universite Cad., Agacli Yol No:35-37 Bornova, 35100, Izmir, Turkey, sel.ozcan@yasar.edu.tr, *Seyda Topaloglu*

In this work, the capacitated lot sizing and scheduling problem on parallel machines with sequence dependent setup times and costs is studied. A reduced variable neighborhood search and a variable neighborhood descent heuristic is developed for its solution. The aim is to find a production plan that minimizes the sum of production, setup and inventory costs while satisfying the demand of each product without delay. An initial solution approach and three types of neighborhood structures are developed for the proposed heuristics. They are tested on the benchmark problem instances and evaluated.

3 - A metaheuristic algor?thm for the dynamic facility layout problems
Gulfem Tuzkaya, Industrial Engineering Department, Marmara University, Goztepe Kampusu, Kadıkoy, 34722, Istanbul, Turkey, gulfem.tuzkaya@marmara.edu.tr, *Mehmet Rıfat Kamber*, *Özalp Vayvay*

Facility layout decisions are strategic decisions and once realized, it maybe time consuming and costly to make modifications on them. However, there is a trade-off between rearrangement costs and flow costs. The dynamic facility layout design models try to analyze whether to rearrange the layout of the facility for every different period or continue with the initial layout design. In this study, a metaheuristic algorithm is proposed for the dynamic facility layout design problem and the validation of the algorithm is tested with some well-known benchmark data from the literature.

4 - Inspection Location Decisions in Capacity-Constrained Lines
Salih Tekin, Industrial Engineering, TOBB University of Economics and Technology, Turkey, stekin@etu.edu.tr, *Sigrun Andradottir*

We consider the effects of inspection and repair stations on the production capacity and product quality in a serial line with possible inspection and repair following each operation. Our model allows for multiple defect types, partial inspection, and inspection errors that may be defect dependent. We construct a profit function that takes into account inspection, repair, and goodwill costs, as well as the capacity of each station. Then we discuss how the profit function can be maximized and provide properties of the optimal inspection plan.

■ TB-05

Tuesday, 10:30-12h00
O4-1

Ecology and Epidemiology

Stream: Optimal Control
Invited session

Chair: *Narcisa Apreutesei*, Department of Mathematics, Technical University, 11, Bd. Carol I, 700506, Iasi, Romania, napreut@gmail.com

1 - An optimal control problem in the treatment of hepatitis B

Gabriela Apreutesei, Department of Mathematics, Faculty of Mathematics, University "Al. I. Cuza", Iasi, Romania, B-d Carol I no 11, Iasi, Romania, 700506, Iasi, Romania, Romania, gapreutesei@yahoo.com, *Narcisa Apreutesei*, *Radu Strugariu*

An optimal control problem is studied related to the treatment of the infection with hepatitis B virus. To describe HBV dynamics we use a model of ordinary differential equations about the number of uninfected liver cells, the number of infected liver cells and the numbers of virions. We give a treatment model with a drug that stimulates the immune system and another drug which inhibit the viral reverse transcriptase.

2 - Optimal Conjunctive Use of Drinking Water Sources and Interactions Between Multiple Providers

Alessandra Buratto, Department of Mathematics, University of Padova, Via Trieste, 63, 35121, Padova, Italy, buratto@math.unipd.it, *Chiara D'Alpaos*

The provision of drinking water and its conservation are key issues worldwide. Optimal management involves conjunctive use of different sources, one of which is flow and the other stock. This is more complex when multiple providers use the same surface water source (i.e., river) to supply distinct groups of customers. In this paper we consider the interaction between two profit maximizer providers. We solve two optimal control problems where the upstream provider solution influences the feasible controls of the downstream one. We determine the optimal conjunctive use at every catchment point.

3 - An optimal control problem for a reaction-diffusion model of invasive species

Narcisa Apreutesei, Department of Mathematics, Technical University, 11, Bd. Carol I, 700506, Iasi, Romania, napreut@gmail.com

Consider a parabolic system of PDEs that models the dynamics of a population of invasive species. It contains normal females, males, supermales and feminized supermales. These supermales and feminized supermales (genetically modified organisms) are created by hormone treatments in laboratory. It is done often in salmon industry. Regard the model as an optimal control problem. Suppose that the feminized mutant is released into the population at some rate which is the control parameter. Our goal is to minimize the female population, maximize the male population, while minimizing this rate.

4 - A Parallel Branch-Cut-And-Price Approach for the Minimum Evolution Problem

Daniele Catanzaro, Computer Science, Université Libre de Bruxelles, Boulevard du Triomphe CP210/01, 1050, Brussels, Belgium, dacatanz@ulb.ac.be

We investigate the combinatorics of the Minimum Evolution Problem and we discuss its relationships with the Balanced Minimum Evolution Problem. Moreover, we present a new exact approach for solving the MEP based on a sophisticated combination of both a branch-price-and-cut scheme and a non-isomorphic enumeration of all possible phylogenies for a set of n taxa. This peculiar approach allows us to break symmetries in the problem and improve upon the performances of the best-so-far exact algorithm for the MEP.

■ TB-06

Tuesday, 10:30-12h00
O4-2

Numerical methods of nonsmooth optimization

Stream: Nonsmooth Optimization
Invited session

Chair: *Annabella Astorino*, ICAR, CNR, C/0 DEIS - UNICAL, CUBO 41 C, 87036, RENDE, Italy, astorino@icar.cnr.it

1 - A Codifferential Method for the Difference of Polyhedral Functions

Ali Hakan Tor, Department of Mathematics, Yüzüncü Yıl University, 65080, Van, Turkey, htor@metu.edu.tr, *Adil Bagirov*, *Julien Ugon*

In this study, the unconstrained optimization problem whose objective function is represented as a difference of polyhedral functions (DP functions) is examined. In the theoretical viewpoint, the necessary and sufficient local and global optimality conditions for the problem are stated using the concept of codifferentials. In the viewpoint of applications, two new algorithms are proposed. The first algorithm is to find a local minimizer of the nonsmooth problems. In the second algorithm, the first algorithm is consecutively used to find global minimizer.

2 - Conjugate subgradient revisited

Manlio Gaudioso, Università della Calabria, 87036, Rende, Italy, gaudioso@deis.unical.it, *Annabella Astorino*, *Enrico Gorgone*

The objective of the talk is to introduce a numerical method for minimizing convex nonsmooth functions which benefits from two classic approaches such as conjugate subgradient and bundle. The aim is to accelerate convergence by using as much as possible bundling of subgradients while avoiding the need of frequent resets. Termination of the algorithm is proved and numerical results are presented.

3 - A derivative free method for nonsmooth nonconvex optimization

Gurkan Ozturk, Industrial Engineering, Anadolu University, AU-MMF-Industrial Engineering, Iki Eylul Campus, 26480, Eskisehir, Turkey, gurkan.o@anadolu.edu.tr, *Adil Bagirov*, *Refail Kasimbeyli*

In this paper, a derivative free algorithm for solving constrained nonsmooth nonconvex optimization problems is proposed. This algorithm uses sharp Augmented Lagrangians and is based on the combination of the modified subgradient and discrete gradient methods. The convergence of the proposed algorithm is studied and results of numerical experiments using wide range of constrained nonlinear and in particular nonsmooth optimization problems are reported.

4 - Generalized radial epiderivatives in nonconvex set-valued optimization

Gonca Inceoglu, Education Faculty - Department of Primary Education - Program in Primary School Mathematic Teaching, Anadolu University, Yunus Emre Campus, Tepebasi, 26470, Eskisehir, Turkey, inceoglugonca@gmail.com

In this paper, the generalized radial epiderivative and its variants for set-valued maps is introduced and its relationship to the radial epiderivative is investigated. Examples show that all these variants are in general different. The characterizations and connections with the radial derivative of these epiderivatives are also presented.

■ TB-07

Tuesday, 10:30-12h00
O4-3

Vector and Set-Valued Optimization V

Stream: Vector and Set-Valued Optimization
Invited session

Chair: *Enrico Miglierina*, Dipartimento di Discipline Matematiche, Finanza Matematica ed Econometria, Università Cattolica del Sacro Cuore, via Necchi 9, 20123, Milano, Italy, enrico.miglierina@unicatt.it

1 - Beta Algorithm for Multiobjective Optimization over compact robust sets
Miguel Delgado Pineda, Matematicas Fundamentales, UNED, Edificio de Ciencias. UNED, C/ Senda del Rey, 9, 28040, Madrid, Spain, miguel@mat.uned.es

Set-monotonic algorithm for the Pareto set in multicriteria optimization problems formulated as min-problem with Lipschitz continuous functions over compact robust sets is presented. A MAPLE code of Beta Algorithm MOP is developed for optimization of k-vectorial functions of n variables. The code does not create ill-conditioned situations, and it is ready for engineering applications. Results of numerical experiments are presented, with grapas. Graphics are included, and the solution set can be visualized in 1, 2 or 3 dimension and in projections on coordinate planes for n>2.

2 - A relationship between multiobjective mathematical programming problems and multiobjective control problems
Manuel Arana-Jiménez, Estadistica e Invesitigacion Operativa, University of Cadiz, Facultad CCSS y de la comunicacion, Av. Universidad s/n, 11405, Jerez de la Frontera, Cadiz, Spain, manuel.arana@uca.es, *Riccardo Cambini*, *Antonio Rufián-Lizana*, *Gracia M. Nieto-Gallardo*

In vector optimization problems, the study of optimality conditions is a way to locate candidates for their solutions. These conditions, called critical point conditions, use to be necessary but not sufficient to obtain optimal solutions. In this regard, the study of the properties of the involved functions plays an important role. So, many classes of nonconvex functions have been studied. We show new classes of functions and optimization results in Mathematical Programming and their extensions to Control Problems, in such a way that we can assure that a critical point is an optimal solution.

3 - Saddle point criteria and duality for a new class of nonconvex nonsmooth multiobjective programming problems
Tadeusz Antczak, Faculty of Mathematics and Computer Science, University of Lodz, Banacha 22, 90-238, Lodz, lodzkie, Poland, antczak@math.uni.lodz.pl

A new class of nonconvex nondifferentiable multiobjective programming problems with inequality and equality constraints is considered. Saddle point criteria and Wolfe duality theorems are proved for this class of nonconvex multiobjective programming problems involving locally Lipschitz functions. The results are established under a new concept of nondifferentiable generalized invexity and related scalar and vector-valued Lagrangians defined for the considered multiobjective programming problem.

4 - Cones with bounded base in infinite dimensional vector optimization
Enrico Miglierina, Dipartimento di Discipline Matematiche, Finanza Matematica ed Econometria, Università Cattolica del Sacro Cuore, via Necchi 9, 20123, Milano, Italy, enrico.miglierina@unicatt.it

Some assumptions concerning the boundedness (or the compactness) of the base of the ordering cones, widely used in the theory of vector optimization, will be discussed. It will be proved that in an infinite dimensional setting this type of assumptions are often unduly restrictive. It will be shown that the hierarchical structure of the relationships between various notions of proper optimality completely changes when the existence of a bounded base is not ensured. The study of these geometrical aspects of the cones allows to prove some results about the structural property of the whole space

■ TB-08

Tuesday, 10:30-12h00
O3-2

Keynote - L. Ozdamar

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Diego Klabjan*, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, IEMS, 60208-3119, 60208, Evanston, IL, United States, d-klabjan@northwestern.edu

1 - Models and Solutions for Emergency Logistics
Linet Ozdamar, Industrial & Systems Eng., Yeditepe University, Turkey, ozdamar.linet@gmail.com

Transportation in post-disaster relief and evacuation consumes an increasing amount of resources. Here, a classification of logistics models is presented for three logistical planning phases (pre-disaster preparedness, post-disaster response and recovery). A review of the models include the decisions made, objectives, constraints and formulation particulars. Vehicle flow related model complexity is discussed along with equity and utilitarian types of objective functions. Finally, road recovery models integrated with relief distribution are presented. (This work is partially funded by TUBITAK.)

■ TB-09

Tuesday, 10:30-12h00
O3-3

Sponsor - INFORMS

Stream: Sponsors
Sponsor session

Chair: *Anna Sciomachen*, DIEM, University of Genova, Via Vivaldi 5, 16126, Genova, Italy, sciomach@economia.unige.it

1 - Analytics — Enabling the way for Operations Research
Anne Robinson, Supply Chain, Verizon Wireless, 1 Verizon Way, 07901, Basking Ridge, New Jersey, United States, Anne.Robinson@verizonwireless.com

It is difficult to read a business or science magazine, walk through an airport terminal or even attend a sporting event and not encounter an advertisement or reference to the benefits of analytics. The McKinsey Global Institute has referred to analytics and big data as the next frontier in innovation, competition and productivity. Gartner predicts that advanced analytics need to be more pervasive to keep up with the explosive growth in data sources. This worldwide trend is opening doors for operational researchers around the globe.

INFORMS defines analytics as the scientific process of transforming data into insight for making better decisions. In 2010, INFORMS began investigating how the topic and field of analytics relates to the operations research profession and the professional society. Capgemini Consulting was hired to research the popular understanding and use of the term analytics, the perceived needs of analytics professionals, and potential products and services missing from the existing landscape. Capgemini delivered a framework in which to discuss analytics. They presented a description that has resonated with several audiences.

Analytics encompasses: • Descriptive Analytics - Prepares and analyzes historical data; • Predictive Analytics - Predicts future probabilities and trends; • Prescriptive Analytics - Evaluates and determines new ways to operate. They also described many products and services being requested in the market. This study spearheaded INFORMS journey into analytics.

In this session, learn about the current trends in analytics and the opportunities it presents for academics and practitioners in our field. Hear about the new Certified Analytics Professional (CAP™) certification and the demographics it is attracting. We will also discuss publications, continuing education and assessing a company's maturity all in the context of analytics. Finally, we would like to conclude with an open discussion on ideas and trends you are witnessing around analytics and operations research.

■ TB-10

Tuesday, 10:30-12h00
G5-1

Wireless networks

Stream: Telecommunications and Network Optimization
Invited session
Chair: *Laura Prati*, University of Florence, Italy, prati@math.unifi.it

1 - A constrained regression model to reconcile conflicting QoS goals in wireless networks
Hennie Kruger, School of Computer, Statistical and Mathematical Sciences, North-West University, Private Bag X6001, 2520, Potchefstroom, South Africa, Hennie.Kruger@nwu.ac.za, *Jan Adriaan Brand*, *Henry Foulds*

QoS in a wireless network refers to a set of attributes that relates to the performance of the network and include metrics such as throughput, delay, jitter, packet loss etc. A constrained regression model is suggested to reconcile conflicting QoS goals — specifically for the case where Throughput and Delay are in conflict, i.e., an increase in Delay would result in a decrease in Throughput. This implies that a specific level (goal) in Delay will have an impact on the Throughput level (goal). Empirical results will be presented.

2 - A queueing system for modelling the performance of power-saving methods in wireless communications with retransmissions
Ioannis Dimitriou, Mathematics, University of Ioannina, Ioannina 45110, Ioannina, Greece, idimit@cc.uoi.gr

In this paper we model the power management in wireless systems such as 3GPP LTE and WIMAX by a variant of a M/G/1 queue with probabilistic inhomogeneous vacations and generalized service time. The service process is suitable to describe the retransmission procedure in such systems. Steady state analysis is investigated and decomposition results are discussed. Energy and performance metrics are obtained and used to provide useful numerical results.

3 - A Non-cooperative Generalized Game for Dynamic Spectrum Leasing
Laura Prati, University of Florence, Italy, prati@math.unifi.it

Dynamic Spectrum leasing is a novel approach in telecommunication wireless networks in which the primary communication system is willing to allow the secondary users to share its own spectrum band in return for an incentive, like monetary rewards. We propose a continuous-time Generalized Game in which the primary system adjusts the maximum tolerable interference while the secondary users select the transmit powers to be allocated in order to obtain a good quality of their own signals and avoid harmful interference. It results in a Generalized Nash Equilibrium Problem that has a solution.

4 - A hybrid matheuristics algorithm for the competitive base stations location problem in Cognitive Radio Networks
Stefano Iellamo, Telecom ParisTech, France, iellamo@telecom-paristech.fr, *Ekaterina Alekseeva*, *Lin Chen*, *Marceau Coupechoux*, *Yury Kochetov*

We present the problem of strategic base stations (BS) placement in Cognitive Radio (CR) Networks. We consider a CR operator (the leader) willing to exploit the unused capacity of a primary network so as to maximize the profits derived from operating the installed BSs and serving Secondary Users (SU). The leader is aware of the future arrival of a second operator (the follower), who is able to capture SUs by appropriately placing his own CR-BSs. We formulate the problem as a mixed integer bi-level program. We show that it is Sigma2P-hard and propose a hybrid matheuristic algorithm to solve it.

■ TB-11

Tuesday, 10:30-12h00
G5-3

Telecommunications, Networks and Social Networks 4

Stream: Telecommunications, Networks and Social Networks (contributed)
Contributed session
Chair: *Jonathan Thompson*, United Kingdom, thompsonjm1@cardiff.ac.uk

1 - Fuzzy logic based decision making on network resource allocation
Julija Asmuss, Institute of Telecommunications, Riga Technical University, Azenes str. 12, Riga, Latvia, julija.asmuss@rtu.lv, *Gunars Lauks*

We consider the problem of network bandwidth resource management accordingly to DaVinci approach. The talk deals with dynamically adaptive bandwidth allocation mechanisms proposed to support multiple traffics with different performance objectives in a substrate network. We present a methodology of decision making on bandwidth allocation based on fuzzyfication and defuzzyfication principles and an expert knowledge database of fuzzy rules and introduce a fuzzy logic based modification of the bandwidth allocation scheme to optimize decision making under uncertain network conditions.

2 - Ant Colony Optimisation for Frequency Assignment Problems
Jonathan Thompson, United Kingdom, thompsonjm1@cardiff.ac.uk

Frequency assignment problems are a class of problems derived from wireless communication. They generally involve assigning frequencies to connections such that some objective is optimised. We describe an ant colony algorithm for these problems intended to produce good solutions in a reasonable time. The run time is important because we extend the work to the dynamic frequency assignment problem, where new communication requests have to be accommodated in real time in the existing solution. Experimental results for the static and dynamic problems are given and discussed.

3 - A new algorithm for blind separation of discrete signals used in digital communications
Abdenour Labed, Computer Science, Ecole Militaire Polytechnique, BP 17, 16111, Bordj El Bahri, Algiers, Algeria, abd.labed@gmail.com

Blind source separation consists in extracting the signals transmitted over Multiple-Input Multiple-Output systems from their unknown mixture, without the use of training sequences and exploiting only the mutual independence between source signals. We introduce a new cost function by augmenting the MU-CMA criterion by a term on priori information. The stochastic gradient algorithm is used to minimize the resulting function. Computer simulation shows that, the derived algorithm outperforms the MU-CMA, the Simplified Constant Modulus Algorithm and the Mutual Information-based CMA.

4 - Optimality Conditions for Coordinate-Convex Policies in Call Admission Control via a Generalized Stochastic Knapsack Model
Marcello Sanguineti, DIBRIS, University of Genoa, Via Opera Pia, 13, 16145, Genova, Italy, marcello.sanguineti@unige.it, *Marco Cello*, *Giorgio Gnecco*, *Mario Marchese*

We derive optimality conditions for Coordinate-Convex (CC) policies in Call Admission Control with K classes of users and nonlinearly-constrained feasibility regions. We adopt a generalized stochastic knapsack model, with random inter-arrival times and sojourn times. General structural properties of the optimal CC policies and properties that depend on the revenue ratio are investigated. Both theoretical and numerical results show that exploiting the proposed analysis the number of candidate optimal CC policies dramatically decrease.

■ TB-12

Tuesday, 10:30-12h00
G5-4

Routing Problems

Stream: Transportation and Logistics
Invited session

Chair: *Elena Fernandez*, Universitat Politecnica de CAtalunya, Barcelona, Spain, e.fernandez@upc.es

1 - Scheduling policies for multi-period collection
Elena Fernandez, Statistics and Operations Research, Technical University of Catalonia, Campus Nord, C5-208, Jordi Girona, 1-3, 08034, Barcelona, Spain, e.fernandez@upc.edu, *Jörg Kalcsics*, *Stefan Nickel*, *Cristina Nuñez*

We study the multi-period collection scheduling problem MCSP. Each of the customers of a given set must be visited with a minimum frequency within a time horizon, and the calendar for visiting each of the customers of a given set must be established. We discuss alternative collection policies and present formulations for each of them. One policy imposes visiting each customer with a fixed frequency, whereas the other one is more flexible as it allows reducing number of periods between consecutive visits. A solution algorithm is proposed and the effect of each collection policy analyzed.

2 - Properties and valid inequalities for the multi-depot arc routing problem
Dmitry Krushinsky, Operations, Planning, Accounting and Control, Eindhoven University of Technology, Den Dolech 2, Eindhoven, Netherlands, d.krushinsky@gmail.com, *Tom Van Woensel*

We examine properties of the feasible polytope for the directed multi-depot arc routing problem and derive several families of valid inequalities. Further, we propose an approach that allows efficiently solving instances of moderate size.

3 - Solving a Real-World Pickup and Delivery Problem with Multiple Time Windows and Transshipment
Pedro Amorim, Industrial Engineering and Management, Faculty of Engineering of University of Porto, Rua Doutor Roberto Frias, 4200-465, Porto, Portugal, amorim.pedro@fe.up.pt, *Fábio Moreira*, *Márcio Antônio Ferreira Belo Filho*, *Luis Guimarães*, *Bernardo Almada-Lobo*

Pickup and delivery problems with time windows are common in courier companies. These companies serve customers that require transportation of a container from a pickup to a delivery location. This presentation is based on a case-study of a courier that has implemented a system of transshipment points in its operation. The distance without any load being carried has to be minimized and multiple real-word side-constraints have to be considered, such as different types of loads. Besides formulating this problem, we present two solution approaches based on exact and approximate methods.

4 - A Unified Framework For Modelling and Solving Vehicle Routing and Scheduling Problems with Environmental Considerations
Konstantinos Androutsopoulos, Department of Management Science and Technology, Athens University of Economics and Business, Evelpidon 47A, 11362, Athens, -, Greece, kandro@aueb.gr, *Konstantinos G. Zografos*

In recent years vehicle routing and scheduling problems with environmental considerations have attracted significant research attention. We are proposing a modelling framework for unifying two important classes of vehicle routing and scheduling problems with environmental considerations, namely the hazardous materials and the pollution routing and scheduling problems. We identify commonalities due to their time and load dependent, and multi-objective characteristics which lead to a unified model and we propose efficient methods for solving it.

■ TB-13

Tuesday, 10:30-12h00
G5-5

Soft computing in transportation

Stream: Traffic
Invited session

Chair: *Riccardo Rossi*, Department of Civil, Architectural and Environmental Engineering, University of Padova, Via Marzolo, 9, I35131, Padova, -, Italy, riccardo.rossi@unipd.it
Chair: *Michele Ottomanelli*, DICATECh, Politecnico di Bari, Via Orabona 4, 70125, Bari, Italy, m.ottomanelli@poliba.it

1 - Analysis of Roundabout Metering Signals by Fuzzy Control
Ziya Cakici, Pamukkale University, Denizli, Turkey, zcakici@pau.edu.tr, *Yetis Sazi Murat*

This study is employed to emphasize junction design problem and to discuss a new approach in roundabout control. The roundabouts are modeled considering conventional (i.e., roundabout with and without metering) and fuzzy control approaches. The Fuzzy Logic Control for Roundabout (FuLCRo) Model is developed in the study. The developed FuLCRo model has been compared with conventional Roundabout with and without metering approach using Sidra Intersection with respect to the average delays of vehicles.

2 - Single Allocation Ordered Median Hub Location Problem: A fuzzy mathematical programming approach
Behnam Tootooni, Industrial Eng., Amirkabir University of Tech., Tehran, Iran, Islamic Republic Of, btootooni@gmail.com

Hubs are facilities that decrease cost of a many-to-many distribution system by acting as inter-connectors between nodes of demand and supply. Obviously this facility can reduce the number of direct links needed in a logistic network. In this paper, the author propose a fuzzy type-I programming approach for one of the new models of the literature which is the single allocation ordered median problem. An exact solution method is used and a numerical example is given.

3 - The use of uncertain data in Multi Regional Input-Output Models for freight demand estimation
Michele Ottomanelli, DICATECh, Politecnico di Bari, Via Orabona 4, 70125, Bari, Italy, m.ottomanelli@poliba.it, *Leonardo Caggiani*

A relevant issue for the definition of freight transportation system is the estimation of freight demand. The traditional procedures are based on statistical estimation that need of a large amount of data that usually are affected by unreliability and incompleteness. Consequently, the results suffer from high level of uncertainty. In this paper, we propose an estimation method of freight demand using uncertain data based on fuzzy programming. The presented method takes as much advantage as possible of the few vague available data. The proposed method is tested with a numerical application.

4 - Driver Gap-acceptance at roundabouts: a fuzzy logic approach
Riccardo Rossi, Department of Civil, Architectural and Environmental Engineering, University of Padova, Via Marzolo, 9, I35131, Padova, -, Italy, riccardo.rossi@unipd.it, *Massimiliano Gastaldi*, *Gregorio Gecchele*, *Claudio Meneguzzer*

Gap-acceptance behaviour at unsignalized intersections has been extensively studied in the field of traffic theory and engineering using various methods. An interesting application of gap-acceptance theory regards roundabouts. This paper describes the development of a model of gap acceptance based on fuzzy system theory and specifically applicable to traffic entering a roundabout. The study is based on data derived from on site observations carried out at a roundabouts near Padova, Italy.

■ TB-14

Tuesday, 10:30-12h00
G5-6

Matheuristics

Stream: Matheuristics
Invited session

Chair: *Marco Boschetti*, Department of Mathematics, University of Bologna, Via Sacchi, 3, 47023, Cesena, FC, Italy, boschett@csr.unibo.it
Chair: *Vittorio Maniezzo*, dept. Computer Science, University of Bologna, via sacchi 3, 47521, Cesena, – Please Select (only U.S. / Can / Aus), Italy, vittorio.maniezzo@unibo.it

1 - Vehicle routing problem for exhausted oil collection: A matheuristic approach
Roberto Montemanni, IDSIA - Dalle Molle Institute for Artificial Intelligence, SUPSI - University of Applied Sciences of Southern Switzerland, Galleria 2, CH-6928, Manno, Canton Ticino, Switzerland, roberto@idsia.ch, *Matteo Salani*, *Dennis Weyland*, *Luca Maria Gambardella*

A vehicle routing problem for the collection of exhausted cooking oil is discussed. The problem is faced within a recycling project running in Bali (Indonesia) and coordinated by Caritas Suisse, where cooking oil is collected and recycled into bio diesel fuel. We describe the underlying problem of collecting exhausted oil, show how it can be modeled as a vehicle routing problem and then solved via a matheuristic approach. We finally discuss how the resulting approach has been used to support strategic decisions about the location of the processing plant and the number of vehicles to employ.

2 - Matheuristics for city logistics scenario assessment
Vittorio Maniezzo, dept. Computer Science, University of Bologna, via sacchi 3, 47521, Cesena, – Please Select (only U.S. / Can / Aus), Italy, vittorio.maniezzo@unibo.it, *Marco Boschetti*

The experience gained in past city logistics initiatives stresses the importance of concertation among stakeholders. Optimization is used to assess KPI for alternative scenarios, which involve different operational constraints and are to be solved using limited computational resources. Matheuristics represent a primary choice for such settings. We describe a Lagrangean optimization of an extended Set Covering problem which proved effective for the assessment of scenarios for a town of ca. 100000 inhabs, and we show how the approach is competitive also on difficult pure set covering instances.

3 - A Hybrid Algorithm based on Gray Petri Net and Tabu Search for Workforce Management
Roberto Aringhieri, Computer Science Department, University of Torino, Corso Svizzera 185, 10149, Torino, Italy, roberto.aringhieri@unito.it, *Bernardetta Addis*, *Marco Gribaudo*, *Andrea Grosso*

Workforce management is an important issue especially in Health Care whose services are usually delivered by teams of individuals working together sharing knowledge, experiences and skills. The random nature of the problem requires the characterization of the team behaviour with a sort of stochastic process to have a more accurate performance evaluation under several demand scenarios. We present a methodology combining Petri Nets (PN) and metaheuristics: the basic idea is to exploit PN to evaluate the team performance while an metaheuristics tries to compose the optimal set of teams.

4 - Matheuristics for the sprint planning in agile methods
Marco Boschetti, Department of Mathematics, University of Bologna, Via Sacchi, 3, 47023, Cesena, FC, Italy, boschett@csr.unibo.it, *Vittorio Maniezzo*

Agile methods for software development promote iterative design and implementation. Most of them divide a project into functionalities (user stories) and at each iteration (sprint) a subset of them are developed. Given the estimates made by the project team and a set of development constraints, the optimal solution is a sprint plan that maximizes the business value perceived by users. We propose some matheuristic approaches for sprint planning based on a MIP model. Computational results on both real and synthetic projects show the effectiveness of the proposed approaches.

■ TB-16

Tuesday, 10:30-12h00
G5-7

Vehicle Routing Problems III

Stream: Routing Problems
Invited session

Chair: *Aristide Mingozzi*, Department of Mathematics, University of Bologna, C.d.L. Scienze dell'Informazione, Via Sacchi, 3, 47023, Cesena, FC, Italy, mingozzi@csr.unibo.it
Chair: *Roberto Roberti*, DEIS, University of Bologna, Via Sacchi, 3, 47521, Cesena, Italy, roberto.roberti6@unibo.it

1 - An exact solution method for the vehicle routing problem with multiple deliverymen
Pedro Munari, Industrial Engineering Department, Federal University of Sao Carlos, Sao Carlos, Sao Paulo, Brazil, munari@dep.ufscar.br, *Reinaldo Morabito*

We address a variant of the vehicle routing problem with time windows which involves the decision of how many deliverymen should be assigned to each vehicle, in addition to the usual routing and scheduling decisions. This variant is relevant when the requests must be delivered on the same day in busy urban areas, and the service times are long and depend on the number of deliverymen. To solve this problem, we propose a branch-and-price method, which is based on the Dantzig-Wolfe decomposition. We present preliminary computational results which indicate the advantages of the proposed approach.

2 - Variable neighborhood search for the Location and Routing problem with multiple routes
Rita Macedo, DPS, Universidade do Minho, Portugal, rita.sgd.macedo@gmail.com, *Bassem Jarboui*, *Saïd Hanafi*, *Nenad Mladenovic*, *Cláudio Alves*, *J. M. Valério de Carvalho*

We address a variant of the location routing problem (LRP), where vehicles can perform several routes in the same planning period and both depots and vehicles have capacities. For this problem, we propose a network flow model, whose variables represent feasible vehicle routes, and a variable neighborhood search (VNS) algorithm to solve it. To evaluate the quality of our method, we conducted a set of computational experiments on benchmark instances. To the best of our knowledge, this is the first time that a VNS based heuristic is proposed for solving this variant of the LRP.

3 - New formulations for the Split Delivery Vehicle Routing Problem
Nicola Bianchessi, Department of Economics and Management, University of Brescia, C.da S.Chiara, 50, 25122, Brescia, Italy, bianche@eco.unibs.it, *Claudia Archetti*, *M. Grazia Speranza*

The Split Delivery Vehicle Routing Problem (SDVRP) is the problem to serve customers with a fleet of capacitated vehicles at minimum traveling cost, possibly visiting customers more than once. In this work, we focus on the optimal solution of the SDVRP. We present branch-and-cut algorithms based on new polynomial size mathematical formulations for the problem. We test the proposed algorithms on benchmark instances. We solve to optimality new instances and find new best solutions.

4 - The Single Vehicle Dial-A-Ride Problem
Enrico Bartolini, DISMI, University of Modena and Reggio Emilia, Italy, enrico.bartolini@unimore.it, *Aristide Mingozzi*

The Single Vehicle Dial-A-Ride Problem is to design a least cost vehicle tour to service a set of transportation requests. The vehicle starts and ends at a depot, and must pick up each request at its origin point before delivering it to a corresponding destination. Ride-time constraints impose an upper bound on the time between the visit to each origin and the corresponding destination. We describe three mathematical formulations, and use them to derive three exact algorithms. Our computational analysis shows that the new algorithms can optimally solve instances with up to 50 requests.

■ TB-17

Tuesday, 10:30-12h00
G5-8

Transportation Planning 2

Stream: Transportation Planning
Invited session
Chair: *Tobias Winkelkotte*, IT, zooplus AG, Sonnenstraße 15, 80331, München, Germany, tobias.winkelkotte@zooplus.com

1 - An Optimization via Simulation Approach for the Travel Salesman Problem with Stochastic Journey Times
Ana Carolina Olivera, Depto. de Ciencias e Ingeniería de la Computación, Universidad Nacional del Sur, Alem 1253, 8000, Bahía Blanca, Buenos Aires, Argentina, aco@cs.uns.edu.ar, *Enrique Gabriel Baquela*

We propose two OvS methodologies to solve the Traveling Salesman Problem with stochastic cost associated to arcs networks. Thesedays, thousands of cars travel to different parts of a city. If the time window in which these journeys are made is relatively large, then the density of vehicles in each arc of the network is a time-dependent function, where the variability is governed not just by purely random factors but also to traffic demand, vehicle density and the network topology. We tested the procedures for different network topologies and vehicles density, with satisfactory results.

2 - Two Algorithms for solving the Traveling Visitor Problem
Milan Djordjevic, DIST, Institute Andrej Marusic, Glagoljaska 8, 6000, Koper, Slovenia, milandjo@gmail.com, *Andrej Brodnik*, *Janez Zibert*

We considered the Traveling Visitor Problem (TVP). In the problem, visitor starts from a hotel to visit all interesting sites in a city exactly once and to come back to the hotel. This problem is similar to the TSP. The difference is that during the visit, visitors must go around buildings. The tested benchmarks come from three real instances of cities Venice, Belgrade and Koper and couple of artificial cases. We introduced and compared two algorithms. In all tested cases, the Koper Algorithm outperforms the Naïve Algorithm for solving TVP-quality of solutions differs from 6.52% to 354.46%.

3 - On good and even better models to optimize replenishment at Zooplus.com
Tobias Winkelkotte, IT, zooplus AG, Sonnenstraße 15, 80331, München, Germany, tobias.winkelkotte@zooplus.com, *Caroline Mader*

Zooplus applies OR to planning deliveries from Asia. The model deals with only one supplier and one warehouse, but various constraints for a lot of features make it very complex. Anyway, we could halve stocks with it. Now, the model has to be able to plan European suppliers, too. But necessary features for that are impossible in the model. So we formulated a new one that can deal with the new features. It considers more complex constraints but is easier to solve because many constraints are part of the underlying structure. This smart structure amends an already good model into a better one.

4 - A Decision Support Approach for Mail Delivery Systems
Roberta Laraspata, Politecnico di Bari, Italy, r.laraspata@poliba.it, *Maria Pia Fanti*, *Giorgio Iacobellis*, *Agostino Marcello Mangini*, *Walter Ukovich*

The research aims to develop a Decision Support System (DSS) of a logistics system for sorting and delivery correspondence able to improve vehicles management and handling. The proposed system manages state and transit of postal product through all postal network nodes. It is devoted to optimize load transport resources and plan empty recovery. Furthermore, the DSS is oriented to evaluate the best route for each vehicle on the basis of daily jobs to satisfy and road network resources. In this way it is possible to decrease manage costs and reduce delivery times.

■ TB-18

Tuesday, 10:30-12h00
G5-9

Stochastic Modeling and Simulation II

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session
Chair: *Elcin Kartal Koc*, Statistics, Middle East Technical University, Statistics Department, METU, 06531, Ankara, Turkey, ekartal@metu.edu.tr
Chair: *Erdem Kilic*, Business Administration, Yeditepe University, İnönü Mah. Kayışdağı Cad., 26 Ağustos Yerleşimi, Ataşehir, 34755 , Istanbul, Turkey, rdmklc@gmail.com

1 - Investigation of a Gaussian Random Walk with Generalized Reflecting Barrier
Basak Gever, Department of Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Cad., No: 43, 06560, Ankara, Turkey, 06560, Ankara, Turkey, bgever@etu.edu.tr, *Tahir Khaniyev*, *Zulfiyya Mammadova*

In this study, an insurance model is considered. A Gaussian random walk with generalized reflecting barrier, which expresses the model, is mathematically constructed. Moreover, the boundary functionals of the process are defined. Under some conditions, the ergodicity of the process is proved. Then, the moments of the boundary functionals and the ergodic distribution are investigated. Using Siegmund' s approximation formula, the asymptotic expansions are derived for the obtained moments. Finally, these approximation results are applied for considered insurance model.

2 - A pseudo random number generator which uses Refined Descriptive Sampling
Abdelouhab Aloui, Computer Science, University of Bejaia, 06000, Bejaia, Algeria, aaloui_abdel@yahoo.fr, *Megdouda Ourbih-Tari*

In this paper, we propose a software component for efficiently implementing a high-quality RDS pseudo random number generator called "getRDS". It was highly tested by statistical properties and some illustrations of the uniformity are also given together with its installation in M/M/1 simulation system. The obtained results demonstrate that "getRDS" software component produces more accurate and efficient point estimates of the true parameters and can significantly improves performance in the M/M/1 queuing system compared to the well known Mersenne Twister random number generator MT19937.

3 - A New Test of Randomness for Lehmer Generators Based on the Manhattan Distance Between Pairs of Consecutive Random Numbers
Amin Khoshkenar, Industrial Engineering, Koç University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, akhoshkenar@ku.edu.tr, *Hashem Mahlooji*

We present a new test of randomness for Lehmer random number generators to analyze the Marsaglia effect. Our test is based on the Manhattan distance criterion between consecutive pairs of random numbers

rather than the usually adopted Euclidian distance. We derive the theoretical distribution functions for the Manhattan distance for both overlapping (two dimensional) as well as non-overlapping cases. Extensive goodness-of-fit testing as well as empirical experimentation provides ample proof of the merits of the proposed criterion.

4 - The generalization of Fick's law for a case of anomalous subdiffusion random walks.
Serzhena Arkhincheeva, Mathematical modeling, numerical methods and software, Buryat State University, Biyskaya st, d.90, kv.30, 670031, Ulan-Ude, Russian Federation, s.arkhin@gmail.com

The problem of multidimensional diffusion in the frame of comb model has been considered. For anomalous subdiffusional random walks has shown that diffusional current is described by the new generalized Fick law. The generalization consists of replacement of usual diffusion coefficient for the diffusion matrix operator with components with fractional order derivatives instead of common coefficient. Asymptotic solutions in two limited cases have been found, and their graphic representations have presented.

■ TB-19

Tuesday, 10:30-12h00
G5-10

Distribution

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Cristina Hayden*, 4flow research, 4flow AG, Hallerstrasse 1, 10587 , Berlin, Germany, c.hayden@4flow.de

1 - Horizontal cooperation in distribution
Benedikt De Vos, Department of industrial managment, Ghent University, Technologiepark 903, 9000, Gent, Oost-Vlaanderen, Belgium, benediktdevos@gmail.com

Optimization in distribution networks has been a popular research topic for several decades. Over the last years, focus has shifted towards horizontal cooperation as an option to reduce costs. This research focuses on collaboration between players of the same supply chain level in the VRP with time windows and pick-up and delivery. The goal is to determine proper ways of collaboration to achieve cost reductions, optimize large instance networks using a combination of heuristics and game theory and study the robustness of the routes and costs.

2 - A multi-objective integer linear programming model to determine the fruits and vegetables market halls location in Istanbul
Özge Nalan Bilişik, Industrial Engineering Department, Yildiz Technical University, Yildiz Technical University, V/202, Yildiz, Besiktas, 34349, Istanbul, Turkey, ozgenalan@gmail.com, *Hayri Baraçlı*

Distribution centers that connect suppliers and factories are located in the middle of the supply chain network and deciding of distribution center location, determining capacity and number of distribution centers are the important problems that must be solved in the strategic level of the supply chain network. In this study, a multi-objective integer linear programming model with fuzzy parameters is proposed to determine the locations of fruits and vegetables market halls that are one of the distribution center types by taking into account the traffic congestion in public system for Istanbul.

3 - Process Improvement in Production Logistics: A Milkrun Routing Application
Umut Rifat Tuzkaya, Department of Industrial Engineering, Yildiz Technical University, YTU, Department of Industrial Engineering,, Yildiz, Besiktas, 34349, Istanbul, Turkey, tuzkaya@yildiz.edu.tr, *Ceren Cigtekin*

There exist various process improvement methods in production logistics systems. Especially, transportation activities between warehouse and production lines should be analyzed and revised to provide more efficient logistics processes in manufacturing environment. In this study, it is focused on milkrun routing and layout planning of milkrun area. A case study on production logistics activities of a home appliances company is applied. The existing processes between warehouse and production lines are developed by improvement methods and results of existing and improved processes are analyzed.

4 - Workload stability vs. logistic costs in retail distribution networks
Cristina Hayden, 4flow research, 4flow AG, Hallerstrasse 1, 10587 , Berlin, Germany, c.hayden@4flow.de, *Hartmut Zadek*

Planning retail distribution networks involves making a variety of interrelated decisions, such as warehouse location, store-warehouse allocation, definition of distribution frequency, vehicle routing, and time-windows planning among others. Moreover, these decisions are normally in conflict with each other, turning the decision problem into a multi-objective one. This study explores a multi-objective extension of the periodic location routing problem with time windows considering two operational objectives. The solution method is applied to a real-life retail distribution network in Germany.

■ TB-20

Tuesday, 10:30-12h00
G5-11

Delays, Disruptions and Uncertainty in Public Transport

Stream: Optimization in Public Transport
Invited session

Chair: *Claus Gwiggner*, Operations Research, University of Hamburg, Von-Melle-Park 5, 20146 , Hamburg, Germany, claus.gwiggner@uni-hamburg.de

1 - Delay Management including Capacities of Stations
Twan Dollevoet, Econometric Institute, Erasmus University of Rotterdam, Burgemeester Oudlaan 50, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, dollevoet@ese.eur.nl, *Dennis Huisman*, *Marie Schmidt*, *Anita Schöbel*

Delay management determines whether trains should wait for delayed feeder trains or should depart on time. A key aspect is the availability of the railway infrastructure. In this paper, we develop a model for delay management that includes the stations' capacities. This model allows rescheduling the platform assignment dynamically. We propose algorithms to solve the problem and present an extension that balances the passenger delay on the one hand and the number of changes in the platform assignment on the other. All models are evaluated on real-world instances from Netherlands Railways.

2 - A Learning Strategy for Online Delay Management
Anita Schöbel, Institute for Numerical and Applied Mathematics, Georg-August Universiy Goettingen, Lotzestrasse 16-18, 37083, Göttingen, Germany, schoebel@math.uni-goettingen.de, *Reinhard Bauer*

The delay management problem asks how to react to exogenous delays in public transportation. More specifically, it is to decide which train should wait for delayed feeder trains and which trains should depart on time such that the overall passenger delay is minimized. The delay management problem is a real-time problem further complicated by its online nature: Source delays are not known in advance. We introduce a learning strategy for delay management which behaves very promising in our experiments where we compared it with other online strategies.

3 - Data Analysis of Delay Occurrences in the Context of Robust Airline Resource Scheduling
Lucian Ionescu, Information Systems, Freie Universität Berlin, Garystr. 21, 14195, Berlin, Germany, Lucian.Ionescu@fu-berlin.de, *Claus Gwiggner*, *Natalia Kliewer*

In robust airline resource scheduling it is essential to use real-world information on disruptions and resulting delays in order to cost-efficiently increase the schedule robustness. In this work we describe the analysis of historical delay data in order to obtain information on the system behavior of resource networks regarding delay occurrences. Derived influential factors and statistical distributions for delay risks can be used in a scheduling and simulation framework. This enables a close-to-reality evaluation regarding the robustness and cost-efficiency of resource schedules.

4 - Aircraft Sequencing Under Uncertainty on Estimated Time of Arrival

Sakae Nagaoka, Air Traffic Management, Electronic Navigation Research Institute, 7-42-23 Jindaiji Higashi-machi, Chofu-shi, 182-0012, Chofu, Tokyo, Japan, nagaoka@enri.go.jp, *Claus Gwiggner*, *Yutaka Fukuda*

Conventionally, aircraft sequences are determined by the first-come-first-served principle. This often requires a swap of the sequence due to estimation errors. To avoid this, it is desirable to determine a sequence taking into account estimation errors. We propose a method for generating a better sequence using uncertainty information which is assumed to be available in the future. We describe algorithms for calculating the swap probability using a shifted Gamma distribution. Then we show the modeling procedure of the estimation errors and some simulation results.

■ TB-21

Tuesday, 10:30-12h00
G6-1

Personnel Scheduling

Stream: Scheduling
Invited session

Chair: *Alena Otto*, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de

1 - Scheduling IT Service Activities Considering Multitasking with Cognitive Overhead

Carlos Cardonha, Human Systems, IBM Research - Brazil, Rua Tutóia, 1157, Paraíso, 04007-900, São Paulo, São Paulo, Brazil, chcardo@br.ibm.com, *Victor Cavalcante*

We present in this article a MIP formulation for the Resource Constrained Project Scheduling Problem with Bounded Multitasking (RCPSPBM), which is about the assignment of services (or tickets) to analysts with limited parallelism capacity. As tickets demand different skills from analysts and as cognitive overheads, which occur when tasks are performed simultaneously, are penalized, the resulting scheduling problem is non-trivial. Preliminary computational results show that our model may provide a satisfactory theoretical framework for decision-support systems destined to human dispatchers.

2 - Scheduling of Service Technicians in the Utility and Telecommunication Industry

Sleman Saliba, Corporate Research Germany, ABB AG, Wallstadter Str. 59, 68526, Ladenburg, Germany, sleman.saliba@de.abb.com, *Carsten Franke*, *Iiro Harjunkoski*, *Lennart Merkert*

A common problem in workforce management is how to allocate skilled technicians to customer requests and route them optimally. We present a column generation approach applying a labeling algorithm as pricing step to construct near optimal schedules. While the column generation approach is used to calculate the schedule for the next day, utilities and telecommunication companies also need to readjust the schedule in real time to reflect the changes during a day. Therefore, the presented approach is complemented by efficient algorithms responding to events happening along the day.

3 - New parameter updating for stabilized column generation solving large-scale tour scheduling problems

Jens Brunner, University of Augsburg, Germany, jens.brunner@wiwi.uni-augsburg.de

In this talk we address the problem of staff scheduling at check-in counters. We face a time varying demand. The main objective is to minimize the assignment periods for a given workforce subject to flexible labor regulations. Solveing the problem with stabilized column generation, we have developed a new parameter updating procedure. Computational results using real-world data show the efficiency of the algorithm. Savings of up to nearly 100 percent in CPU time are realized.

4 - Multi-objective Approaches to the Unit Crewing Problem in Airline Crew Scheduling

Matthias Ehrgott, Engineering Science, University of Auckland, Private Bag 92019, 1001, Auckland, New Zealand, m.ehrgott@auckland.ac.nz, *Bassy Tam*

Crew pairing assigns flights to crew at minimum cost and is solved for all crew ranks. Optimal pairings contain little buffer time and crew splitting after delayed flights contribute to delay propagation. Keeping different ranks together during pairings (unit crewing) avoids this. We investigate sequential and simultaneous methods for unit crewing with the objectives of minimising cost and maximising unit crewing. Numerical tests show that multi-objective approaches increase unit-crewing. The simultaneous approach is superior in terms of solution quality but computationally more expensive.

■ TB-22

Tuesday, 10:30-12h00
G6-2

Scheduling in supply chains and production systems

Stream: Scheduling II
Invited session

Chair: *Mohamed Ali Aloulou*, LAMSADE - Universite Paris Dauphine, Place du Marechal de Lattre, 75775, Paris Cedex, France, aloulou@lamsade.dauphine.fr

1 - Minimizing the makespan of a multiagent project scheduling problem: the price of stability

Cyril Briand, LAAS - CNRS, 7, Av. Colonel ROCHE, 31077, Toulouse Cedex 4, France, briand@laas.fr, *Alessandro Agnetis*, *Jean-Charles Billaut*, *Sandra Ulrich Ngueveu*, *Premysl Sucha*

We consider cooperative projects involving a set of self-interested contractors, each in charge of a part of a project. Each contractor is able to reduce the duration of his activities at a given cost. Accordingly, the project makespan depends on all contractors' strategies. On his/her side, the project client is interested in a short makespan and, as an incentive, offers a daily reward to be shared among contractors. We take an interest in the problem of finding a strategy profile and a sharing policy that minimize the project makespan while ensuring schedule stability (Nash equilibrium).

2 - Scheduling Trucks in a Cross-Dock with Mixed Service Mode Dock Doors

Peter Bodnar, Department of Economics and Business, Aarhus University, Fuglesangs Allé 4, 8210 , Aarhus, Denmark, pbodnar@asb.dk, *René de Koster*

We consider the problem of scheduling trucks at a multi-door cross-dock in which an intermixed sequence of inbound and outbound trucks can be processed at the dock doors. We focus on operational costs by considering the cost of handling temporarily stored products, as well as the cost of tardiness. An adaptive neighborhood search heuristic is proposed to compute near-optimal solutions of real size instances. Computational experiments show that the average gaps between our heuristic and the optimal solutions are less than 3%.

3 - Coordination of production and inbound batch delivery with outsourced distribution
Mohamed Ali Aloulou, LAMSADE - Universite Paris Dauphine, Place du Marechal de Lattre, 75775, Paris Cedex, France, aloulou@lamsade.dauphine.fr, *Alessandro Agnetis*, *Liang Liang Fu*

We investigate the complexity of coordinated production and inbound distribution scheduling problems, where a third-party logistics (3PL) delivers semi-finished products in batches from one production location to another production location belonging to the same manufacturer. The 3PL is required to deliver each product within a time T from its release at the upstream stage. We consider two transportation modes: economic transportation, for which delivery departure dates are fixed at the beginning, and express transportation, for which delivery departure dates are flexible.

4 - Component inventory space allocation and balancing in assembly lines
Tugbanur Sezen, Industrial Engineering, İstanbul Kültür University, İstanbul Kültür University, 34100, İstanbul, Turkey, tsezenn@gmail.com, *Hande Şİmal Baydur*, *Rifat Gürcan Özdemir*

This paper develops a mathematical model to solve the problems of component inventory allocation and assembly line balancing. Components assembled throughout the line require different types of containers. The model determines the allocation of containers occupied by components with respect to lead-time consumption. The line balancing and inventory space allocation problems are handled simultaneously by the proposed model for minimizing total cost incurred related to installation of containers used for storage of components. The model is then implemented in an automotive assembly line.

■ TB-23

Tuesday, 10:30-12h00
G6-3

Fuzzy Optimization Applications

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Jose-Luis Verdegay*, DECSAI. ETS I2(I+T), Universidad de Granada, 18071 , Granada, Spain, verdegay@decsai.ugr.es
Chair: *David Pelta*, University of Granada, Granada, Spain, dpelta@decsai.ugr.es

1 - Fuzzy Optimization Models for Port Logistics
Belen Melian Batista, Estadística, I.O. y Computación, University of La Laguna, Astrofisico Sanchez s/n, Campus de Anchieta, 38271, La Laguna, Spain, mbmelian@ull.es, *Christopher Expósito Izquierdo*, *Eduardo Lalla Ruiz*, *M^{a} Teresa Lamata*, *Marcos Moreno-Vega*

This work has a twofold purpose. On one hand, it presents an analysis of the possible imprecise data that arise in port logistics; particularly, in those data that appear in the seaside and yard problems. On the other hand, several fuzzy optimization models are proposed to handle this imprecision. In order to solve the obtained mathematical linear programs, alternative metaheuristic procedures are developed and tested.

2 - Sensitivity analysis in multicriteria fuzzy portfolio selection problems
Carlos Ivorra, Matemáticas para la Economía y la Empresa, Universidad de Valencia, Spain, carlos.ivorra@uv.es, *Clara Calvo*, *Vicente Liern*

The original portfolio selection problem provides a portfolio satisfying the investor's requirements about risk and expected return. When the investor imposes additional constraints, the optimal solution can be very sensitive to small changes on the risk-return preferences. We present here some fuzzy techniques to select a portfolio best fitting the investor's preferences.

3 - A Simple Cooperative Strategy for Dynamic Vehicle Routing Problem
David Pelta, University of Granada, Granada, Spain, dpelta@decsai.ugr.es, *Jose-Luis Verdegay*

Many problems within the current socio-technological context cannot be precisely defined, nor they remain static along the time. Some of them can be modelled as "dynamic optimization problems". We focus here in the dynamic version of the well-known vehicle routing problem, where new clients appear during the day and the routes need to be reorganized to serve them. Using simultaneously a set of basic constructive heuristics, we were able to obtain a fast and simple strategy to obtain very good solutions in short time.

4 - The non-dominated frontier of fuzzy portfolio selection problems with additional constraints using a multi-objective genetic algorithm
Raquel Martinez, University of Murcia, Spain, raquel.m.e@um.es, *José Manuel Cadenas*, *Clara Calvo*, *Maria del Carmen Garrido*, *Carlos Ivorra*, *Vicente Liern*

An approach to the portfolio selection problem has the double objective of maximizing the return on an investment while minimizing risk (the set of risk-return pairs is called non-dominated frontier). We address two kinds of constraints: fuzzy semicontinuous variable and fuzzy cardinality. Therefore, the non-dominated frontiers become more irregular and new specific computation techniques are required. We describe a multiobjective genetic algorithm that allows us to get the frontier through explicit expressions and to establish a system of preferences of different efficient portfolios.

■ TB-24

Tuesday, 10:30-12h00
G6-4

Topics in Machine and Flow Shop Scheduling

Stream: Project Management and Scheduling
Invited session

Chair: *Kerem Bulbul*, Manufacturing Sys. & Industrial Eng., Sabanci University, Faculty of Engineering and Natural Sciences, Orhanli, Tuzla, 34956, Istanbul, Turkey, bulbul@sabanciuniv.edu

1 - Scheduling tasks with outtree precedence graph, constant timelags and variable release times on a single machine
Gulcin Ermis, Department of Industrial Engineering, Koc University, Istanbul, Turkey, gulermis@ku.edu.tr, *Ceyda Oguz*

We propose a polynomial time algorithm for the following scheduling problem, which has an open complexity status. A set of identical tasks should be processed on a single machine without preemption. The tasks have release times and precedence constraints in form of an outtree. There exists a constant timelag (strictly less than the processing time), which requires delaying the start time of a task if it is scheduled immediately after its predecessor. Simultaneous processing of tasks on the machine is not allowed. The aim of the scheduling problem is to minimize the makespan.

2 - Scheduling in 3-machine Flowshops with Flexible Operations
Seda Sucu, Industrial Engineering, TOBB Economy and Technology University, Sogutozu Cad. No:43, Sogutozu, 06560, Ankara, Turkey, ssucu@etu.edu.tr, *Hakan Gultekin*

We consider a 3-machine flowshop in which each part has 3 operations to be performed on the machines; one for each machine. Additionally, each part has a special operation, named the flexible operation, that can be performed by more than one machine. The problem is to sequence the jobs as well as to determine the assignment of the flexible operations for each part to the machines. We formulated the problem as a mathematical program and developed three different heuristics. The results of the computational study indicate that the heuristics are very efficient in finding high quality solutions.

3 - A mixed-integer programming approach for a hybrid flow shop scheduling problem
Ali Tamer Unal, Industrial Engineering, Bogazici University, PK 2 Bebek, Istanbul, Turkey, unaltam@boun.edu.tr, *Z. Caner Taşkın*, *Semra Agrali*

A hybrid flow shop consists of a multistage flow line with parallel machines at some stages. We consider a hybrid flow shop where there are k stages; at each stage there exist either parallel non-identical discrete or batch processing machines with earliest start and latest finish time constraints as well as machine eligibility restrictions. We formulate the problem as a mixed-integer programming problem and discuss reformulation strategies to improve its solvability. A decision support system based on our model has been implemented at a major European company manufacturing transformers.

4 - A Strong Preemptive Relaxation for Weighted Tardiness and Earliness/Tardiness Problems on Unrelated Parallel Machines
Kerem Bulbul, Manufacturing Sys. & Industrial Eng., Sabanci University, Faculty of Engineering and Natural Sciences, Orhanli, Tuzla, 34956, Istanbul, Turkey, bulbul@sabanciuniv.edu, *Halil Şen*

We develop a new preemptive relaxation for the single machine total weighted tardiness and earliness/tardiness problems on unrelated parallel machines. Our key contribution is devising an effective Benders decomposition algorithm for solving the preemptive relaxation formulated as a mixed integer linear program. The optimal solution of the preemptive relaxation offers a near-optimal partition of the jobs to the machines, and we then construct non-preemptive solutions to the original problem. High quality lower and upper bounds are obtained for instances with up to 5 machines and 200 jobs.

■ TB-25

Tuesday, 10:30-12h00
G9-1

Genetic Algorithms

Stream: Artificial Intelligence, Fuzzy systems (contributed)
Contributed session

Chair: *Heinrich Rommelfanger*, Economics and Business Administration, Goethe University, Niebergallweg 16, 65824, Schwalbach a. Ts., Hessen, Germany, Rommelfanger@wiwi.uni-frankfurt.de
Chair: *Marcelo Henrique dos Santos*, Universidade de Uberaba - UNIUBE, Brazil, marcelo.h.santtos@gmail.com

1 - Genetic Algorithm for Semantic Web services Composition under QoS Constraints
Khaled Sellami, LMA Laboratory, Bejaia University / EISTI France, 06000, Bejaia, Algeria, skhaled36@yahoo.fr, *Nadia Halfoune*, *Mohamed Ahmed-Nacer*, *Rachid Chelouah*, *Hubert Kadima*

To establish the existence of a global component market, in order to reach higher levels of software reuse, service composition experienced increasing interest in doing a lot of research effort. The purpose of this work is to propose a genetic algorithm based on semantic descriptions of Web services and their non-functional properties (QoS parameters) that are crucial for selecting the web services to take part in the composition.

2 - Optimization by genetic algorithms of the dissimilarity between two signals in speech recognition systems
Zahira Benkhellat, informatique, Bejaia university, 12345, Algeria, benkhellat_zahira@yahoo.fr

In speech recognition, the training process plays an important role. When a good training model for a speech pattern is obtained, this not only enhances the speed of recognition tremendously, but also improves the quality of the overall performance in recognizing the speech utterance. A genetic algorithm is applied to solve nonlinear, discrete and constrained problems for DTW. The associated non trival K-best paths of DTW can be identified without extra computational cost. Results show the important contribution of GA in temporal alignment through the increasingly small factor of distortion.

3 - Finding the Optimum Sequence for the Contents of a Database Course with Rule Based Genetic Algorithms
Didem Abidin, Tire Kutsan Vocational School, Ege University, Turkey, doktem@hotmail.com

The contents of a course must be arranged well for the course to be effective. In the study, an effective solution to the course content sequencing problem with genetic algorithms is put forward. The input of the GA is the modules of a database course. Parameter tuning is done to find the best parameter combination of the best sequence. The results are compared with an experts' via a nonparametric correlation test. Results show that the system is very successful. The parameter combination of the most reliable result is determined and the contents of other courses can be sequenced with it.

4 - Investigation of Global Convergence Properties of Random Search Algorithms
Vaida Bartkute-Norkuniene, Vilnius University Institute of Mathematics and Informatics & Utena University of Applied Sciences, Akademijos 4, 08663, Vilnius, Lithuania, vaidaba@ukolegija.lt

Article is dealing with investigation of global convergence property (GCP) of several random search algorithms. The Bayesian search algorithm with memory restricted by one objective function measurement (BA) is introduced, which is compared with Simulated Perturbation Stochastic Approximation (SPSA) and Simulated Annealing (SA). We said the method distinguishing by the global convergence property if the probability to hit to the attraction zone of global minima increases during optimization by this algorithm. The GCP of stochastic search algorithms considered is studied by computer simulation.

■ TB-26

Tuesday, 10:30-12h00
G9-7

Cutting, packing and applications

Stream: Combinatorial Optimization I
Invited session

Chair: *Enrico Malaguti*, DEI, University of Bologna, Viale Risorgimento, 2, 40136, Bologna, Italy, enrico.malaguti@unibo.it

1 - Models for Two-Dimensional Guillotine Knapsack Problems
Dimitri Thomopulos, Dipartimento di Ingegneria dell'Energia Elettrica e dell'Informazione "Guglielmo Marconi" - DEI, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, Italy, dimitri.thomopulos@unibo.it, *Fabio Furini*, *Enrico Malaguti*

We propose a new model and solution method for the two-dimensional knapsack problem with guillotine constraints. The model has a pseudo-polynomial number of variables, and all variables are explicitly generated and stored in a pool. The method consists in solving the linear relaxation of a restricted problem and iteratively adding negative reduced columns from the pool, until the relaxation is optimally solved. The final dual solution is then used to generate a reduced problem containing all optimal integer solutions, that is then solved by a general purpose integer programming solver.

2 - Convergent lower bounds in column generation via aggregation: applications for bounded vertex coloring
Daniel Porumbel, LGI2A & IUT Béthune, Universite Artois, rue de l'université, 62400, Bethune, France, daniel.porumbel@univ-artois.fr, *François Clautiaux*

A dual bound in column generation is obtained: 1. impose artificial constraints on the dual variables 2. solve the resulting linear program– it can become much simpler. An artificial (group-wise) constraint is based on partitioning the dual values into k groups: force all variables in a group to take the same value. When k=n, the lower bound is the dual polytope optimum. The approach has already been applied to classical cutting-stock. These ideas are now investigated for bounded vertex coloring with interval graphs. We show that the sub-problem can become much simpler in certain cases.

3 - Data center machines reassignment problem: models and computations
Paolo Tubertini, DEI, University of Bologna, Italy, paolo.tubertini@unibo.it, *Alberto Caprara*, *Andrea Lodi*, *Enrico Malaguti*, *Dimitri Thomopulos*

We study a machines reassignment problem coming from a real-world data center management. Processes and machines are characterized by multiple dimensions that are not geometrically correlated. The problem can be modeled as a generalization of the Bin Packing Problem with additional requirements: re-assignment is constrained by inter-machine and inter-process subset relations also called service, spread and dependence constraints. Natural and column generation models are given. Computational experiments are performed on realistic instances with incremental dimension of processes and machines.

4 - A Metaheuristic algorithm for a Real World Cutting Problem
Rosa Medina, Ingeniería Industrial, Universidad de Concepción, 4030000, Concepción, Chile, rosmedina@udec.cl, *Enrico Malaguti*, *Paolo Toth*

We consider a real-world generalization of the Cutting Stock Problem arising in the wooden board cutting industry. In addition to the classical objective of trim loss minimization, the problem also asks for the maximization of the cutting equipment productivity, which can be modeled by a non-linear cost function. We present an algorithm based on a heuristic column generation followed by a metaheuristic selection of a set of good columns, where a tabu search algorithm in embedded within a diversification procedure.

■ TB-27

Tuesday, 10:30-12h00
G9-8

Combinatorial problems of multi-model line balancing and model sequencing I

Stream: Combinatorial Optimization II
Invited session

Chair: *Alexandre Dolgui*, IE & Computer Science, Ecole des Mines de Saint Etienne, 158, cours Fauriel, 42023, Saint Etienne, France, dolgui@emse.fr
Chair: *Mikhail Y. Kovalyov*, United Institute of Informatics Problems, National Academy of Sciences of Belarus, Surganova 6, 220012, Minsk, Belarus, kovalyov_my@yahoo.co.uk

1 - Minimizing station activation costs in a line design problem
Alexandre Dolgui, IE & Computer Science, Ecole des Mines de Saint Etienne, 158, cours Fauriel, 42023, Saint Etienne, France, dolgui@emse.fr, *Sergey Kovalev*, *Mikhail Y. Kovalyov*, *Jenny Nossack*, *Erwin Pesch*

A multi-model production line is considered. A station is activated if at least one operation is executed on this station. There are station activation costs and times. Each operation is characterized by the number of standard tools required and its processing time. We need to assign operations to stations to minimize the number of stations (primary) and total station activation cost (secondary objective). We establish computational complexity of various cases of this problem, present constructive heuristic algorithms, integer linear programs as well as computational results.

2 - An enumeration procedure for the mixed-model assembly line balancing problem
Mariona Vila Bonilla, Organització d'Empreses, UPC, Spain, mariona.vila.bonilla@upc.edu, *Jordi Pereira*

Assembly line balancing deals with the assignment of different production tasks among the workstations on the assembly line such that the total efficiency of the line is maximized. In this work, we explore the applicability of a station-oriented bidirectional branch-and-bound procedure for solving the mixed-model assembly line balancing problem given a determined cycle time for every model. To increase the quality of the proposed algorithm, new lower bounds and dominance rules are presented and their applicability is tested using instances derived from the literature.

3 - Line re-balancing for make-to-order mixed model assembly lines
Mary Kurz, Industrial Engineering, Clemson University, 110 Freeman Hall, 29634-0920, Clemson, SC, United States, mkurz@clemson.edu, *Bryan Pearce*

We present a two-stage robust optimization approach for assembly line rebalancing in a mixed model, make-to-order production environment with uncertain demand for one time period. The first stage uses a metaheuristic to maximize line efficiency. In the second stage, the metaheuristic optimizes a horizontal balancing metric to seek solutions that are robust to demand variation. We observe that extreme demand scenarios may render any solution infeasible but can be accommodated by the use of penalization, representing the cost of future recourse action.

4 - An approximation algorithm for embedding a graph into dominating distance matrix
Mozhgan Hasanzade, Mathematics, Zanjan university, 12345, zanjan, zanjan, Iran, Islamic Republic Of, mozhgan_hasanzade@yahoo.com, *Mohammadreza Ghaemi*

In this paper we describe a method named "embedding into dominating distance matrix", and we present an approximation algorithm with application in network design problems. In this method an undirected graph underlying a metric space, embeds into a matrix metric named "dominating distance matrix", which the distance of any two vertices of graph, in the obtained matrix is no smaller than those in the original metric. Our algorithm is more efficient than other methods, because the result is a matrix that has more usages in programming problems and also the performance guarantee is been better.

■ TB-29

Tuesday, 10:30-12h00
G9-3

Call Centers

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Ger Koole*, Mathematics, VU University Amsterdam, De Boelelaan 1081 a, 1081 HV, Amsterdam, Netherlands, koole@few.vu.nl

1 - Employee scheduling and rescheduling in call centers
Ger Koole, Mathematics, VU University Amsterdam, De Boelelaan 1081 a, 1081 HV, Amsterdam, Netherlands, koole@few.vu.nl

In call centers, many parameters are still uncertain the moment employees are scheduled. This leads to the necessity of real-time adjustments to the schedule. This requires different forms of flexibility in the initial schedule. Ideally, when making agent schedules the right amount of flexibility should be introduced. In this talk, we discuss the different forms of parameter uncertainty, different ways to do rescheduling, and how this can be incorporated in the initial schedule.

2 - Adaptative Blending in Call Centers
Benjamin Legros, Génie Industriel, Ecole Centrale Paris, France, belegros@laposte.net, *Ger Koole*

We examine a model with inbound calls and outbound emails. We consider a threshold policy of c busy tasks as developed by Bhulaï (2003). Our problem is to maximize the email throughput while respect a service level on the proportion of calls that wait less than a duration during a period. We propose a segmentation of the period, after each interval we consider the possibility of changing the threshold. We propose an efficient method for adaptating the threshold. We evaluate this method in comparison with non adaptative methods and with the analytical answer of the optimization problem.

3 - Impact of Delay Announcements in Call Centers: An Empirical Approach
Zeynep Aksin, Graduate School of Business, Koc University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, zaksin@ku.edu.tr, *Baris Ata*, *Seyed Emadi*, *Che-Lin Su*

Delay announcements in call centers inufluence callers' decision to keep waiting or to abandon. In turn, abandonment behavior affects system performance. We model callers' abandonment decisions endogenously in the presence of delay announcements, and study the questions: What is the impact of announcements on callers' behavior? How does the callers' behavior affect the system performance? We propose an empirical approach that combines the estimation of callers' patience parameters, the model of callers' abandonment behavior and the queuing analysis that incorporates this abandonment behavior.

4 - On the Estimation of Redial and Reconnect probabilities of call center data sets with incomplete information
Sihan Ding, Stochastics, Centrum Wiskunde en Informatica, Science Park 123, 1098 XG, Amsterdam, Netherlands, dingsihan@hotmail.com, *Ger Koole*, *Rob van der Mei*

We study a call center for which the total call volume consists of fresh calls, redials (re-attempts after abandonments) and reconnects (re-attempts after answered calls). We propose a model to estimate the redial and reconnect probabilities and the fresh call volume for call center data without customer identity information. We show that these three unknown variables cannot be estimated simultaneously. However, if one variable is given, the other two variables can be estimated accurately. We validate our estimation results via real call center and simulated data.

■ TB-30

Tuesday, 10:30-12h00
G9-10

Advances in Discrete and Global Optimization III

Stream: Discrete and Global Optimization
Invited session

Chair: *Peter Recht*, OR und Wirtschaftsinformatik, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, peter.recht@tu-dortmund.de
Chair: *Shinji Mizuno*, Industrial Engineering and Management, Tokyo Institute of Technology, 2-12-1 Oh-Okayama, Meguro-ku, 152-8552, Tokyo, Japan, mizuno.s.ab@m.titech.ac.jp

1 - Enhanced Snakes and Ladders Heuristic for Hamiltonian Cycle Problem
Vladimir Ejov, School of Computer Science, Engineering and Mathematics, Flinders University, Sturt Road, 5042, Bedford Park, SA, Australia, vladimir.ejov@flinders.edu.au, *Serguei Rossomakhine*

The SLH algorithm uses operations inspired by the Lin-Kernighan heuristic to reorder the vertices on the circle to transform some ladders, the chords of the circle where all the vertices are placed into snakes, which are the arcs of the circle. The use of a suitable stopping criterion ensures that the heuristic terminates in cubic time. So far, SLH has been successful even in cases where such cycles are extremely rare. Presentation will be accompanied by online demonstration.

2 - A Randomized Online Algorithm for the k-Canadian Traveller Problem
Marco Bender, Institute for Numerical and Applied Mathematics, University of Goettingen, Germany, m.bender@math.uni-goettingen.de, *Stephan Westphal*

We consider the k-Canadian Traveller Problem, which asks for a shortest path between two nodes s and t in an undirected graph, where up to k edges may be blocked. An online algorithm learns about a blocked edge when reaching one of its endpoints. Recently, it has been shown that no randomized online algorithm can be better than (k+1)-competitive against an oblivious adversary, even if all s-t-paths are node-disjoint. We show that this bound is tight by constructing a best possible randomized online algorithm.

3 - One certain optimal cycle packing always existing for generalized Petersen graphs P(n,k) with k even and n big enough
Eva-Maria Sprengel, Operations Research, Technische Universität Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, eva-maria.sprengel@tu-dortmund.de, *Peter Recht*

For an undirected graph a maximum cycle packing is a collection of pairwise edge-disjoint cycles. The maximum cardinality of such a packing is denoted as the cycle packing number. In general the determination of a maximum cycle packing and the cycle packing number, respectively, is NP-hard. In this lecture we consider the family of generalized Petersen graphs P(n,k) with k even. We outline, that there exists always an optimal cycle packing, where all cycles excepted one are shortest cycles of length eight, if n is big enough. For some cases we also determine the cycle packing number.

4 - Long term production scheduling of Sungun Copper Mine by ant colony optimization method
Christian Niemann-Delius, RWTH Aachen, 52062, Aachen, Germany, niemann-delius@bbk3.rwth-aachen.de, *Masoud Soleymani Shishvan*, *Javad Sattarvand*

The problem of long-term production scheduling of open pit mines is a NP-Hard problem which cannot be solved in a reasonable time span through the mathematical programming models due to its large size. This paper presents an application of recently developed metaheuristic algorithm based on Ant Colony Optimization (ACO). It has the capability of considering any type of objective functions and non-linear constraints and real technical restrictions. The proposed process was programmed and tested on Sungun Copper deposit.

■ TB-31

Tuesday, 10:30-12h00
G9-11

Retail Demand Planning

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Winfried Steiner*, Marketing, Clausthal University of Technology, Institute of Management and Economics, Julius-Albert-Str. 2, 38678 Clausthal-Zellerfeld, 38678, Clausthal-Zellerfeld, Germany, winfried.steiner@tu-clausthal.de

1 - Utility Independence and the IIA Property in Discrete Choice Models
Friederike Paetz, Marketing, Clausthal University of Technology, Institute of Management and Economics, Germany, friederike.paetz@tu-clausthal.de, *Winfried Steiner*

In the context of Conjoint Choice experiments, estimation of consumer preferences can be carried out by using Multinomial Logit (MNL) or Independent Probit (IP) Models. Both model types assume independence between utilities of alternatives. Estimating those models and comparing their (ratios of) choice share predictions, we show that only the MNL model suffers from the Independence of Irrelevant Alternatives (IIA) property, while the IP model does not. Hence, we confute empirically that the IIA property results from the independence assumption, as is often stated in the literature.

2 - A General Heterogeneity (SUR) Model for Optimal Category Pricing
Anett Weber, Clausthal University of Technology, Germany, anett.weber@tu-clausthal.de, *Winfried Steiner*

An important objective of a retailer is to maximize chain-level profit within a given product category. Store-specific pricing (micromarketing) constitutes one possibility to increase profitability. In this study, we explore pricing scenarios resulting from store sales models with different representations of heterogeneity. In an empirical application, the comparison of uniform, segment-level and store-level pricing strategies obtained from a general heterogeneity (SUR) model and its nested versions to the retailer's current pricing policy reveals huge potential for increasing profits.

3 - Combined Pricing and Inventory Management for Perishable Goods with Two-Period Lifetime
Prashant Chintapalli, Operations Management, Indian Institute of Management, Bangalore, FPM Office, IIMB, Bannerghatta Road, 560076, Bangalore, Karnataka, India, prashant.ch@gmail.com

This paper addresses the problem of combined pricing and inventory management in the context of perishable goods. The finite life of perishable goods induces uncertainty in the revenues realised by a profit-maximizing retailer and the retailer has to optimally manage his pricing and ordering policies. Using linear demand functions and treating the old and new units of the product as substitutes, we analyse the single period problem when both the old and new units are simultaneously put for sale and the consumer is free to choose between them. We draw a few insights from numerical experiments.

4 - Integrated Retail Decisions with Multiple Selling Periods and Customer Segments: Optimization and Insights
Bacel Maddah, Engineering Management, American University of Beirut, Bliss Street, Beirut, Lebanon, bm05@aub.edu.lb, *Ahmed Ghoniem*

We examine a multi-period selling horizon where a retailer jointly optimizes assortment planning, pricing, and inventory decisions for a product line of substitutable products, in a market with multiple customer segments. Focusing on fast-moving retail products, the problem is modeled as a mixed-integer nonlinear program where demand is driven by exogenous consumer reservation prices. A mixed-integer linear reformulation is developed, which enables an exact solution to large problem instances in reasonable times. Computational results and managerial insights are discussed.

■ TB-32

Tuesday, 10:30-12h00
G8-1

Information Issues in Supply-Chains

Stream: Supply Chain Optimization
Invited session

Chair: *Noam Shamir*, Northwestern University, United States, n-shamir@kellogg.northwestern.edu

1 - Estimating Out-of-Stock Status Using Only Point-of-Sale Transaction Data
Margaret Aksoy-Pierson, Operations Management, Tuck School of Business at Dartmouth, 100 Tuck Hall, 03766, Lebanon, New Hampshire, United States, mpierson@dartmouth.edu, *Juan Manuel Chaneton*, *Garret van Ryzin*

We develop a procedure for predicting out-of-stock products in a retail store using only point of sale transaction data, not inventory levels or in-bound delivery data, by postulating a Hidden Markov Model (HMM) incorporating inventory status and purchase behavior. The procedure is validated with data from micro-retailers in Mexico.

2 - Role and Value of Information in Emergency Medical Services Coordination
Masha Shunko, Purdue University, United States, mshunko@cmu.edu, *Varun Gupta*, *Alan Scheller-Wolf*
While many emergency departments (ED) experience crowding, ambulances often make decisions for patients' routing without information from the EDs, which worsens crowding. Centralized Emergency Medical Services can use information about EDs status to coordinate traffic and alleviate the crowding problem. We model and compare ED profit and patient wait time in two cases: 1) EDs share information, the central controller makes routing decision, and 2) ambulances make routing decision independently. We show when the information sharing has the highest value.

3 - Condition Based Spare Parts Inventory Control with Imperfect Monitoring
Engin Topan, Department of Industrial Engineering and Innovation Sciences, Eindhoven University of Technology, 5616 SC, Eindhoven, the Netherlands, Netherlands, e.topan@tue.nl, *Geert-Jan van Houtum*, *Tarkan Tan*, *Rommert Dekker*
We consider a capital goods manufacturer supplying parts for a critical component installed on machines at different customer sites, for which future demand can be predicted with a degree of precision by condition monitoring. We formulate a Discrete Time Markov Decision Process to use the imperfect information available via condition monitoring and find the optimal ordering policy. We obtain several monotonicity properties of the optimal policy and examine the value of imperfect information, its impact on the customer service level, the effect of imperfectness.

4 - Public Forecast Information Sharing in a Market with Competing Supply Chains
Noam Shamir, Northwestern University, United States, n-shamir@kellogg.northwestern.edu, *Hyoduk Shin*
We study the operational motivation of a retailer to publicly announce his forecast. Our work suggests that by making forecast information publicly available to both his manufacturer and to the competitor, a retailer can credibly share his forecast, and thus secure ample capacity at the manufacturer's level. Moreover, the retailer even prefers public forecast announcement to advance purchase contract — a contract in which the information is shared only with his manufacturer and it is concealed from the competitor.

■ TB-33

Tuesday, 10:30-12h00
G8-3

Supplier Relationships and Supply Chain Risk Management

Stream: Supply Chain Risk Management
Invited session

Chair: *Nilesh Ware*, Department of Management Studies, Indian Institute of Technology Delhi, Vishwakarma Bhawan, shaheed Jeet Singh Marg, 110016, New Delhi, Delhi, India, nilesh.ware@gmail.com

1 - Analysing the effect of demand variation on multi-product, mutli-source, multi-period model for supplier selection problem
Nilesh Ware, Department of Management Studies, Indian Institute of Technology Delhi, Vishwakarma Bhawan, shaheed Jeet Singh Marg, 110016, New Delhi, Delhi, India, nilesh.ware@gmail.com, *Surya Singh*, *Devinder Banwet*
This paper proposed a mixed-integer non-linear mathematical model for dynamic supplier selection problem under deterministic scenario which handles multi-product, multi-source and multi-period case for supplier selection. The model considers cost, quality, and lead time as primarily factors with penalty cost. Robustness of the proposed model is tested using LINGO coding by varying demand while keeping other data constant. Output of the model gives inference on selection of supplier(s) for particular product and for how long time period for a given demand variation.

2 - Supplier evaluation using a network DEA approach
Vassilis Dedoussis, Industrial Management & Technology, University of Piraeus, 80 Karaoli & Dimitriou str., 185 34, Piraeus, Greece, vdedo@unipi.gr, *Stella Sofianopoulou*

In this paper, a two-phase approach for the supplier selection problem is proposed. The paper aims to formulate a model that includes transportation and inventory costs in order to examine their effect on decisions. First, the sum of transportation and inventory costs for each supplier is determined by employing a Genetic Algorithm. Second, a network DEA (Data Envelopment Analysis) approach is adopted to evaluate performance of suppliers based on multiple criteria including transportation and inventory costs and at the same time suggest negotiation strategies for inefficient suppliers.

3 - Agile Methodology for Software Application Development: A Comparison Application of Software Projects Using Agile and Waterfall Methods
Nurgül Demirtaş, Industrial Engineering, Yildiz Technical University, 0090, Istanbul, Turkey, nurguldemirtas@gmail.com, *Umut Rifat Tuzkaya*

Software applications are getting critically important and indispensable component of the business in parallel with the developing technology. Therefore, successful product development processes are based on fast and high quality software development processes. Waterfall models have been used for many years in the software development projects. However, alternative have been emerged. In this study, outcomes of implementing the agile methodologies to software application development are discussed. Then they are compared with the waterfall model in detail.

4 - Risk Identification & Modeling in Healthcare Supply Chain
Tugba Efendigil, Yildiz Technical University, Turkey, tugbae@yildiz.edu.tr, *Jalal Ashayeri*

Over the past 20 years, an increasing attention is paid to the significance of healthcare (HC) supply chain (SC) all around the world due to the increased or aging population of communities. Due to the effects on people's health requiring adequate and accurate medical supply according to the patients' requirements, SC management is becoming quite complex in HC than other industries. This study investigates the quantified risks in HC-SC using a MILP model which trades off costs, taking into the typical SC network design constraints in addition to different risks tolerance constraints.

■ TB-34

Tuesday, 10:30-12h00
G8-4

Sustainability: Closed loop production systems

Stream: Supply Chain Planning
Invited session

Chair: *Gerlach Van der Heide*, Economics and business, University of Groningen, Nettelbosje 2, 9747AE, Groningen, Netherlands, g.van.der.heide@rug.nl

1 - Assessing the performance of hybrid lines for disassembly
Z. Pelin Bayindir, Department of Industrial Engineering, Middle East Technical University, Middle East Technical University, Department of Industrial Engineering, 06800, Ankara, Turkey, bpelin@metu.edu.tr, *Volkan Gümüşkaya*, *F. Tevhide Altekin*

We consider a disassembly line where the task durations are stochastic (some tasks at certain stations cannot be completed within the cycle time). Our objective is to investigate the performance of hybrid line concept developed for assembly lines where in case of an incompletion, certain tasks are performed offline. For the others, the line is stopped until the tasks are completed. We develop methods to determine the classification of tasks and calculation of associated expected costs. A computational study is performed to assess the performance of hybrid lines for disassembly.

2 - The Dynamic Behaviour of Returns in Closed-Loop Production Systems
Thomas Nowak, Transport and Logistics Management, Vienna University of Economics and Business, Nordbergstrasse 15, 1090, Wien, Austria, thomas.nowak@wu.ac.at, *Vera Hofer*

Since recycled materials are of increasing importance in modern production economies from an economic and ecological point of view, the integration and control of these inputs in existing production systems is of immense importance. Due to the fact that product returns show high variability, firms may be kept off from expanding their usage of secondary resources. In this article we develop a nonlinear discrete dynamical system, which allows us to analyze conditions when returns converge to an equilibrium and when they show oscillatory or chaotic behavior in closed form.

3 - An Inventory Model to Determine The Optimal Mix of Owned and Rented Items
Leonardo Epstein, School of Business and Economics, Universidad de los Andes, Ingeniería Comercial / Edificio el Reloj, San Carlos de Apoquindo 2200 / Las Condes, 7620001, Santiago, Santiago, Chile, lepstein@uandes.cl, *Eduardo González-Császár*

Inventory models for rental items help plan operations that involve reusable items such as tools or telephone lines. We consider inventories whose size may be insufficient to meet demand, but where additional items may be rented from another provider. We determine the optimal number of owned items in the inventory to maximize the expected profit in a time horizon. Our approach is useful for problems of optimal size such as the number of trucks in a fleet or the number of wireless bypasses. Our approach takes into account uncertain future demand with a Bayesian model for historical data.

4 - Take-back policy for two-echelon rental systems
Gerlach Van der Heide, Economics and business, University of Groningen, Nettelbosje 2, 9747AE, Groningen, Netherlands, g.van.der.heide@rug.nl

We consider a two-echelon rental system with a central depot and several locations. The system contains a fixed amount of rental stock. Locations deal with demands and returns of products, while the central depot serves as a storage from which products are transshipped in case of backorders. The central location periodically performs a take-back of stock from the locations in order to meet future transshipment requests. This research determines the parameters for a take-back policy resembling the (s,S) policy. Dynamic programming will be applied to optimize the parameters of the policy.

■ TB-35

Tuesday, 10:30-12h00
G8-2

Manufacturing in the Process Industries

Stream: Manufacturing and Warehousing
Invited session

Chair: *Martin Grunow*, TUM School of Management, Technische Universität München, Arcisstr. 21, 80333, München, Germany, martin.grunow@tum.de

1 - Optimal integration of hierarchical decision making using knowledge management
Edrisi Muñoz, Information Technologies, Centro de Investigacion en Matematicas A.C., Jalisco S/N Mineral y Valenciana, 36240, Guanajuato, Guanajuato, Mexico, emunoz@cimat.mx, *Elisabet Capon-García*, *Jose M Lainez*, *Antonio Espuña*, *Luis Puigjaner*

Ontologies improve information sharing and communication in the enterprise and can even represent holistic mathematical models facilitating the use of analytic tools and providing higher flexibility for model building. In this work we exploit this capability to address the optimal integration of planning and scheduling using a Lagrangean decomposition approach. We create the scheduling/planning sub-problem for

each facility/entity and share their dual solution information by means of the ontological framework. A case study based on STN supply chain planning and scheduling models is presented.

2 - Tactical customer allocation under production plant outages for liquid gas distribution
Nicoleta Neagu, Claude Delorme Research Center, Air Liquide, 1, chemin de la Porte des Loges, Les Loges en Josas, 78354 , Jouy en Josas, France, Nicoleta.Neagu@Airliquide.com, *Hugues Dubedout*, *Pierre Dejax*, *Thomas Yeung*

The distribution costs of gas product are significant part of the supply chain delivery cost and are highly impacted by the tactical decision of clients' allocation to supply plants. We propose a model for customer allocation to production plants over a single period under supply uncertainty due to plant outages. The main objective is to minimize total estimated costs which include production, distribution and contractual costs. The solving approach proposed is based on stochastic programming with recourse. This methodology was applied to real test cases from bulk supply chain of Air Liquide.

3 - Campaign and supply network planning based on a network flow model
Daniel Tonke, TUM School of Management, TU Munich, Schellingstr. 134, 80797, München, Deutschland, Germany, daniel.tonke@gmail.com, *Markus Meiler*, *Martin Grunow*, *Hans-Otto Guenther*

A key issue of production planning and scheduling in the process industries is the coordination of plant operations, storage and transportation in multinational supply networks. In our paper, we propose an approach for a multi-site, multi-product, multi-stage supply network. It is based on a novel aggregation scheme and network flow formulation. The developed optimization model uses a continuous representation of time. Our approach is tested for an industry case. It efficiently generates a comprehensive schedule for coordinating the production activities in the network including the campaigns.

4 - Managing risks in procurement planning for oil refineries
Thordis Anna Oddsdottir, DTU Management Engineering, Technical University of Denmark, Produktionstorvet, Building 424, 2800, Kgs. Lyngby, Denmark, thod@dtu.dk, *Martin Grunow*, *Renzo Akkerman*

Procurement of crude oils account for more than 90% of operational costs in refining. However, crude oil procurement and inventory decisions are made under high degrees of uncertainty. The prices of crude oil and oil products fluctuate and crude oil varies in quality. It is therefore important for refineries to evaluate the effects of these uncertainties. We are proposing a stochastic planning framework that is capable of handling uncertainties and illustrate its usefulness for historical data from Statoil A/S.

■ TB-36

Tuesday, 10:30-12h00
G7-1

Preference Learning V

Stream: Preference Learning
Invited session

Chair: *Krzysztof Dembczynski*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, kdembczynski@cs.put.poznan.pl

1 - Preference learning, robust classification and the linear stochastic order
Ori Davidov, University of Haifa, Israel, davidov@stat.haifa.ac.il

The relationship between the linear stochastic order, robust classification and its application to preference learning and ranking is rigorously discussed. Relationship with discriminant analysis, ordered inference and ordinal regression are highlighted. Efficient computational tools are developed along with the large sampling behavior of the proposed procedures.

2 - Bayesian Recommendations and Utility Elicitation with Intensity of Preference Statements
Frédéric Borzee, Faculté Polytechnique, UMons, 18 rue du souvenir, 7350, Hainin, Belgium, fredericborzee@gmail.com, *Vincent Mousseau*, *Marc Pirlot*, *Xavier Siebert*, *Paolo Viappiani*

Eliciting the user's preference model or an approximation thereof is an important issue in many decision support applications and recommender systems. The Bayesian approach to utility elicitation typically adopts the maximization of the Expected Value Of Information as a criterion for selecting queries. Recent work has considered myopic EVOI optimization using choice queries. Here, we introduce intensity of preference information into the framework. Answering a query consists in picking the most preferred item in a set and giving indications on how much an item is preferred to others.

3 - Implicit feedback and personalization in a web shop
Peter Vojtas, Software Engineering, Charles University, Faculty of Mathematics and Physics, Malostranske nam. 25, 118 00, Prague, Czech Republic, vojtas@ksi.mff.cuni.cz, *Alan Eckhardt*, *Ladislav Peska*

We deal with preference learning from a software engineering point of view (and comment on machine learning and OR aspects). We focus on small to medium (SM) web shops which typically are not dominant on market and customers typically do not register to search. Our data about customers are restricted to data from a HTTP session or stored in a cookie. We restrict ourselves to implicit feedback and purchase information. We present our dominantly content based filtering model and offline experiments on real production data from a SM travel portal.

4 - Recommender Systems: From Academic Research to Industrial Practice
Willem Waegeman, NGDATA, Dok-Noord 7, 9000, Ghent, Belgium, willem.waegeman@ugent.be

In recent years the machine learning community has witnessed an increasing interest in the development of large-scale recommender systems. Driven by competitions such as the Netflix prize, the industrial possibilities of recommender systems have been clearly demonstrated. However, still a large gap exists between academic research and industrial requirements. In this talk I would like to give an overview of existing challenges and appropriate solutions.

■ TB-37

Tuesday, 10:30-12h00
G7-4

Multicriteria Decision Making and Its Applications III

Stream: Multicriteria Decision Making
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Gordon Dash*, Finance and Decision Sciences, University of Rhode Island, 7 Lippitt Road, College of Business Administration, 02881, Kingston, RI, United States, ghdash@uri.edu

1 - A multiple criteria model to ranking fusion based on preferences analysis
Nelson Hein, Mathematics, FURB, Rua Antonio da Veiga, 140, 89012971, Blumenau, Santa Catarina, Brazil, hein@furb.br, *Adriana Kroenke*, *Volmir Wilhelm*

The proposal of this study is to show a model of ranking fusion that seeks to establish a consensus between the judgement (rankings) of the various judges involved, considering different degrees of relevance or importance among them. The baseline of this proposal is the preference analysis, a set of techniques that allows de treatment of multidimensional data handling.

2 - Collective decision making and preference disaggregation
Nikolaos Matsatsinis, Decision Support Systems Laboratory, Technical University of Crete, University Campus, Kounoupidiana, 73100, Chania, Crete, Greece, nikos@ergasya.tuc.gr, *Evangelos Grigoroudis*
The proposed methodology is a collective preference disaggregation approach, which may be considered as an extension of the UTA method for the case of multiple DMs. The method takes into account different input information and preferences for a group of DMs in order to optimally infer a set of collective additive value functions, by minimizing potential individual deviation from the inferred group preference system. Different optimality criteria are considered in order to increase the robustness of the results and achieve a higher group and/or individual consistency level.

3 - Selection of Material in Automotive Industry with Fuzzy VIKOR
Onur Yilmaz, INDUSTRIAL ENGINEERING, YILDIZ TECHNICAL UNIVERSITY, YTU BESIKTAS KAMPUSU, ENDUSTRI MUHENDISLIGI BOLUMU, 34349, ISTANBUL, Turkey, onyilmaz@yildiz.edu.tr, *Bahadir Gulsun*, *Zeynep DÜzyol*
Competition in the automotive sector forces PD (Product Development) departments to use their resources effectively. In this context, performance of materials that are considered to be used by PD should be evaluated and precautionary measures should be taken according to the results of this evaluation. In this study, we apply fuzzy VIKOR (VIse Kriterijumska Optimizacija I Kompromisno Resenje) method in the selection of materials. VIKOR is one of the multi-criteria decision making methods based on determining the ranking of alternatives and reaching a compromise solution.

4 - SVM Classification for Imbalanced Data Sets Using a Multiobjective Optimization Framework
Serpil Sayin, College of Administrative Sciences and Economics, Koc University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, ssayin@ku.edu.tr, *Aysegul Askan*
Classification of two-class imbalanced data sets is a difficult problem. We propose an L1-norm SVM approach that is based on a three objective optimization formulation so as to incorporate the error sums for the two classes independently. We utilize reductions into two criteria formulations and investigate the efficient frontier systematically. The results indicate that a comprehensive treatment of distinct positive and negative error levels may lead to performance improvements that have varying degrees of increased computational effort.

■ TB-39

Tuesday, 10:30-12h00
G7-3

Analytic Hierarchy Process 5

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Ziqi Liao*, Hong Kong Baptist University, ..., Hong Kong, victor@hkbu.edu.hk

1 - Performance Evaluation of APP in IOS system –An application of Context-Dependent DEA
Hsiao Chih Yung, National University of Kaohsiung, 700, Kaohsiung University Rd., Nanzih District, 811. Kaohsiung, Taiwan, R.O.C., Kaohsiung, Taiwan, hsiao315@gmail.com, *Ting-Lin Lee*, *Po-Cheng Ho*
IDC indicated that the global App market revenue would grow from $10.7 billion in 2010 to $182.7 billion in 2015. This study adopted the Content-Dependent DEA model proposed by Seiford and Zhu (2003) to conduct the App evaluation. It will make the App inventors understand their product ranking in the customer's mind, and improve their R&D efficiency. We compare the different categories of top 150 IOS paid App in the United States for six month. The result of this analysis can provide the App inventors with referral of performance improvement and assist them to identify the competitors.

2 - Dissimilar Project Type Selection with a Fuzzy Decision Making Approach For the Academic Research Project
Ufuk Bolukbas, The Department of Industrial Engineering, Yildiz Technical University, YTU Project Support Office, Yildiz, Besiktas, 34349 , ISTANBUL, TURKEY, Turkey, bolukbas@yildiz.edu.tr, *Betül Özkan*, *Huseyin Basligil*

Research projects have some benefits and positive impression for academic career. There are the different project institutions that support academic studies to find funds easily. Whenever a researcher actualizes a research and development (R&D) project attempt, there will always be a multi criteria decision making problem to choose which project fund type is the most suitable for the project. In this work there are five alternative project types, Fuzzy Analytic Hiearchy Process method is used to determine criteria weigths and select the most eligible project type under five main criteria.

3 - A MCDM Approach to a Study case for Switching equipment selection in a Gas & Oil Company using AHP Technique
Alirio Rivera Cuervo, Engineering, Politecnico di milano, Italy, ariveracu@unal.edu.co, *Felix Antonio Cortes Aldana*

It was generated an innovative project for the selection and renovation of the commutation equipment used by one of the leading Oil & Gas companies in Colombia. The project implemented techniques of the MCDA methodology, in particular: Decision Matrix and AHP, to evaluate three types of equipment, by four experts, and certify the final choice. For the organization, the application of this new methodology and the construction of a hierarchical structure, to express the problem, were a major breakthrough in their decision making processes, and an opportunity to support easily a complex decision.

4 - The Evaluation of Information Technology Infrastructure Projects
Ziqi Liao, Hong Kong Baptist University, ..., Hong Kong, victor@hkbu.edu.hk

The paper explores the evaluation of information technology infrastructure projects. The model framework based on the Analytic Hierarchy Process can be customized to cope with the challenges in rapidly changing situations. The analysis shows that it is imperative to formulate strategic criteria and identify project alternatives through consultation with senior executives and assessment of the firm's business and market environments.

■ TB-40

Tuesday, 10:30-12h00
Y12-1

DEA Theory II

Stream: DEA and Performance Measurement
Invited session

Chair: *Joe Zhu*, School of Business, Worcester Polytechnic Institute, 01609, Worcester, MA, United States, jzhu@wpi.edu

1 - A Supply Chain Model with Time-Staged Outputs
Raha Imanirad, OMIS, Schulich School of Business, York University, 4700 Keele Street, M3J 1P3, Toronto, Ontario, Canada, rimanirad09@schulich.yorku.ca, *Wade Cook*, *Joe Zhu*

We investigate efficiency measurement in a two-stage supply chain setting using data envelopment analysis. Since 1978, DEA literature has witnessed the expansion of the original concept to encompass a wide range of theoretical and applied research areas. One such area is network DEA, and in particular two-stage DEA. In the conventional closed serial system,the only role played by the outputs from stage 1 is to behave as inputs to stage 2. The current paper examines a variation of that system. We develop a DEA-based methodology that is designed to handle what we term time-staged outputs.

2 - A graphical procedure for DEA Benchmarking
Clara Simon de Blas, Statistics & Operations Research, Rey Juan Carlos University, Departamental II, Desp. 042, C/Tulipan s/n, 28933, Mostoles, Madrid, Spain, clara.simon@urjc.es, *Jose Simon Martin*, *Alicia Arias*

We propose a new graphical procedure based on social networks to facilitate benchmark efficiency interpretation on DEA analysis. We construct a valued directed net where nodes represent the DMU's in study and arcs represent peer relationships. DMU's that are primarily identified as efficient are submitted to a complementary analysis based on hubs and authorities to establish the superiority of performance. Several classical application cases are presented to exhibit the strength of the methodology.

3 - Models for unbiased efficiency assessments in an additive two-stage DEA framework
Dimitris Despotis, Department of Informatics, University of Piraeus, 80, Karaoli & Dimitriou Street, 18534, Piraeus, Greece, despotis@unipi.gr, *Gregory Koronakos*

We discuss how the assumptions made in multi-stage DEA models affect the efficiency assessments and we present an unbiased approach to assess the efficiencies of the two stages in an additive two-stage DEA framework. Then we enhance our models by introducing a sufficient condition that allows us to treat the deficiencies reported in the literature for the additive decomposition approach. We illustrate our approach with a data set drawn from the literature.

4 - Issues in DEA and Network DEA
Joe Zhu, School of Business, Worcester Polytechnic Institute, 01609, Worcester, MA, United States, jzhu@wpi.edu, *Wade Cook*, *Kaoru Tone*, *Yao Chen*, *Chiang Kao*

This presentation will discuss issues prior to applying a DEA model, and pitfalls in network DEA approaches. While the multiplier and envelopment DEA models are dual models and equivalent under the standard DEA, such is not necessarily true for the two types of network DEA models. Pitfalls in network DEA are discussed with respect to the determination of divisional efficiency, frontier type, and projections. We believe within the DEA community, researchers, practitioners, and reviewers may have concerns and incorrect views about these issues.

■ TB-41

Tuesday, 10:30-12h00
Y12-5

DEA Applications XI

Stream: DEA and Performance Measurement II
Invited session

Chair: *Ioannis Tsolas*, Humanities Social Sciences and Law, National Technical University of Athens, 9 Iroon Polytechniou Str, Zografou Campus, 157 80, Athens, Greece, itsolas@central.ntua.gr

1 - Measuring the efficiency of police stations efficiency in Slovenia: an application of a multi-stage data envelopment analysis
Jernej Mencinger, University of Ljubljana, Faculty of Administration, Gosarjeva ulica 5, 1000, Ljubljana, Slovenia, jernej.mencinger@fu.uni-lj.si, *Aleksander Aristovnik*

In the paper, we attempt to examine the relative efficiency of the Slovenian Police at the local level. In particular, a three-stage Data Envelopment Analysis technique is presented and then applied to measure the relative efficiency of police-work-related data for all police stations in 2010. The data obtained from the police databases are analysed through the Frontier Analyst 4.0 and SPSS 19.0 statistical package software. The results of the DEA empirical analysis reveal some significant differences between police stations in Slovenia in 2010 in terms of their efficiency and effectiveness.

2 - Wineries' performance, response to a crisis period
Katrin Simon-Elorz, Gestión de Empresas, Universidad Publica de Navarra, Campus Arrosadia, 31006, Pamplona, Navarra, Spain, katrin@unavarra.es, *Juan Sebastián Castillo*, *Maria Carmen Garcia-Cortijo*

This study investigates the key variables to explain the crisis effect in the performance index of the wineries in Castilla-La-Mancha—Spain. At the core lies the difference between the performance variable and the commercial and financial strategies adopted. Our Database is an unbalanced panel data and include the wineries operating 2004-2010. Measures of managerial performance comprise index of VA, EBITDA, ROA, ROI & Total Solvency. Using Pooled Cross Section Time series, we test a model that includes environmental variables; commercial variables; financial variables; and special events.

3 - Efficiency and risk in the Greek banking industry
Ioannis Tsolas, Humanities Social Sciences and Law, National Technical University of Athens, 9 Iroon Polytechniou Str, Zografou Campus, 157 80, Athens, Greece, itsolas@central.ntua.gr

The purpose of this paper is to examine the relationship between efficiency and risk in the Greek banking industry. Efficiency is measured by means of Data Envelopment Analysis (DEA) whereas risk is proxied by credit risk provisions and haircut losses on Greek bonds held by domestic banks. The new proposed DEA measure is compared with an intermediate-based DEA metric omitting risk variables. As the omission of the risk leads in biased estimates, the merit of the proposed metric is evident.

■ TB-42

Tuesday, 10:30-12h00
Y12-3

Methodological Issues in Decision Modelling

Stream: Decision Processes
Invited session

Chair: *Antti Punkka*, Department of Mathematics and Systems Analysis, Aalto University School of Science, SAL, Aalto University, P.O.Box 11100, 00076, Aalto, Finland, antti.punkka@aalto.fi

1 - A Careful Look at the Importance of Criteria and Weights
Jyrki Wallenius, Information and Service Economy, Aalto University School of Business, Runeberginkatu 22-24, 00076Aalto, Helsinki, Uusimaa, Finland, jyrki.wallenius@aalto.fi, *Pekka Korhonen*, *Anssi Oorni*, *Kari Silvennoinen*

We investigate the connection between weights, scales, and the importance of criteria, when assuming a linear value function. Our considerations are based on a simple two-criteria experiment. We use the subjects' pairwise responses to estimate the weights for the criteria. Our results imply that there is reason to question two common beliefs, namely that the values of the weights would reflect the importance of criteria, and that such weights could reliably be "provided" by humans without estimation.

2 - Caveats of comparing alternatives' multi-attribute value differences under incomplete preference information
Antti Punkka, Department of Mathematics and Systems Analysis, Aalto University School of Science, SAL, Aalto University, P.O.Box 11100, 00076, Aalto, Finland, antti.punkka@aalto.fi, *Ahti Salo*

We show that many decision rules exhibit rank reversals if there is incomplete information about the decision maker's preferences and the two (hypothetical) alternatives for normalizing the additive multi-attribute value function are replaced by other alternatives. As a remedy, we determine what rankings the alternatives can attain for value functions that are consistent with the stated preference information and illustrate the use of such rankings in decision support.

3 - Modelling Incomplete Information about Baselines in Portfolio Decision Analysis
Juuso Liesiö, Systems Analysis Laboratory, Aalto University, P.O.Box 11100, 00076Aalto, Espoo, Finland, juuso.liesio@tkk.fi, *Antti Punkka*

A key issue in applying multi-objective project portfolio models is choosing baselines that define the value of not doing a project. Yet, specifying these baselines can be difficult as it may require, for instance, scoring the strategic fit of not doing a project. We develop advanced techniques for specifying baselines which admit incomplete preference statements. Furthermore, we develop mixed integer programming models to analyse the robustness of project and portfolio decision recommendations when only incomplete information about the baselines is available.

4 - A choice model with imprecise ordinal evaluations
Mohamed Ayman Boujelben, Institut des Hautes Etudes Commerciales de Sfax, Route Ain km 5, Koucha Ben Amer, Chez Boujelbene Ridha (Quincaillerie), 3042, Sfax, Tunisie, Tunisia, ayman_boujelben@yahoo.fr, *Yves De Smet*

We consider multicriteria choice problems where the actions are evaluated on ordinal criteria and where they can be assessed imprecisely. In order to select the subset of best actions, the pairwise comparisons between the actions on each criterion are modeled by basic belief assignments (BBAs). Dempster's rule of combination is used for the aggregation of the BBAs of each pair of alternatives in order to express a global comparison between them on all the criteria. A model inspired by ELECTRE I is also proposed and illustrated by a pedagogical example.

■ TB-43

Tuesday, 10:30-12h00
Y12-2

Mathematical Economics and Turnpike Theorems

Stream: Mathematical Economics
Invited session

Chair: *Alexander Zaslavski*, Technion, 32000, Haifa, Israel, ajzasl@techunix.technion.ac.il

1 - Recent results for infinite-horizon dynamical problems issued from Economics and Management Sciences: the Pontryagin viewpoint and oscillation phenomas
Joel Blot, University Paris 1, 4543, Paris, France, Joel.Blot@univ-paris1.fr

We present results on infinite-horizon optimal control problems which are motivated by macroeconomic models of optimal growth and by dynamical management models. These results are applications of recent advances in the mathematical treatment of infinite-horizon optimal control theory; they concern the discrete time and the continuous time. Among the considered points there are elements on the necessary conditions of optimality in the spirit of Pontryagin viewpoint and on oscillation phenomenas.

2 - Nonlinear Markov games on a finite state space (mean-field and binary interactions)
Vassili Kolokoltsov, Statistics, University of Warwick, CV4 7AL, Coventry, United Kingdom, v.kolokoltsov@warwick.ac.uk

Managing large complex stochastic systems, including competitive interests, when one or several players can control the behavior of a large number of particles (agents, mechanisms, vehicles, subsidiaries, species, police units, etc.), the complexity of the game-theoretical (or Markov decision) analysis can become immense. We shall analyze some situations when the limit of large number of species can be described by a deterministic differential game.

3 - Turnpike properties for the Robinson-Solow-Srinivasan model
Alexander Zaslavski, Technion, 32000, Haifa, Israel, ajzasl@techunix.technion.ac.il

We study the structure of solutions for a class of discrete-time optimal control problems. These control problems arise in economic dynamics and describe a model proposed by Robinson, Solow and Srinivasan. We are interested in turnpike properties of the approximate solutions which are independent of the length of the interval, for all sufficiently large intervals. We show that these turnpike properties are stable under perturbations of an objective function.

■ TB-44

Tuesday, 10:30-12h00
Y12-4

Game Theory Applications

Stream: Dynamical Systems and Game Theory
Invited session

Chair: *José Martins*, Polytechnic Institute of Leiria, Portugal, jmmartins@ipleiria.pt
Chair: *Bruno M.P. M. Oliveira*, FCNAUP, R. Dr. Roberto Frias, 4200-465, Porto, Portugal, bmpmo@fcna.up.pt

1 - On the convergence to Walrasian prices in random matching Edgeworthian economies
Bruno M.P. M. Oliveira, FCNAUP, R. Dr. Roberto Frias, 4200-465, Porto, Portugal, bmpmo@fcna.up.pt, *Alberto Pinto*, *Luis Ferreira*, *Barbel Finkenstadt*, *Athanasios Yannacopoulos*

We show that for a specific class of random matching Edgeworthian economies, the expectation of the limiting equilibrium price coincides with the equilibrium price of the related Walrasian economies. This result extends to the study of economies in the presence of uncertainty within the multi-period Arrow-Debreu model, allowing to understand the dynamics of how beliefs survive and propagate through the financial market.

2 - Influence of individual decisions in competitive market policies
Alberto Pinto, Mathematics, University of Porto, Portugal, aapinto1@gmail.com, *Renato Soeiro*, *Abdelrahim Mousa*

We observed that in a decision model, where individuals have gains in their utilities by making the same decisions as the other individuals of the same group, the pure Nash equilibria are cohesive. However if there are frictions among individuals of the same group, then there will be disparate Nash equilibria. Finally, we did a full analysis of a resort-tourist game that might become a paradigm to understand comercial interactions between individuals that have to choose among different offers of public or private services and care about the other individuals choices.

3 - Two characterizations of the Shapley value for regression games
Enrique González-Arangüena, Statistics and Operation Research III, Complutense University of Madrid, Avda. Puerta de Hierro s/n, 28040, Madrid, Madrid, Spain, egaran@estad.ucm.es, *Rene van den Brink*, *Conrado M. Manuel*

We can associate to any given regression model a cooperative game, the players being the set of explanatory variables (regressors) and the worth of each coalition the coefficient of determination of the regression model in which the regressors are only those in the coalition. The Shapley value of this game associates to each regressor a real number that can be interpreted as an index of its importance. In this work, using a pair of axioms related to the classic balanced contributions property (Myerson, 1980), we obtain two characterizations of the Shapley value for these regression games.

■ TB-45

Tuesday, 10:30-12h00
Y10-3

Mathematical Models in Macro- and Microeconomics 5

Stream: Mathematical Models in Macro- and Microeconomics
Invited session

Chair: *Ludmilla Koshlai*, Systems analysis and OR, Institute of Cybernetics, Gonchar str.,65-a,apt.20, 01054, Kiev, Ukraine, koshlai@ukr.net
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Optimal contracts in construction projects to mitigate information asymmetry

Yamini S, Department of Management Studies, Indian Institute of Technology, Madras, Research Scholar, Department of Management Studies, IIT Madras, 600036, Chennai, Tamil Nadu, India, yamini.bubbly@gmail.com, *Rahul R Marathe*

We study a principal agent setting in construction projects with lack of quality. The effort to improve the quality of construction is private information to contractor. To mitigate this, the owner designs a contract with the contractor and determines the optimal wage and effort of the contractor satisfying her individual rationality and incentive compatibility. We analyze the monitoring mechanism by owner and by a consultant with rent seeking behavior. We analytically prove that incentive mechanism to agents with rectification liability and retention is a dominant regime to avoid collusion.

2 - The Impact of Issue Authority Allocation in Business Negotiations: Who Benefits from Post Negotiation Procedures?

Ralf Wagner, Int. Direct Marketing, University of Kassel, Moencheberstr. 17, 34125, Kassel, Germany, rwagner@wirtschaft.uni-kassel.de, *Katrin Zulauf*

This study investigates the impact power allocations in a two party negotiation task covering eight issues with each four solutions. We propose a modified version of the Adjusted Winner algorithm for improving the negotiators settlements with respect to efficiency assessed by the distance to the nearest Pareto-optimal solution. The core of this study is the relationship of negotiation power allocation and the benefits of applying the post-settlement optimization.

3 - Equilibrium Customers Strategies in a Single Server Markovian Queue with Batch arrivals of K Customers

Fazia Aoudia-rahmoune, Operational Research, Laboratory LAMOS University of Bejaia, Laboratory LAMOS University of Bejaia, Traga Ouzemmour, 06000, Bejaia, Algeria, foufourah@yahoo.fr, *Sofiane Ziani*, *Mohammed Said Radjef*

In this paper we investigate the equilibrium customers behavior in a single server Markovian queue with batch arrivals of k customers. We examine the observable and the nonobservable cases at the arrival epoch of customers before they make their decision. In each case, we define the corresponding game, characterize customer equilibrium strategies, analyze the stationary behavior of the corresponding system and derive the benefit for all customers. We also explore the effect of the information level on the benefit via numerical comparisons.

4 - Numerical probabilistic analysis for microeconomic problems

Olga Popova, Siberian Federal University, 79, Svobodny Prospect 660041 Krasnoyarsk, Russian Federation, olgaarc@yandex.ru

We develop a technique that uses Numerical Probabilistic Analysis for microeconomic problems and company management under aleatory and epistemic uncertainty. Using the arithmetic of probability density functions and probabilistic extensions, we can construct numerical methods that enable us solving systems of linear and nonlinear algebraic equations with random parameter and some linear programming problems with inexact coefficients. In particular, we consider risk assessment of investment projects, where NPV and IRR are computed.

■ TB-46

Tuesday, 10:30-12h00
Y10-1

Operations Research Games (ORG)

Stream: Game-theoretical Models in Operations Research
Invited session

Chair: *Greys Sosic*, Marshall School of Business, University of Southern California, Bridge Hall 401, 90089, Los Angeles, CA, United States, sosic@marshall.usc.edu

1 - Cost Allocation Approaches for the Cooperative Traveling Salesman Problem with Rolling Horizon

Igor Kozeletskyi, Chair for Logistics and Operations Research, University of Duisburg-Essen, Lotharstr 65, 47057, Duisburg, Germany, igor.kozeletskyi@uni-due.de, *Alf Kimms*

We present a game-theoretic approach for cost allocation in horizontal cooperation on the example of TSP with rolling horizon. The cost allocation is determined using two alternative concepts: the core and the Shapley value. The developed core computation algorithm, based on mathematical programming techniques, provides a core element or, in case of an empty core, a least core element. The Shapley Value is computed heuristically using an estimation algorithm. The developed computational study tests the performance of solution procedures and compares results for both concepts.

2 - Cost allocation and stable coalition structure models

Mario Guajardo, Business and Management Science, NHH Norwegian School of Economics, NHH, Institutt for Foretaksøkonomi, Helleveien 30, 5045, Bergen, Norway, Mario.Guajardo@nhh.no, *Mikael Rönnqvist*

Given a set of players and the cost of each possible coalition, we formulate mixed integer linear programming models to determine the coalition structure and the cost allocations. We consider core stability conditions and other criteria such as maximum size constraints and strong stability among coalitions. We illustrate our approach in situations motivated from the forest and petroleum industries. In these situations, collaboration can result in savings for companies, but due to several reasons it may be better to group them in different subcoalitions rather than in the grand coalition.

3 - Cooperation on capacitated inventory situations with fixed storage costs

M[a] Gloria Fiestras-Janeiro, Universidade de Vigo, 36310 , Vigo, Spain, fiestras@uvigo.es, *Ignacio García-Jurado*, *Ana Meca*, *Manuel Alfredo Mosquera Rodríguez*

In this paper we analyse a situation in which several firms deal with inventory problems concerning the same type of product. We consider that each firm uses its limited capacity warehouse for storing purposes and that it faces an economic order quantity model where storage costs are irrelevant (and assumed to be zero) and shortages are allowed. In this setting, we show that firms can save costs by placing joint orders. Besides, we propose a rule to share the costs among the firms which has attractive properties from the points of view of fairness, stability and computability.

4 - Benefactors and Beneficiaries: the Effects of Giving and Receiving on Cost-Coalitional Problems

Greys Sosic, Marshall School of Business, University of Southern California, Bridge Hall 401, 90089, Los Angeles, CA, United States, sosic@marshall.usc.edu, *Ana Meca*

We introduce a class of cost-coalitional problems, based on a-priori information about the cost faced by each agent in each set. We assume that there are players whose participation in an alliance contributes to the savings of alliance members (benefactors), and players whose cost decrease in such an alliance (beneficiaries). We use k-norm cost games

to analyze the role played by benefactors and beneficiaries in achieving alliance stability, and provide conditions for stability of the grand coalition and of some alternative coalition structures by considering the core and the bargaining set.

■ TB-47

Tuesday, 10:30-12h00
Y10-2

Applications in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Thomas Winter*, Department of Mathematics, Physics, and Chemistry, Beuth Hochschule für Technik Berlin, Luxemburger Str. 10, 13353, Berlin, Germany, thomas.winter@beuth-hochschule.de

1 - Elective patient admissons under multiple resource constraints
Kumar Rajaram, UCLA Anderson School, 100 Westwood Plaza, 90095, Los Angeles, CA, United States, krajaram@anderson.ucla.edu, *Christiane Barz*

We consider a patient admission problem to a hospital with multiple resource constraints (e.g., OR and beds) and a stochastic evolution of patient care requirements across multiple resources. There is a small but significant proportion of emergency patients who arrive randomly and have to be accepted at the hospital. However, the hospital needs to decide whether to accept, postpone or even reject the admission from a random stream of non-emergency and elective patients to maximize expected contribution net of overbooking costs.

2 - Internal and external cannibalization of refurbishing products under competition
Erwin van der Laan, RSM Erasmus University, P.O.Box 1738, 3000DR, Rotterdam, Netherlands, elaan@rsm.nl, *Niels Agatz*

Refurbishing entails the process of repairing products that return due to production defects, warranty, customer remorse or buy-back. More and more companies sell refurbished products at a discount, while offering similar warranty as that of new products. Here, we quantify the key drivers of cannibalization when offering refurbished products. We contribute to the extant literature by explicitly modeling the supply and demand side of refurbishing, cannibalization, and market extension, and determining optimal quantities for new and refurbished products under various competition scenarios.

3 - Pricing control of closed queuing networks: Service maximization in Vehicle Sharing Systems
Ariel Waserhole, G-SCOP, Grenoble-INP, 46, avenue Félix Viallet, 38031, Grenoble Cedex 1, France, ariel.waserhole@g-scop.grenoble-inp.fr, *Vincent Jost*, *Nadia Brauner*

We study self regulation through pricing for Vehicle Sharing Systems (VSS). Without regulation VSS have poor performances. We want to improve the efficiency of VSS using pricing as incentive. We take as base model a Markovian formulation of a closed queuing network with finite buffer and time dependent service time. This model is unfortunately intractable for the size of instances we want to tackle. We discuss heuristics: a scenario approach, a fluid approximation, simplified stochastic models and asymptotic approximations. We compare these heuristics on toy cities.

4 - Dynamic programming for several leg compartments
Thomas Winter, Department of Mathematics, Physics, and Chemistry, Beuth Hochschule für Technik Berlin, Luxemburger Str. 10, 13353, Berlin, Germany, thomas.winter@beuth-hochschule.de

In airline revenue management, leg compartments are typically controlled separately which in practice is not a valid approach because the customers choice sets are not perfectly segmented by the products offer per compartment, for instance when several economy products are offered. We present two dynamic programming approaches for controlling several leg compartments in parallel. We discuss the usage of marginal revenues in the preprocessing of offered product sets. In addition, we consider different objective functions for maximizing the revenue for single leg and network problems.

■ TB-48

Tuesday, 10:30-12h00
Y11-1

Statistical Modelling

Stream: Simulation Methods in Finance
Invited session

Chair: *İsmail Kınacı*, Statistics, Selçuk University, Selçuk University, Science Faculty,, Konya, Turkey, ikinaci@selcuk.edu.tr
Chair: *Demet Sezer*, Statistics, Selcuk University, Selcuk University Faculty of Science, Department of Statistics, Konya, Turkey, dsezer@selcuk.edu.tr

1 - A New Dimension Reduction Approach in The Classification Of High-Dimensional Data
Aydın Karakoca, Department of Statistics, Necmettin Erbakan University, Faculty of Arts and Sciences, Konya, Turkey, akarakoca@selcuk.edu.tr, *Ulku Erisoglu*, *Murat Erisoglu*, *Ahmet Pekgör*

In many studies, the number of variables may be greater than the number of observations. This situation leads to some new problem with it. Approaches used in the solution of this problem is called the dimension reduction techniques. In this study for the case of a classification problem that the number of observations (n) is less than the number of variables (p) were considered. Before the classification a new data reduction method applied to problem then data were classified. Finally performance of suggested method compared by some selected dimension reduction methods.

2 - Bayesian Inference of the Exponential Geometric Distribution
İsmail Kınacı, Statistics, Selçuk University, Selçuk University, Science Faculty,, Konya, Turkey, ikinaci@selcuk.edu.tr, *Demet Sezer*, *Aydın Karakoca*, *Adem Yılmaz*

In this study, Maximum likelihood and Bayes estimates for the two parameters of the Exponential-Geometric (EG) distribution are obtained. An approximation method developed by Tierney and Kadane is used for obtaining the Bayes estimates. An extensive computer simulation is used for comparing maximum likelihood and Bayes estimates in that their estimated risks.

3 - Estimation of stress-strength parameter of a parallel system for exponential distribution based on masked data
Demet Sezer, Statistics, Selcuk University, Selcuk University Faculty of Science, Department of Statistics, Konya, Turkey, dsezer@selcuk.edu.tr, *İsmail Kınacı*

In this study, we estimate the stress-strength parameter(R) for a parallel system with two components based on masked data. In particular, we compute the maximum likelihood and Bayes estimates of R. The considered system consists of two independent components having non-identical complementary exponential lifetime distribution. Also in the numerical simulation study, a comparison between Bayesian and maximum likelihood estimates is introduced.

4 - The Use of Robust Estimates for Variable Selection in Semiparametric Regression Models
Alper Sinan, Statistics, Sinop University, Sinop University, Faculty of Science and Arts, Department of Statistics, 57000, Sinop, Sinop, Turkey, alpsin@sinop.edu.tr, *B.Baris Alkan*

Semiparametric regression is a commonly used method for the analysis of economical data. As it is well known, the variable selection for the parametric and nonparametric components of model is the first encountered problem in the estimation procedure. In this study, we

showed that, the outliers causes wrong classification of variables when the classical methods used for variable selection. We used robust estimation methods for variable selection in an artifical data set and obtained that, robust methods are more useful for variable selection in the presence of outliers in the data sets.

■ TB-49

Tuesday, 10:30-12h00
Y11-2

Investment for life-cycle and pension

Stream: Actuarial Sciences and Stochastic Calculus
Invited session

Chair: *Francesco Menoncin*, Economics, Brescia University, Via S. Faustino, 74/B, 25122, Brescia, Italy, menoncin@eco.unibs.it

1 - Stochastic pension funding and time inconsistent preferences
Jorge Navas, Dpt. de Matematica economica, financera i actuarial, Universitat de Barcelona, Facultat d'Economia i Empresa, Avinguda Diagonal 690, 08034, Barcelona, Spain, jnavas@ub.edu, *Ricardo Josa-Fombellida*

The study of dynamic models with time inconsistent preferences has received an increasing attention in order to account for some agents' behaviors observed from empirical studies, such as impatience in their short-run decisions. In this work we introduce time inconsistent preferences for the promoter of a defined benefit pension plan and study the effect of these preferences on the optimal decision rules when the decision maker minimizes a combination of the contribution rate risk and the solvency risk over an infinite time horizon.

2 - Longevity Risk Management in an Incomplete Market
Francesco Menoncin, Economics, Brescia University, Via S. Faustino, 74/B, 25122, Brescia, Italy, menoncin@eco.unibs.it

In this paper we present the optimal portfolio problem for an economic agent who cannot invest in actuarial derivatices written on the longevity risk (or who can invest in such derivatives which nevertheless present a basis risk). We are able to show some special cases where even if the financial market is incomplete with respect to the longevity risk, the optimal portfolio can be computed in closed form. In particular we show some conditions on diffusion matrices of both risky assets and state variables under which market incompleteness becomes immaterial for the optimal portfolio.

3 - Optimal strategy for public pension plan
Tadashi Uratani, Industrial and System Engineerig, Hosei University, Kajinocho 3-7-2, Koganei, 184-8584, Tokyo, Japan, uratani@k.hosei.ac.jp, *Masanori Ozawa*

Public pension is suffering from longevity and less fertility in many countries. The strategies of management are premium benefit and the start age, and government subsidy. The objective is to sustain the system in future economic and demographic uncertainty. It should satisfy the condition of positive present value for pension participation, generational equality, minimum level of replacement ratio of income. The uncertainties of pension are defined as stochastic processes. We formulate the mathematical programing model and solve it in the case of Japanese public pension plan.

4 - Portfolio Optimization with Jumps - Illustration with a Pension Accumulation Scheme
Olivier Le Courtois, EM Lyon Business School - Lyon, 69130, Ecully, France, lecourtois@em-lyon.com

We compute optimal portfolio in a quasi-closed-form formula when stock dynamics are modeled by general Lévy processes in a pension scheme. We show how to switch back and forth between the stochastic differential and standard exponential representations of Lévy processes (we use two Lévy dynamics: the Variance Gamma process, and a Lévy process admitting an arrival rate of jumps exponentially decreasing with respect to their size). We show that when jumps are taken into account, the risky asset weight in optimal portfolio may be around half that obtained in the Gaussian framework.

■ TB-50

Tuesday, 10:30-12h00
Y11-3

Operational Research in Financial and Management Accounting

Stream: Operational Research in Financial and Management Accounting
Invited session

Chair: *Matthias Amen*, Chair for Quantitative Accounting & Financial Reporting, University of Bielefeld, Universitaetsstrasse 25, 33615, Bielefeld, Germany, Matthias.Amen@web.de

1 - A quantitative approach for coping with IFRS 8 requirements for segment reporting
Matthias Amen, Chair for Quantitative Accounting & Financial Reporting, University of Bielefeld, Universitaetsstrasse 25, 33615, Bielefeld, Germany, Matthias.Amen@web.de

The International Financial Reporting Standard (IFRS 8) "Operating Segments" requires providing financial information about a set of segments of a company. A segment should consist of similar activities of the company. IFRS 8.13 describes a variety of quantitative thresholds that should be fulfilled when designing the segment reporting. In practice this is usually be done be methods of trial and error. We present a first quantitative approach that enables to define the segments subject to the requirements of IFRS 8.

2 - The association between the level of risk disclosure and corporation characteristics in the annual reports of Egyptian companies
Antonio Chirico, University of Rome "Tor Vergata", 12345, Roma, Italy, chirico@economia.uniroma2.it, *Bassam Baroma*

The main objective of this study is to test and examine the relationship between specific firm characteristics in Egypt and the level of risk disclosure in the annual reports of Egyptian firms Findings: the results show that firm size was significantly positive (in all the three years) with the level of risk disclosure. Industry type variable was found insignificantly association with the level of risk information disclosed in the annual reports for all the three years. However, leverage was found insignificantly associated with the level of risk information disclosed in the annual reports.

3 - Social Comparison in Principal-Agent Models: The Role of Perception
Ulrich Schäfer, Professur für Finanzen und Controlling, Georg-August-Universität Göttingen, Platz der Göttinger Sieben 3, 37073, Göttingen, Germany, ulrich.schaefer@wiwi.uni-goettingen.de, *Stefan Dierkes*

The effects of social comparison in principal-agent relationships have been studied intensively. Analytical models assume that individuals compare realized effort costs and income. However, while compensation and effort might be observable, effort costs are generally not. In this case, behavioral sciences emphasize that comparison is based on perceptions instead of realized effort costs. This study uses a LEN model to analyze the role of perception. We assume that an agent evaluates his opposite's unobservable effort costs by applying his own effort cost function to the other's effort.

4 - How organizational culture influences the quality of service processes
Corinna Grau, Management Research Department, Process Lab, Frankfurt School of Finance and Management, Sonnemannstrasse 9-11, 60314, Frankfurt am Main, Germany, c.grau@fs.de

Organizational culture (oc) plays an important role in BPM research, especially with regard to service processes as there is a strong influence of the processing employees. We present results of the exploration of how to take the influence of oc on the quality of service processes into consideration. Our empirical study is based on a questionnaire survey with a sample of 145 employees working on the same service process in a financial services company. Regression analyses show deep insights on the underlying mechanisms of the strong positive influence of oc on the quality of service processes.

■ TB-51

Tuesday, 10:30-12h00
Y11-4

Financial Modeling 2

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *A. Can Inci*, College of Business - Finance, Bryant University, 1150 Douglas Pike, 02917, Smithfield, RI, United States, ainci@bryant.edu

1 - Quantile Hedging in Discrete Time
Erdinc Akyildirim, Swiss Finance Institute, Switzerland, erdinc.akyildirim@math.ethz.ch

In this paper, we develop a discrete-time approach to the quantile hedging problem introduced by Föllmer and Leukert (1999). They describe quantile hedging as the optimal hedge when the initial capital is less than the minimal super-hedging or perfect hedging cost. By using the techniques from Bouchard et al. (2009), we investigate the quantile hedging problem under different market constructions. Numerical results from our model compared to the analytical solution demonstrate the efficiency of our algorithm.

2 - Investment strategies under debt issuance amount constraints
Takashi Shibata, Graduate School of Social Sciences, Tokyo Metropolitan University, 1-1, Minami-osawa, 192-0397, Hachioji, Tokyo, Japan, tshibata@tmu.ac.jp, *Michi Nishihara*

This paper examines the optimal investment timing decision problem of a firm subject to a debt issuance constraint. We show that the investment thresholds have a U-shaped relation with the debt issuance constraints, in that they are increasing (decreasing) with the constraint for high (low) debt issuance limit. Debt issuance constraints lead to debt holders experiencing low risk and low returns. That is, the more severe the debt issuance limits, the lower the credit spreads and default probabilities. Our theoretical results are consistent with stylized facts and empirical results.

3 - Data Sampling Frequency and Stochastic Processes of Bond Rates and Currencies
A. Can Inci, College of Business - Finance, Bryant University, 1150 Douglas Pike, 02917, Smithfield, RI, United States, ainci@bryant.edu

Higher frequency data may enable better separation of continuous and jump components of a stochastic process. Low frequency monthly or quarterly data may not demonstrate the advantages of dynamic processes with jumps since these jumps may be smoothed out unintentionally. This study examines various two-country multi-state nonlinear and affine stochastic models in the context of sampling frequency. Empirical performances of the models are compared to determine the impact of higher frequency data on forecasting performance.

4 - Design and Pricing of Derivative Contracts in a Spectrum Market
Aparna Gupta, Lally School of Mgmt, Rensselaer Polytechnic Institute, Troy, NY, United States, guptaa@rpi.edu, *Praveen Kumar Muthuswamy*, *Koushik Kar*

We propose a secondary spectrum market that allows wireless providers to purchase spectrum access licenses of short duration in the form of spot contracts and derivative contracts. We develop a model for spot price of spectrum licenses, which are modeled as driven by fractional Brownian motion owing to the self-similarity of network traffic. Utilizing fractional stochastic calculus, we solve a partial differential equation governing the value of derivative contracts in the proposed spectrum market. We design a variety of derivative contracts for the risk profile of spectrum providers.

■ TB-52

Tuesday, 10:30-12h00
B13-1

Energy forecasting II

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Juan Trapero*, Business Administration, Universidad de Castilla-La Mancha, Facultad de Quimicas, Campus universitario s/n, 13071, Ciudad Real, US & Canada only, Spain, juanramon.trapero@uclm.es

1 - Incorporating structural information in combination offorecasts from neural networks
Juan Rendon, Management, Cass Business School, City University, London, 106 Bunhill Row, EC1Y 8TZ, London, United Kingdom, juan.rendon.1@cass.city.ac.uk, *Lilian De Menezes*

Forecasts combinations normally use point forecasts from different models or sources.This paper explores the inclusion of structure of forecasting models, as a combining approach.Neural networks (NN) were selected due to their straightforward structural representation.Pools of NNs are generated, for later being summarized in centre NNs, which are used, with a final combination, to produce forecasts.Hourly wind power and electricity load data are used to test the approach, forecasting up to 24 hours ahead.Results show marginal improvements compared to the sample average of the pools' forecasts.

2 - webSTLF - Short Term Load Forecasting over the Web
Reenu Morya, Information Technology, Tata Consultancy Services, PowerAnser Labs, Room No. 200, 2nd Floor,, Electrical Engg. Dept., IIT Bombay, Powai, 400076, Mumbai, Maharashtra, India, reenu2488@gmail.com, *Manish Punjabi*, *Krishna Prasad*, *Shreevardhan Soman*

webSTLF is a modular, flexible and reliable approach to day ahead load forecasting using SaaS. Java Swings based client has the flexibility to dynamically define different - data sets, exogenous weather parameters and forecasting models to use a common framework for customizable solutions. Available Forecast engines are Similar Day Approach, Artificial Neural Networks, Time Series Models like ARIMA and combination of these. Data processing for pre-forecast and post-forecast can be manual or automatic for the end user. Solution is hosted on highly available platform to eliminate uncertainties

3 - Short-term solar irradiance forecasting based on Holt-Winters exponential smoothing
Juan Trapero, Business Administration, Universidad de Castilla-La Mancha, Facultad de Quimicas, Campus universitario s/n, 13071, Ciudad Real, US & Canada only, Spain, juanramon.trapero@uclm.es, *Alberto Martin*, *Fausto Pedro Garcia Marquez*

Due to the progressive effort that modern economies are doing towards a more sustainable energy supply, solar power generation is becoming an area of paramount importance. To integrate this generated energy into the grid, solar irradiance must be forecasted. This work analyses the Holt-Winter method to forecasting solar irradiance at short-term (from 1 to 6 hours). In order to illustrate the results Global Solar Irradiance and Direct Normal Irradiance data have been hourly collected from stations located in Spain. The results show that the proposed method provides competitive forecasts.

■ TB-53

Tuesday, 10:30-12h00
B13-2

Stochastic Optimization Methods in Energy Planning

Stream: Stochastic Modeling in Energy Planning
Invited session

Chair: *Michel Gendreau*, MAGI and CIRRELT, École

Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca

1 - A Novel Value Function Approximation Technique Leading to Efficient Renewable Energy Resource Allocation

Arta Jamshidi, Opertions Research and Financial Engineering, Princeton University, Sherrerd Hall, 08544, Princeton, NJ, United States, arta@princeton.edu, *Warren Powell*

We present a fast and recursive function approximation technique that does not require the storage of the arrival data stream without compromising accuracy. This serves algorithms in stochastic optimization which require approximating functions in a recursive setting. The unique collection of these features is essential for modeling large data sets where storage of data becomes prohibitively expensive or updated information arrives. This leads to an efficient way of value function approximation in the context of approximate dynamic programming for renewable energy resource allocation.

2 - Benders Decomposition for solving multi-stage stochastic mixed complementarity problems.

Ruud Egging, Industrial Economics and Technology Management, NTNU, Trondheim, Norway, ruud.egging@iot.ntnu.no

The Stochastic Global Gas Model is a mixed complementarity problem for the global natural gas market. Uncertainty about future parameter values is represented using an extensive-form stochastic model formulation. The inclusion of multiple scenarios enlarges the model size drastically with a severe impact on memory and time needed to solve the model. An alternate Benders Decomposition approach is discussed and implemented successfully in GAMS. Several numerical issues are discussed and resolved.

3 - An L-shaped method for mid-term hydro scheduling under uncertainty

Michel Gendreau, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca, *Pierre-Luc Carpentier*, *Fabian Bastin*

We propose a new approach for solving the mid-term hydro scheduling problem (MHSP) with stochastic inflows. We partition the planning horizon into two stages and assume that the hydrological stochastic process loses memory of previous realizations at the end of the first stage. This allows us to represent inflow uncertainty using two successive scenario trees. The special structure of the resulting mathematical program is exploited using a two-stage decomposition scheme. The proposed approach is tested on a large hydroelectric power system in Québec (Canada) for a 92-week planning horizon.

■ TB-54

Tuesday, 10:30-12h00
B14-1

Mathematical Optimisation in Power Systems I

Stream: Energy, Environment and Climate
Invited session

Chair: *Nikita Zhivotovskiy*, Faculty of Control and Applied Mathematics, Moscow Institute of Physics and Technology, Russian Federation, nikita.zhivotovskiy@phystech.edu
Chair: *Maria Teresa Vespucci*, Dept. of Management, Economics and Quantitative Methods, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, maria-teresa.vespucci@unibg.it

1 - Capacity planning in residential heat supply with optimising energy system models: an application and methodological extension in TIMES

Erik Merkel, KIT-IIP, Germany, erik.merkel@kit.edu, *Daniel Fehrenbach*, *Russell McKenna*, *Wolf Fichtner*

Large multi-sector optimising energy system models generally lack accurate and realistic capacity planning methods for decentralised residential heat systems. This talk bridges this gap by providing a novel approach and an application to the German residential heat sector in the TIMES modelling environment. A solution procedure is presented to explore a special built-in TIMES feature and a methodological extension of the standard TIMES code developed based on mixed-integer programming. Obtained model results are in compliance with the realistic capacity planning of heat supply systems.

2 - Breaking Symmetry in MILP Formulations of Power Systems Problems

Ricardo Pinto de Lima, LNEG - Laboratório Nacional de Energia e Geologia, Estrada do Paço do Lumiar, 22, 1649-038, Lisboa, Portugal, ricardo.lima@lneg.pt, *Marian Marcovecchio*, *Augusto Novais*

Specific symmetry breaking constraints (SBC) are applied to the optimization of two classes of problems: short term hydro scheduling (nonconvex MINLP) and thermal unit commitment (MILP). Both involve MILP formulations and both include multiple sets of indistinguishable power generator units that introduce significant symmetry in the formulations.

Optimization results indicate that the proposed SBC, combined with tight linear relaxations, enable solvers to tackle these problems within short CPU times, that would otherwise defy solution or require lengthier CPU times.

3 - A model for the optimal management of medium-voltage AC networks with distributed generation and storage devices

Maria Teresa Vespucci, Dept. of Management, Economics and Quantitative Methods, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, maria-teresa.vespucci@unibg.it, *Alessandro Bosisio*, *Diana Moneta*, *Stefano Zigrino*

A medium-voltage AC network with distributed generation and storage devices is considered for which set points are assigned in each time period of a given time horizon. When some parameters vary, in order to restore feasibility, new set points need to be determined, so as to minimize distributor's dispatching costs, while satisfying service security requirements and ensuring service quality. In the proposed solution procedure a MILP model determines the active power production and the use of storage devices; reactive variables are then computed by solving a nonlinear programming model.

4 - A Multiobjective Optimization Model for Biomass to Energy Supply Chain Network Design

Sebnem Yilmaz, Industrial Engineering, Dokuz Eylul University, Dokuz Eylul University, Faculty of Engineering, Department of Industrial Engineering, Tinaztepe Campus, Buca, 35160, Izmir, Turkey, s.yilmaz@deu.edu.tr, *Hasan Selim*

Today, one of the challenges in biomass to energy industry is to design an efficient supply chain network. The network design problem is one of the most comprehensive strategic decision problems that need to be optimized for the efficient operation of whole SC. This study presents a biomass to energy network design model that incorporates multiple types of biomass and products of the system. The model is a comprehensive multiobjective optimization model that considers financial and environmental performance factors simultaneously subject to technical, economic and environmental constraints.

■ TB-55

Tuesday, 10:30-12h00
B14-2

Supply Chain Design in the Forest Industry II

Stream: Biomass-based Supply Chains
Invited session

Chair: *Eldon Gunn*, Industrial Engineering, Dalhousie University, 5269 Morris St., B3J 2X4, Halifax, Nova Scotia, Canada, eldon.gunn@dal.ca

Chair: *Corinne MacDonald*, Industrial Engineering, Dalhousie University, 5269 Morris St, B3H 4R2, Halifax, NS, Canada, corinne.macdonald@dal.ca

1 - Robust optimization and stochastic programming approaches for demand uncertainties in the wood supply game
Patrik Flisberg, The Forestry Research Institute of Sweden, 75183, Uppsala, Sweden, pafli@mweb.co.za, *Mikael Rönnqvist*

We study the wood supply game which models a value chain problem with demand uncertainty for multiple products. The demand fluctuates considerably over many time periods. The decisions taken cover several units along a divergent value chain. Coordination and good inventory management is critical. We describe a solution approach where we first make a forecast of the demand based on historical data. Second, we use both robust optimization and stochastic programming to develop efficient solution methods. We test the approach on a set of well-known instances used in international competitions.

2 - Construction of forest road network at harvest areas
Mikael Rönnqvist, Département de génie mécanique, Université Laval, G1V 0A6, Québec, Canada, mikael.ronnqvist@nhh.no, *Patrik Flisberg*, *Petrus Jönsson*

We develop a decision support tool to construct road network at harvest areas for harvesters and forwarders. We use high quality GIS information to minimize ground damage and at the same time have efficient operations. The solution method is based on a Lagrangian relaxation of a network design model and where each subproblem is a shortest path tree. In addition of the network design, we also find an efficient routing of forwarders. The system is tested on case studies from Swedish forest companies.

3 - Aligning spatial forest objectives with supply chain economics using a stand-based LP
Evelyn Richards, Forestry, University of New Brunswick, 46 Cameron Court, UNB, E3B2R9, Fredericton, New Brunswick, Canada, Evelyn.Richards@gmail.com, *Eldon Gunn*, *Andrew Martin*

Forest policy identifies desirable forest conditions at overlapping spatial scales. Stand location relative to several zones is required to create strategic plans. Supply chain economics also depend on stand proximity to the transport network and distance to product destination(s). We propose a Model I stand-based LP that effectively addresses spatial strategic planning. It includes a practical number of prescriptions, and addresses economic and environmental goals. Results from this model on a forest of 200,000 stands encompassing 22 ecodistricts and 22 watersheds are assessed.

■ TB-56

Tuesday, 10:30-12h00
B15-3

Optimization Modeling I

Stream: Software for OR/MS
Invited session

Chair: *Bjarni Kristjansson*, Maximal Software, Ltd., Boundary House, Boston Road, W7 2QE, London, United Kingdom, bjarni@maximalsoftware.com
Chair: *Robert Fourer*, AMPL Optimization, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com

1 - New Interface Developments in the AMPL Modeling Language & System
Robert Fourer, AMPL Optimization, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com

The AMPL optimization language consists of declarations for formulating models, and commands for manipulating, solving, and analyzing problem instances. Commands can be typed interactively or stored in executable scripts. This presentation describes two expansions of the AMPL interface to further address users' needs. New language extensions and a new model development environment make AMPL models even easier to build and maintain. At the same time a new interface to popular programming languages greatly facilitates embedding and deploying AMPL models within large-scale applications.

2 - Deploying MPL Optimization Models on Servers and Mobile Platforms
Bjarni Kristjansson, Maximal Software, Ltd., Boundary House, Boston Road, W7 2QE, London, United Kingdom, bjarni@maximalsoftware.com

The IT industry is currently undergoing a major shift, away from traditional standalone applications, to new platforms such as tablet computers and mobile phones. We will demonstrate a new server-based version of MPL OptiMax, which makes writing mobile applications relatively quick and easy. We will demonstrate how to integrate optimization models seamlessly with online data, and then deploying them on a server for servicing both web and mobile clients, using standard programming languages.

3 - Open-source Quality Assurance and Performance Analysis Tools
Michael Bussieck, GAMS Software GmbH, Eupener Str 135-137, 59033, Cologne, Germany, MBussieck@gams.com, *Steve Dirkse*, *Stefan Vigerske*

Until recently, much of the math programming community has focused primarily on performance testing and benchmarking, while the general commercial environment has emphasized reliability over performance. Around 10 years ago we introduced the PAVER platform (Performance Analysis and Visualization for Efficient Reproducibility) to aid in both QA and performance analysis of solver software. We will present new and enhanced QA and performance tools implemented in the second generation of the PAVER platform.

4 - Latest Developments in SAS Optimization Solvers
Yan Xu, SAS Institute, Inc., Cary, NC, United States, yan.xu@sas.com

SAS provides a suite of solvers for linear, mixed-integer, quadratic, nonlinear and local search optimization. Those solvers are used widely by external customers and in many SAS products as well as SAS business solutions. We present the latest techniques used in our continual effort to enhance optimization solvers. Besides presenting linear and integer program solvers, we introduce a recent solver for local search optimization, and new solvers that exploit special structures. Furthermore, we show how to utilize the latest high performance and big data technology in solver developments.

■ TB-57

Tuesday, 10:30-12h00
B15-4

Pricing, Lead Times, and VMI

Stream: Operations/Marketing Interface
Invited session

Chair: *Kathryn E. Stecke*, University of Texas at Dallas, United States, KStecke@utdallas.edu

1 - The Impact of Profit Criterion on the Distribution Channel Structure for Competing Supply Chains with Price and Lead-Time Sensitive Demand
Zhengping Wu, Singapore Management University, 178899 , Singapore, zpwu@smu.edu.sg, *Lucy Gongtao Chen*, *Jihong Ou*

This paper studies distribution channel structure strategies (to centralize or decentralize) for two competing supply chains that sell substitutable products with price and lead-time sensitive demand. We find that price substitution favors decentralization whereas lead-time substitution tends to result in centralization. Surprisingly, manufacturers prefer channel profit, rather than their own profit, to be used as the channel structure decision criterion when price substitution dominates.

2 - Retailer vs. Vendor-managed Inventory and Customers' Store Loyalty
Jun Ru, University at Buffalo, 326D Jacobs Management Center, 14260, Buffalo, NY, United States, junru@buffalo.edu

It has been widely accepted in the industry that retailers improve profitability by implementing vendor-managed inventory (VMI). We, however, demonstrate that a retailer may be worse off by adopting VMI when retail competition is present. Moreover, the examination of the impact of customers' store loyalty on the value of VMI to the retailer reveals that a retailer with a high customer loyalty benefits from VMI for a wider range of wholesale prices than a retailer with a low customer loyalty.

3 - Integrated Inventory, Pricing and Refund Policy Decisions for Online Retailers when Consumer Valuations are Uncertain
Mehmet Altug, Decision Sciences, George Washington University, 2201 G. Street, NW, Funger Hall 415P, 20052, Washington, DC, United States, maltug@gwu.edu, *Tolga Aydinliyim*

We consider a newsvendor problem in which a retailer needs to make a stocking, pricing and a refund decision where the products purchased in the first period can be returned. Customer valuation is uncertain and they are assumed to be "fully strategic' meaning that they make purchase decision with respect to two dimensions: 1. Fill rate 2. Return policy/refund which in turn has two effects: i) valuation effect ii) fill-rate effect. Interestingly, we find out that retailers will stock more and price higher making them even better off with fully strategic customers under certain conditions.

4 - Trust, Trustworthiness and Information Sharing in Supply Chains Bridging China and the U.S.
Ozalp Ozer, Operations Management, University of Texas at Dallas, United States, oozer@utdallas.edu, *Karen Zheng*

We experimentally study how cultural distinctions between China and the U.S. affect the efficiency of information sharing and operational decisions in global supply chains. We show how spontaneous trust and trustworthiness are lower in China than in the U.S., and Chinese show higher trust towards U.S. partners. The two populations exhibit drastically different behavioral dynamics under repeated interactions, rendering a Chinese supply chain to benefit more from a long-term relationship.

■ TB-58

Tuesday, 10:30-12h00
B15-6

OR and Real Implementations I

Stream: OR and Real Implementations
Invited session

Chair: *Belarmino Adenso-Diaz*, Engineering School at Gijon, Universidad de Oviedo, Campus de Viesques, 33204, Gijon, Spain, adenso@epsig.uniovi.es

1 - Railway time tabling robustness: new aspects and measures
Alejandro Zarzo, Matematica Aplicada, ETS. Ingenieros Industriales, Universidad Politecnica de Madrid, C/Jose Gutierrez Abascal 2, 28006, Madrid, Spain, alejandro.zarzo@upm.es, *Eva Barrena*, *David Canca*, *Juan A. Mesa*, *Alicia De Los Santos Pineda*

We consider perturbations in a railway timetable such as train failures, which increase the average waiting time of the users. This increment may bring the users to prefer an alternative transport mode decrasing in this way the railway network profitability. So, from the passenger as well as from the network profitability point of view, it is important to generate robust timetables.

In this work we provide robustness measures for a railway timetable, which will allow us to quantify different aspects of the robustness of a timetable in the presence of failures of the trains.

2 - Centralization vs. Decentralization in logistic decisions under a bicriteria objective
Belarmino Adenso-Diaz, Engineering School at Gijon, Universidad de Oviedo, Campus de Viesques, 33204, Gijon, Spain, adenso@epsig.uniovi.es, *Santiago Carbajal*, *Sebastián Lozano*

The decision of choosing a supply network centralized or a distributed one, is a classical problem in logistics management. Many works have discussed the advantages of each alternative, from the point of view of total costs. However, given the environmental impact of the logistics operations, the green logistics paradigm is being considered by more and more companies. In this paper we study how the centralization decisions change as the environmental impact of transportation is considered using a fuzzy bicriteria model, embedded in a genetic algorithm that look for the most promising solution.

3 - Modeling and solving the cell loading problem in cellular reconfigurable manufacturing systems
Ignacio Eguia, Dpt. of Industrial Management, University of Seville, Camino de los Descubrimientos s/n, 41092, Sevilla, Spain, ies@esi.us.es, *Sebastián Lozano*, *Jesus Racero*, *Jose Carlos Molina*

In this work, the cell loading problem in the presence of alternative routing within a cellular manufacturing system containing reconfigurable machine tools (RMT) and computer numerical control (CNC) machines is modeled and solved. The cell formation is part of the input data of the loading problem. A new mixed-integer linear programming model has been developed in that framework, minimizing intercellular movements and workload imbalances, and considering production limitations on tools of the CNC machines and modules of the RMT. A heuristic algorithm has been developed to solve the model.

4 - Multi-objective vehicle routing problem with cost and emission functions
Jose Carlos Molina, Dpt. of Industrial Management, University of Seville, 41092, Seville, Spain, jmolina12@etsi.us.es, *Ignacio Eguia*, *Jesus Racero*, *Sebastián Lozano*

This paper proposes a multi-objective problem model based on Tchebycheff methods for VRP with a heterogeneous fleet, in which vehicles are characterized by different capacities, costs and emissions factors. Three objective functions are used to minimize the total internal costs, while minimizing the CO2 emissions and the emission of air pollutants such as NOx. Moreover, this study develops an algorithm based on C&W savings heuristic to solve the model when time windows are not considered. Finally, a real case application is analyzed to confirm the practicality of the model and the algorithm.

■ TB-59

Tuesday, 10:30-12h00
B15-5

Topic Modeling and Information Retrieval

Stream: Machine Learning and Its Applications
Invited session

Chair: *Ivan Reyer*, Dorodnicyn Computing Centre of RAS, ul. Vavilova d. 42, k. 267, 119333, Moscow, Russian Federation, reyer@forecsys.ru

1 - A Bibliometric Analysis of Operations Research & Management Science
Jose M Merigo, Manchester Business School, University of Manchester, Booth Street West, M15 6PB, Manchester, United Kingdom, jose.merigolindahl@mbs.ac.uk, *Jian-Bo Yang*

Bibliometric analysis is the quantitative study of bibliographic material. It provides a general picture of a research field that can be classified by papers, authors, journals and countries. This paper presents a bibliometric overview of research published in operations research & management science during the last decades. Its main objective is

to identify some of the most relevant research in this field and some of the newest trends according to the information found in the Web of Science. The results obtained are in accordance with the usual assumptions although some variations are found.

2 - Hierarchical thematic model visualizing algorithm
Arsenty Kuzmin, MIPT, Russian Federation, senatormipt@gmail.com, *Vadim Strijov*, *Alexander Aduenko*

The talk is devoted to the problem of the thematic hierarchical model construction. One must to construct a hierarchcal model of a scientific conference abstracts, to check the adequacy of the expert models and to visualize hierarchical differences between the algorithmic and expert models. An algorithms of hierarchical thematic model constructing is developed. It uses the notion of terminology similarity to construct the model. The obtained model is visualized as the plane graph.

3 - Predictive topic modeling : Complex Networks approach using dynamics of authors's communities.
Karim Sayadi, Laboratoire Informatique des Systèmes Complexes, Ecole Pratique des Hautes Etudes, 41 Rue Gay Lussac, 75005, Paris, France, karim.sayadi@etu.ephe.fr, *Marc Bui*, *Michel Lamure*

We address the problem of predictive topic modelling in unstructured dataset of papers. We propose a model to highlight clusters of data with new set of topics in the healthcare field by using the dynamics of authors' communities. Our model combines a pretopological and a probabilistic framework to model the dynamics of the authors' communities in a constructed network of scientific papers. We applied Gibbs sampling to estimate the topic distributions and show that the extracted topics capture a meaningful structure in the data consistent with the keywords provided by the authors.

4 - Finding scientific article similarities by self-organizing maps
Pavel Stefanovič, Vilnius University, Institute of Mathematics and Informatics, Akademijos str. 4, LT-08663, Vilnius, Lithuania, pavel.stefanovic@mii.vu.lt

There are a lot of scientific articles in the Internet. When we are looking for specific area, we have to read a lot of articles to find some useful information. We suggest a way based on self-organizing map (SOM) to find the articles (text documents) similar to a selected one. A dictionary and text document matrix have to be created according to the selected article. A SOM is applied for clustering and visualization of the text document matrix. Similarities of scientific articles analyzed can be observed in the SOM results. Only similar articles to the selected one can be chosen for reading.

■ TB-60

Tuesday, 10:30-12h00
B15-7

Data Mining in Early Warning Systems 2

Stream: Data Mining in Early Warning Systems
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Fatma Yerlikaya Ozkurt*, Scientific Computing, Institute of Applied Mathematics, Industrial Engineering Department, Middle East Technical University, 06800, Ankara, Turkey, fatmayerlikaya@gmail.com
Chair: *Elcin Kartal Koc*, Statistics, Middle East Technical University, Department of Statistics, No:234, 06800, Ankara, Turkey, kartalelcin@gmail.com

1 - Georgian SME business development analysis: Case Study
Shorena Kalandarishvili, Economics, International School of Economics at Tbilisi State University, 26 Belinski Street, 0108, Tbilisi, Georgia, shorena.kln@gmail.com, *Levan Labadze*

Our paper will present business development difficulties faced by the small and medium enterprises (SMEs) in Georgia (former Republic), particularly for the firms operating in services sector. The analysis will be undertaken based on an example of a private firm for which we have created a mathematical model enabling us to draw conclusion in response to changes in real parameters and other relevant factors.

2 - The Influence of Financial Crisis on UK SMEs
Meng Ma, Business School, The University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, M.Ma-4@sms.ed.ac.uk, *Jake Ansell*, *Galina Andreeva*

This research analyses the influence of financial crisis on UK SMEs by tracking a large set of SMEs active in 2007 up to 2010. Besides cross-sectional method, panel dataanalysis is introduced to score SMEs. The data set is segmented by age due to the differences between start-up and non-startup performances. Regressors are chosen by stepwise logistic regressions to avoid strong co-linearity amongst initial 79 variables. To account for effect of the recession, macroeconomic factors have been included and these provide some evidence. Predictive accuracy measures are given for comparison.

3 - Using DTW for Clustering Time Series and Finding Leading Series
Efe Pınar, Koç University, Turkey, efepinar@ku.edu.tr, *Ozden Gur Ali*

The leading retail sales company in Turkey wants to forecast their category level sales across almost a thousand stores. We developed a two step method, which accounts for calendar and marketing mix effects in the first step. The resulting residuals reflecting cyclical irregular effects are used to cluster stores with Dynamic Time Warping distance. We explore using residuals of similar stores to provide better forecasts and to provide insights about unexpected trends.

4 - Incorporating measures of evolution of customer choice behavior in churn prediction
Andrey Volkov, Department of Marketing, Ghent University, Tweekerkenstraat 2, 9000, Gent, België, Belgium, volkovand@gmail.com, *Dirk Van den Poel*, *Anita Prinzie*

In this study we investigate the predictive power of the evolution of customer product choice in the context of customer churn models. In particular, we examine how changes in market baskets from multiple time periods impact the customer's propensity to defect. By analyzing and contrasting customer-specific association rules extracted from different periods we construct a set of variables measuring similarities and differences between market baskets. These variables are used as input in a classification model that predicts whether a customer with given characteristics is likely to churn.

■ TB-62

Tuesday, 10:30-12h00
R18-1

MINLP methods

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Claudia D'Ambrosio*, LIX, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, dambrosio@lix.polytechnique.fr

1 - Proximity Search for 0-1 Mixed-Integer Convex Programs
Matteo Fischetti, DEI, University of Padua, via Gradenigo 6/a, 35100, Padova, Italy, Italy, fisch@dei.unipd.it, *Michele Monaci*

Large-Neighborhood Search heuristics define a neighborhood of the incumbent by introducing invalid constraints into the formulation, and use a black-box solver to search the restricted problem.

In this talk we will address an alternative approach: instead of modifying the constraints of the model at hand with the aim of reducing search space, we modify its objective function with the aim of easing the search. We will computationally investigate the effects of replacing the objective function of a 0-1 Mixed-Integer Convex Program by a "proximity" one.

2 - Second Order Cone Models for Delay Constrained Routing
Antonio Frangioni, Dipartimento di Informatica, Universita' di Pisa, Largo B. Pontecorvo, 3, 56125, Pisa, Italy, frangio@di.unipi.it, *Laura Galli*

Many network applications (IPTV, VoIP) require both large bandwidth and stringent QoS guarantees. The corresponding Traffic Engineering procedures require to simultaneously compute paths and reserve resources along them, with delay bounds depending nonlinearly on the latter. In a single-flow single-path setting with affine arrival curves and leaky-bucket traffic shapers this can be formulated as a Mixed-Integer Second-Order Cone problem. We compare two models: one based on big-M constraints and an improved one where convex-envelope techniques are used to tighten the continuous relaxation.

3 - A new Hybrid Lagrangian-MILP approach for the unit commitment problem
Claudio Gentile, IASI-CNR, Viale Manzoni, 30, I-00185, Roma, Italy, gentile@iasi.cnr.it, *Marianna De Santis*, *Antonio Frangioni*

Unit Commitment is a fundamental MINLP problem in short-term electrical generation scheduling. Traditionally it has been approached either with Lagrangian techniques, that quickly provide good lower bounds, or by piecewise-linear approximations and MILP reformulations solved by MILP solvers, that quickly provide good feasible solutions. We present a new hybrid approach which combines the two methods, trying to exploit each one's strengths, by approximately solving the Lagrangian dual inside a well-chosen set of nodes of the B&B tree starting from the node LP dual optimal variables.

■ TB-63

Tuesday, 10:30-12h00
R18-2

Discrete Problems in Control Theory III

Stream: Operational Research and Control Problems
Invited session

Chair: *Alexander Lazarev*, Institute of Control Sciences, Profsoyuznaya st. 65, 117997 Moscow, Russia, 117997, Moscow, Russian Federation, jobmath@mail.ru

1 - Train scheduling problem on double-track railroad with single-track lines
Alexey Karpychev, Institute of Control Sciences, Russian Federation, karpich@gmail.com, *Alexander Lazarev*, *Maiia Laskova*

We have a double-track railroad with several single-track lines (some tracks are closed due to technical reasons). It is assumed that some maintenance works are performed during the planning horizon. The optimal train schedule, when every track is opened, is known. The objective is to find the train schedule for a new railroad with minimum deviations from the inital schedule for a railroad with opened tracks. We solve this problem as an integer programming problem. In the case when the railway is closed in one direction we suggest using the method of successive batching.

2 - The problem of train timetable change for the case of repair works
Alexander Lazarev, Institute of Control Sciences, Profsoyuznaya st. 65, 117997 Moscow, Russia, 117997, Moscow, Russian Federation, jobmath@mail.ru, *Elena Musatova*, *Evgeny Gafarov*

We consider the following railway scheduling problem. There are two stations connected by a double-track railway and a cyclic train timetable is given for movement on the road. Some segments of this road are closed (in one direction) for repair works during some time periods. It is necessary to construct the new schedule for train movement between stations which is the closest to the initial one by the value of the total completion time. We propose a special polynomial algorithm based on dynamic programming to solve this problem.

3 - Minimization of maximum lateness for railway system with tree-like topology
Dmitry Arkhipov, ORSOT, Institute of Control Sciences, Pervomayskaya str., 28a - 53, 141707, Dolgoprudny, Moscow, Russian Federation, miptrafter@gmail.com, *Alexander Lazarev*

The following scheduling problem is considered. There is a double-track railway system with tree-like topology. It is assumed that the schedule of passenger trains and the repairs-and-maintenance plan are known. Our goal is to construct the optimal schedule for cars and freight trains according to the Lmax criterion. Both the problem of long-term planning and that of operational planning are considered. We use the DPA algorithm to construct the optimal and the approximate solutions.

■ TB-64

Tuesday, 10:30-12h00
R18-3

Defence and Security V

Stream: Defence and Security
Invited session

Chair: *Ana Isabel Barros*, Military Operations, TNO, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - Transportation infrastructure protection: a temporal analysis with recovery times.
Stefano Starita, Kent Business School, University of Kent, United Kingdom, ss882@kent.ac.uk

Given the growing number of natural and man-made disasters in recent years, the problem of protecting transportation infrastructures is becoming more and more crucial. We propose a network model to identify the optimal allocation of security resources in a shortest path network. The model includes a temporal component to study the impact of network disruptions over time. Specifically, it accounts for recovery times associated with each disrupted component. The goal is to describe a transportation infrastructure in a more realistic way and obtain effective protection strategies.

2 - Biosecurity On-Ship: Prevention and Detection of and Response to Infectious Agents
Ezgi Uzel, SUNY Maritime College / Yeditepe University, 6 Pennyfield Ave., Throggsneck, 10465, Bronx, NY, United States, e_uzel3@yahoo.com, *Larry Howard, PhD*, *Carlos Jerome, PhD*, *Jameela Androulidakis*

The purpose of this paper is to demonstrate that security activities and processes,in particular the prevention and detection of and response to infectious agents onboard ships, contribute to a primary economic value in the supply chain.After discussing strengths and weaknesses of existing methods,the paper proposes an approach to improve both prevention and control of bio-terror infectious agents.

3 - A method for assessing internal processes of command and control systems using design and analysis of experiments
Fábio Nascimento, Engenharia Aeronáutica e Mecânica - Produção, Instituto Tecnológico de Aeronáutica, H9A, Apt 302, Campus do DCTA, APT 302, 12228610, SAO JOSE DOS CAMPOS, SP, Brazil, fabiosn@ita.br, *Denise Ferrari*

Military operations can be understood as a system (or a collection of systems) in which information, energy and material flow through various units that constitute a military force. We propose a method that establishes a connection between Systems Engineering and Mathematical Modeling, by mapping and modeling (using SysML diagrams and design of experiments) the processes in the context of military operations. We also develop metrics to evaluate the performance of such processes.

4 - Learning from the past: Analysing history to support UK Defence policy
Rachael Walker, Defence Science and Technology Lab, PO17 6AD, Fareham, United Kingdom, rlwalker@dstl.gov.uk, *Stevie Ho*, *Deborah Cheverton*, *David Richardson*

Historical analysis evolved to quantify some of the intangible factors of warfare, but over time has developed into a tool for providing reality checks to the UK Defence policy. HA has a reputation for robust analysis, providing a credible and independent aid to decision-making within MOD. HA has adapted to meet the needs of future defence environments; HA now incorporates techniques from single case studies to large-N statistical analysis. This paper will demonstrate the impact that the discipline has on UK Defence policy and planning, and will continue to have in the challenging times ahead.

■ TB-65

Tuesday, 10:30-12h00
R18-5

Portfolio Selection

Stream: Emerging Applications in Portfolio Selection and Management Science
Invited session

Chair: *Shijie Liu*, HERIOT-WATT UNIVERSITY, 47 SAUGHTON MAINS GARDENS, EH11 3QD, EDINBURGH, Lothian Region, United Kingdom, lsj19870904@gmail.com

1 - An Optimistic-Pesimistic Compromise Programming Model for Mutual Funds' Socially Responsible Portfolio Selection with Fuzzy Data
Blanca Pérez-Gladish, Economía Cuantitativa, University of Oviedo, Facultad de Economía y Empresa, avda. del Cristo s/n Oviedo Asturias, España, 33006, Oviedo, Asturias, Spain, bperez@uniovi.es, *Paz Mendez-rodriguez*, *Ana Garcia-bernabeu*, *María Rosario Balaguer Franch*

In this paper we propose a multicriteria portfolio selection model based on Compromise Programming which takes into account both, a financial and a non-financial dimension, the last one usually characterized by its ambiguous and/or uncertain nature. The proposed model is intended to be an individual investment decision making tool for mutual funds' portfolio selection taking into account the subjective and individual preferences of an individual investor.

2 - Impact of Luck on Performance Classification of Socially Responsible and Conventional Mutual Funds
Eva Kvasnickova, Department of Economics and Finance, Tor Vergata University, Via Columbia 2, Roma, Italy, Italy, ekvasnickova@gmail.com

We analyse performance of socially responsible (SR) equity mutual funds comparing them to conventional peers, looking not only at region-adjusted alpha at both portfolio and individual level, but also on how funds performed with vintage, how they learn with time and survivorship analysis. We estimate proportion of false-discoveries for SR and conventional funds across the regions. In 5 of 6 regions we evaluated false-discovery proportions higher for conventional funds, while SR funds appear to be more robust in performance-classification.

3 - Modeling stock market regime-switching dynamics with internet search query data
Oliver Kristen, BRU - Business Research Unit, ISCTE - University Institute of Lisbon, Av. das Forças Armadas, Edificio ISCTE, 1649-026, Lisboa, Portugal, Oliver_Kristen@iscte.pt, *José G. Dias*, *Sofia B. Ramos*

This paper investigates the relationship between stock volatility and web search query activity, for a sample of 36 salient European stocks between 2004 and 2011. We are extracting weekly data on stock tickers from the Google Search Volume Index (GSVI). Specifying a mixture version of the standard hidden Markov model, results indicate two regimes with distinct volatility patterns (high and low volatility). Model calibration yields three stock classes characterized by (mostly) idiosyncratic volatility shifts. We thereby gain notable evidence against the geographical clustering of stock markets.

4 - Effects of Tax on Investment Portfolios and Financial Markets Under Mixed Integer Stochastic Programming
Shijie Liu, HERIOT-WATT UNIVERSITY, 47 SAUGHTON MAINS GARDENS, EH11 3QD, EDINBURGH, Lothian Region, United Kingdom, lsj19870904@gmail.com

This paper investigates the effects of income tax on large scale portfolio optimization. A new numerical approach based on basic Greedy heuristics, in which integer and non-linear restrictions are considered simultaneously, is proposed. Quantitative effects of tax on portfolio management are tested and discussed in detail. A further study of price effects finds that market equilibrium are affected by relative as well as absolute tax rates. In theory, both governments and investors are better able to forecast how the markets will react to tax update in the short term.

■ TB-66

Tuesday, 10:30-12h00
R18-4

Optimization for Sustainable Development I

Stream: Optimization for Sustainable Development
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id

1 - Sustainable Production Planning of Multi-Product Seafood Production Planning Under Uncertainty
Tutiarny Naibaho, Mathematics, Quality University, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, tutiarny.naibaho@yahoo.com, *Intan Syahrini*, *Herman Mawengkang*

A multi-product fish production planning produces simultaneously multi fish products from several classes of raw resources. The sustainable production planning problem aims to meet customer demand subject to environmental restrictions. This paper considers the management which performs processing fish into several seafood products.The uncertainty of data together with the sequential evolution of data over time leads the sustainable production planning problem to a nonlinear mixed-integer stochastic programming.Direct search is used for solving the deterministic equivalent model.

2 - Sustainable Production Planning of Crude Palm Oil Industry under Uncertainty
Hendaru Sadyadharma, Grad.School of Env. Manag & Natural Resources, University of Sumatera Utara, PSL USU, 20155, Medan, North Sumatera Province, Indonesia, sadyadharmah@yahoo.com, *Herman Mawengkang*

There is a growing need for efficient production planning models that take into account the trade-off between return and environmental costs and therefore reduce the penalties paid for overcoming the pollution levels. This paper addresses a multi-objective stochastic programming model of the sustainable production planning of crude palm oil. The model takes into account conflicting goals such as return and financial risk and environmental costs. The uncertainty comes from the price of crude palm oil.

3 - A Model to minimize the spread of infectious disease based on social network
Firmansyah Firmansyah, Mathematics, University Muslim Nusantara, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, fnasution94@yahoo.com

The basic framework of epidemiology models were based on population wide random-mixing, but in practice each individual has a finite set of contacts to whom they can pass infection The dynamic of human contact can be considered as a potential point for predicting the spread of infectiuous disease. In this paper we consider the SIRS model. We include the dynamic of human social interaction and social distance in the model such that it would be possible to minimize the spread of the disease.

4 - Classification of real estate for execution of municipal functions

Egle Klumbyte, Department of Civil Engineering Technologies, Kaunas University of Technology, Krasevskio 30-25, LT-50280, Kaunas, Lithuania, egleklumbyte@gmail.com, *Raimondas Bliudzius*

Municipal real estate (RE) management becomes more and more important. However, municipalities face difficulties in classifying their assets in order to achieve more effective management due to the abundance of explicit legal acts and standards regulating RE allocation and requirements for executing feasibility functions of buildings. In order to increase the effectiveness of municipal RE management and simplify its classification, the authors present a functional RE classification scheme, define the requirements for buildings and determine buildings characteristics database.

■ TB-68

Tuesday, 10:30-12h00
R19-2

Dynamic Programming and its Applications 2

Stream: Discrete Optimal Control
Invited session

Chair: *Toshiharu Fujita*, Graduate School of Engineering, Kyushu Institute of Technology, 1-1 Sensui-cho, Tobata-ku, 804-8550, Kitakyushu, Japan, fujita@mns.kyutech.ac.jp

1 - Dynamic Programming with Quantifier Elimination

Akifumi Kira, Graduate School of Economics and Management, Tohoku University, 27-1 Kawauchi Aoba-Ku, 980-8576, Sendai, Japan, kira-ra-6890@kyudai.jp, *Hidenao Iwane*, *Hirokazu Anai*

DP is a technique for breaking down a large problem into a sequence of much smaller parametric problems. However, how can we handle problems involving continuous parameters? As a symbolic method, quantifier elimination (QE) for real closed fields has been studied in the field of computer algebra. QE obtains the exact optimal value function in polynomial parametric optimization. But the use of QE is restricted to small problems due to its complexity. Hence, we see that DP and QE compensate each other. Our collaboration scheme leads a successful solution for DP problems described as polynomials.

2 - A stochastic and dynamic approach for maintenance planning with multiple machines

Raha Akhavan-Tabatabaei, Departamento de Ingeneria Industrial, Universidad de los Andes, ML-711, Bogota, Colombia, r.akhavan@uniandes.edu.co, *Luis Annear*, *Verena Schmid*

We consider a set of machines that degrade or fail over time due to usage and are maintained or repaired by a group of technicians with distinct skill sets. Maintaining a machine before it fails is assumed to be less costly than repairing it after failure. The behavior of this system is governed by random time to failure, usage-based but random degradation and random time for repair or PM and is modeled as a Markovian process. We propose to solve this problem via Approximate Dynamic Programming and show that the total costs can be reduced by 21% compared to non-dynamic policies.

3 - Hybrid synchronisation of different hyperchaotic systems using adaptive control

Sudipta Chakraborty, Electrical Engineering, B.P.Poddar Institute of Mgmt. & Tech., West Bengal, India, Kolkata, West Bengal, India, sudipta_ch1@rediffmail.com

This article deals with hybrid synchronisation of different hyperchaotic systems using adaptive control. Adaptive control techniques are extremely effective for real life systems which are prone to parameter uncertainties and disturbance. In hybrid synchronization of master and response systems, the odd states of the two systems are completely synchronized, while their even states are anti-synchronized. The stability results derived in this paper are proved using Lyapunov stability theory. Numerical simulation results are carried out using MATLAB.

■ TB-69

Tuesday, 10:30-12h00
R19-3

OR for Development and Developing Countries 2

Stream: OR for Development and Developing Countries
Invited session

Chair: *Honora Smith*, Academic Unit of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, honora.smith@soton.ac.uk
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Providing a Road Map to Improve Innovation Performance of the Countries through Bayesian Nets

Esma Nur Cinicioglu, School of Business, Quantitative Methods Department, Istanbul University, Istanbul Universitesi, Isletme Fakultesi, Sayisal Yontemler Anabilim Dali, 34320, Istanbul, Turkey, esmanurc@istanbul.edu.tr, *Sule Onsel Ekici*, *Fusun Ulengin*, *Gündüz Ulusoy*

This study serves as a a road map to policy makers in their attempt to develop strategies for improving the innovation level of their country. With that purpose, first a cluster analysis is performed and then a Bayesian network is constructed using 2010-2012 period performance of 148 countries for 22 pillars and subpillars reported on the World Economic Forum's Global Competitiveness Report. Using the Bayesian net constructed, the dependency structure between the variables is analyzed and sensitivity analysis is performed to reveal relevant policies for countries' innovation performance.

2 - Feature Selection for Bank Bankruptcy: The Case of Turkish Bank

Soner Akkoç, Banking and Finance, Dumlupınar University, Dumlupınar Üniversitesi Uygulamalı Bilimler Yüksekokulu Evliya Çelebi Yerleşkesi, 43100, Kütahya, Turkey, akkocsoner@hotmail.com

Bank bankruptcies are crucial for country economies. Machine learning techniques have been applied effectively to predict the bank bankruptcies. Feature selection is one of the substantial steps in developing prediction models. This paper aims to identify features with high representative power to evaluate the bankruptcy risk of Turkish Banking Sector. Following the identification of the best representative features, prediction models will be developed by applying ANN and ANFIS. The paper also presents which feature selection method is more successful in prediction of bank bankruptcy.

3 - Future development of power markets based on prospective and system dynamics. methodology approach: colombian case

Miguel David Rojas Lopez, Universidad Nacional de Colombia, carrera 80 # 65-223 M8b-105, Medellin, Antioquia, Colombia, mdrojas@unal.edu.co, *Laura Londoño*, *Lina Maria Bastidas*

This paper studies power markets and complex variables such as power energy demand and supply that have high impact in markets. Methodologies are applied to analyze current developments and to consider qualitative aspects that may impact them. A methodological approach that combines prospective, indicators and system dynamics is done to predict power markets in medium and long term, illustrating this methodology with cases of Colombia and other countries. The dynamic model is useful for making timely decisions to expand the capacity in generation and transmission of power energy in 20 years.

4 - Industrial heritage as an educational polygon for development strategies
Vladimir Hain, Institute of History and Theory of Architecture and Monument Restoration, Slovak university of technology, Faculty of architecture, Námestie slobody 19, 812 45, Bratislava, Slovakia, Slovakia, vladimirhain@gmail.com

Industrial heritage provides one of the most important records on development of cities and towns during the last two centuries. Conservation of the industrial heritage is a necessary aspect of a city development. The basic purpose of the "Educational polygon" is to develop a model and operational tools, to raise the awareness of the importance of technological history, to stimulate social, economical and political decisions. Polygon is a tool for identifying potential industrial heritage, serving as an effective tool for communication and education in the width of the optimization process.

■ TB-70

Tuesday, 10:30-12h00
R19-4

EURO Journal on Decision Processes 1

Stream: Journals
Sponsor session

Chair: *Ahti Salo*, Systems Analysis Laboratory, Aalto University School of Science and Technology, P.O. Box 11100, Otakaari 1 M, 00076, Aalto, Finland, ahti.salo@aalto.fi

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■ TB-71

Tuesday, 10:30-12h00
R16-1

Health Care Management (Financial Management)

Stream: Health Care Management
Invited session

Chair: *Angela Testi*, Department of Economics and Quantitative Methods (DIEM), University of Genova, Facolta di Economia, via Vivaldi 5 -16126, 16126, Genova, Italy, testi@economia.unige.it

1 - The Intermediary Roles of Group Purchasing Organizations (GPOs) in the Healthcare Supply Chain
Vera Tilson, University of Rochester, 14627, Rochester, United States, vera.tilson@simon.rochester.edu, *Abraham Seidmann*, *Rajib Saha*

Manufacturers of expensive medical devices are secretive about pricing, which makes price benchmarking difficult for hospital buyers. These buyers are often being measured by the savings they negotiate relative to the manufacturers' list prices or to the GPO-negotiated discounted prices. We present a game theoretic model that explains why, contrary to perceived wisdom, these two benchmarks are grossly misleading. We also explain why hospitals are better off joining a GPO that forbids contract re-negotiation beyond the GPO discounted price list.

2 - Evaluating different copayment scenarios using an agent based simulation model
Michele Sonnessa, Department of Economics and Quantitative Methods (DIEM), University of Genova, Italy, sonnessa@gmail.com, *Angela Testi*, *Elena Tanfani*

Some forms of co-payment are required in health systems both to avoid moral hazard and consequent excessive consumption as well as to help in financing increasing health expenditure. Literature and empirical findings do not agree about the final impact of co-payments, in particular on system sustainability and equity attainment. In this context we propose an agent-based simulation model intended to be a tool for decision makers to compare different co-payment scenarios. The proposed approach allows to mix empirical data with theoretical assumptions about individual behavior and preferences.

3 - KeyPathwayMiner: Detecting Case-Specific Biological Pathways Using Expression Data
Hande Kucuk, Computer Science, University of Miami, United States, handek@cs.miami.edu

There exists massive amounts of pathway data that describe the interplay of genes and their products. These biological networks can be modeled as graphs. Here, we introduce KeyPathwayMiner, a method that enables the extraction and visualization of interesting subpathways by using gene expression studies. We aim to detect highly connected subnetworks in which most genes or proteins show similarly in all similarly in all but l cases in the gene expression data. Since identifying these subgraphs is computationally intensive, we developed a heuristic algorithm based on Ant Colony Optimization.

■ TB-72

Tuesday, 10:30-12h00
R16-2

Stochastic Models in Health Care

Stream: OR in Health & Life Sciences (contributed)
Contributed session

Chair: *Reza Noubary*, Mathematics, Bloomsburg University, 17815, Bloomsburg, PA, United States, rnoubary@bloomu.edu

1 - Screening Policies for Alzheimer's Disease
Zehra Önen, Koç University, Turkey, zonen@ku.edu.tr, *Serpil Sayin*

Alzheimer's disease (AD) is the most common type of dementia and is predicted to have a growing number of persons that will be suffering from it in the next decades. While currently there is no known cure for AD, research suggests that early intervention may slow down disease progress. The aim of this work is to investigate the applicability of Markov decision process-based screening models to this disease. Related costs and quality of life trade-offs will also be discussed.

2 - Optimal Observation Times for a Partially-Observable Pure Birth Process
Ali Eshragh, School of Mathematical Sciences, The University of Adelaide, North Terrace Campus, 5005, Adelaide, South Australia, Australia, ali.eshraghjahromi@adelaide.edu.au

Our goal is to estimate the rate of growth of a population governed by a pure-birth process. For this purpose, we choose n observation time points at which to count the number of individuals present, but due to detection difficulties, or constraints on resources, we may observe them partially, that is, we are able only to observe each individual with a fixed probability p. We discuss the optimal times at which to make our n observations in order to maximize the volume of information obtained from those observations. We present both theoretical and numerical findings.

3 - Appointment capacity planning in specialty clinics with no-shows and cancellations: a queueing approach
Navid Izady, University of Southampton, United Kingdom, n.izady@soton.ac.uk

Specialty clinics provide specialized and often complex care for patients who have been seen and referred by primary care physicians. In this study, we develop two novel queueing models for performance evaluation of clinics in the presence of no-shows and hospital cancellations. Using illustrative as well as real data, we demonstrate how the models could be used for studying the joint impact of no-show probability, service and referral variability. We also present some counter-intuitive results with regards to the impact of no-shows on systems with constant traffic internsity.

4 - Training Support Vector Machines by Using Particle Swarm Optimization and a Bone Age Example
Hüseyin Haklı, Computer Engineering, Selçuk University, 42151, Konya, Turkey, hhakli@selcuk.edu.tr, *Gür Emre Güraksın*, *Harun Uğuz*
In this study we recommend a training algorithm for the support vector machines (SVM) by using Particle Swarm Optimization (PSO). By using PSO, we acquired a new training instance which represents the training set of the related class.These new instances of the classes are generated from the training set of the related classes.The performance of the proposed approach is demonstrated with a bone age data set and compared with the standard linear SVM.The classification results show us, better classification accuracy can be achieved by using the proposed method.

■ TB-73

Tuesday, 10:30-12h00
R16-3

OR in Agriculture II

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *Victor M. Albornoz*, Departamento de Industrias, Universidad Tecnica Federico Santa Maria, Av. Santa Maria 6400, 6671219, Santiago, Chile, victor.albornoz@usm.cl

1 - Game theory concepts and spatial changes in the Brazilian agriculture
Fernando L. Garagorry, Strategic Management, Embrapa, CP 2247, 70343-970, Brasilia, DF, Brazil, fernando.garagorry@embrapa.br
The evolution of the Brazilian agriculture, over the last four decades, has shown substantial changes in the geographical distribution of many products, and the study of that mobility (under the general name of "agrodynamics") is the subject of on-going research. The present work shows the initial results of the application of some game-theoretical concepts, generally referred to as indices of power, as auxiliary techniques to identify those years where some relatively important territorial change took place. The results for several crops and animal products are presented.

2 - Analysis of a Revenue-Sharing Contract with a Payment Guarantee in A "Firm + Farmers" Agribusiness Model
Kekun Wu, Management Sciences, City University of Hong Kong, Department of Management Sciences, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, wukekun@gmail.com, *Yanzhi Li*, *Ke Fu*
Motivated by a major agricultural firm's practice in China, we consider an agribusiness model called "firm+farmers", which have attracted growing attention from the industry, government, and the farmers in developing economies. The firm offers contracts to a group of farmers who decide to accept or reject based on their expected returns and risks. The contract retains a revenue sharing mechanism, and guarantees a minimum payment, which distinguishes our model from previous works. We analyze the optimal supply chain decisions under such contracts and derive managerial insights.

3 - Application of cellular automata for analysis of land use cover change
Francisco Javier Sahagún Sánchez, Políticas Públicas, Universidad de Guadalajara, Periférico Norte N 799. Núcleo Universitario Los Belenes, ND, Zapopan, Jalisco, Mexico, momotus@gmail.com
The land use cover change is a major environmental problem that treats ecosystems integrity. Therefore the analysis of trends and future change in land use are of focal importance to ensure sustainable development. In this work we used cellular automata to analyze the processes of land use cover change and generated scenarios of future change in central region of Mexico. This allowed us to determine vulnerable areas based on socio-economic and governance variables to support the process of decision making and develop better public policy.

4 - An optimization model for determining agricultural management zones
Victor M. Albornoz, Departamento de Industrias, Universidad Tecnica Federico Santa Maria, Av. Santa Maria 6400, 6671219, Santiago, Chile, victor.albornoz@usm.cl, *Néstor Cid-García*, *Rodrigo Ortega*, *Yasmin Rios-solis*
A methodology that combines the use of precision agriculture and optimization for determining cultivation zones that are homogeneous in terms of soil properties is presented. More precisely, the method consists in using precision agricultural information considering various chemical properties of the soil, from which a given set of potential land sections is generated, and from them an optimum subset is selected using an integer programming model that guarantees a partition of the land. The results achieved, conclusions, and extensions of this research are presented.

■ TB-74

Tuesday, 10:30-12h00
R16-4

EEPA Finalists

Stream: Prizes
Invited session

Chair: *Daniele Vigo*, DEIS, University of Bologna, Via Venezia 52, 47023, Cesena, Italy, daniele.vigo@unibo.it

1 - Medium-Term Rail Scheduling for an Iron Ore Mining Company
Gaurav Singh, Mathematics, Informatics & Statistics, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Private Bag 33, 3169, South Clayton, Victoria, Australia, Gaurav.Singh@csiro.au, *Rodolfo Garcia-Flores*, *Andreas Ernst*, *Palitha Welgama*, *Meimei Zhang*, *Kerry Munday*
In mineral supply chains, medium-term plans are made for scheduling crews, production, and maintenance. These plans must respect a number of constraints and compliance with grade quality depends on blending minerals from different sources. In this paper, we present an optimization tool developed for a major multinational iron ore mining company to manage the operations of its supply network in the Pilbara region of Western Australia. The plans our tool produces allow the company to ship a higher amount of iron ore than it did when it followed the plans obtained by its former manual approach.

2 - Geometric Clustering for the Consolidation of Farm- and Woodland
Peter Gritzmann, Mathematics, TU München, Arcisstr. 21, D-80290, Munich, Germany, gritzman@ma.tum.de, *Andreas Brieden*, *Steffen Borgwardt*
In many regions farmers cultivate a number of small lots that are distributed over a wider area. This results in a non-favorable cost structure of production. We developed a new mathematical model, where in effect the centers of the clusters are pushed apart. The analysis of the mathematical structure of the model provided proof of its favorable properties (existence of feasible power diagrams) and allowed the derivation of efficient approximation algorithms (based on the approximation of certain semi-norm level sets by polytopes) with a provably small error bound.

3 - SPRINT: Optimization of Staff Management for Desk Customer Relations Services
Daniele Vigo, DEIS, University of Bologna, Via Venezia 52, 47023, Cesena, Italy, daniele.vigo@unibo.it, *Claudio Caremi*, *Angelo Gordini*, *Sandro Bosso*, *Giuseppe D'Aleo*, *Beatrice Beleggia*
We illustrate a Decision Support System for Staff Management of Desk Customer Relation Services (DCRSs). The system, called SPRINT, incorporates state-of-the-art forecasting and optimization methods has been developed for a large multi-utility company in northern Italy that manages a large network of DCRS. After two year of service SPRINT has achieved very high level of service and introduced relevant savings in terms of resource consumption devoted to DCRSs.

Tuesday, 12:30-14:00

■ TC-03

Tuesday, 12:30-14:00
O1-3

Novel opportunities of Nonconvex Programming for Industry and Finance

Stream: Nonconvex Programming: Local and Global Approaches
Invited session

Chair: *Nguyen Viet Hung*, University Paris 6, LIP6, 4 Place Jussieu, 75252, Paris, France, hung.nguyen@lip6.fr

1 - Objective-oriented tracking of potentially threatening targets
Frédéric Dambreville, DGA, 16bis Av. Prieur de la Cote d'Or, 94110, Arcueil, France, submit@fredericdambreville.com

Tracking methods associate measures into tracks, thus building a synthetical image of the theatre. Classical tracking maximizes the global likelihood. This is reliable when the probabilistic models are known and the measure frequency is sufficient. These hypotheses are not always fulfilled, especially when dealing with threatening targets. Then, it is necessary to consider complementary prior informations implied by potential theatre vulnerabilities. This paper addresses such problem which takes the form of non-convex dynamic optimization.

2 - Metaheuristic cooperative resolutions for the integrated problem of qc-agv-asc planning in automated maritime terminal
Hamdi Dkhil, UFRST, University Of Le Havre, 25 rue Philippe Lebon, 76600, Le Havre, France, dkhil_hamdi@yahoo.fr, *Adnan Yassine*, *Habib Chabchoub*

In our works we propose a new mathematical model and cooperative algorithms of QC-AGV-ASC (Quay Crane — Automated Guided Vehicle — Automated Stacking Crane) planning, the problem of tasks in an automated container terminal. We consider the import case. Our objective is to minimize the operating cost. We evaluate the handling cost using three elements: the number of used AGVs, the number of used ASCs, the makespan and the number of unproductive moves caused by the container location decisions. We developed a multi-thread cooperative metaheuristic resolutions.

3 - On the Solution of a Graph Partitioning Problem under Capacity Constraints
Nguyen Viet Hung, University Paris 6, LIP6, 4 Place Jussieu, 75252, Paris, France, hung.nguyen@lip6.fr, *Pierre Bonami*, *Michel Minoux*

We study a variant of the graph partitioning problem where the weight of a cluster in the partition depends on the edges incident to its nodes. This problem was first proposed in the context of optical networks design. We recall complexity results and establish new inaproximability results. We then study several mixed integer quadratic programming formulations for the problem and different solutions techniques. We present experimental results comparing the various formulations and solution techniques.

■ TC-04

Tuesday, 12:30-14:00
O4-4

Fractional Programming and Applications

Stream: Mathematical Programming
Invited session

Chair: *Tunjo Perić*, Department of Mathematics, University of Zagreb, Faculty of economics and business, Trg J. F. Kenedya 6, 10000, Zagreb, Croatia, tperic@efzg.hr

1 - Vendor Selection and Determination of Supply Quotas by using Revised Weighting Method and Multiple Objective Linear Fractional Programming Techniques
Tunjo Perić, Department of Mathematics, University of Zagreb, Faculty of economics and business, Trg J. F. Kenedya 6, 10000, Zagreb, Croatia, tperic@efzg.hr

This paper proposes a new methodology for vendor selection and supply quotas determination. The proposed methodology includes the revised weighting method and multiple objective linear fractional programming model. The folowing criteria for vendor selection and quantities supplied by individual vendors has been used: (1) product quality and purchase costs ratio, and (2) vendor's reliability and purchase cost ratio. The proposed methodlogy has been tested on the example of flour purchase by a company that manufactures bakery products and solved by using goal programming techniques.

2 - Financial Structure Optimization by Using Multiple Objective Fractional Linear Programming Methods
Zoran Babic, Quantitative methods, Faculty of Economics, Cvite Fiskovica 5, 21000, Split, Croatia, babic@efst.hr

Financial structure optimization is a multi-criteria problem, where the criteria functions are fractional linear, and the constraints are linear. For solving such problems we can use different multiple objective fractional linear programming (MOFLP) methods. However, different methods have different efficiency in solving those problems. In this paper we investigate the efficiency of the satisfactory goals method, STEM method and goal programming method on the example of a company's financial structure optimization problem.

3 - Solving multiple objective fractional linear programming models by using goal programming techniques
Jadranka Kraljević, Mathematics, Faculty of Economics, University of Zagreb, Trg J.F.Kennedya 6, 10000, Zagreb, Croatia, jkraljevic@efzg.hr

Solving multiple objective fractional linear programming models by using goal programming techniques is connected with some computational problems, because in this case we have to solve a mathematical programming problem which contains nonlinear constraints. To resolve this difficulty we discuss the use of two known fractional linear function linearization techniques: (1) linearization by Taylor series approach and (2) linearization by revised Kornbluth — Steuer's approach. The efficiency of the approach is illustrated on several examples.

4 - Feed blend optimization by using a multiple objective programming model
Vedran Horvatic, Department of Mathematics, Faculty of Economics, University of Zagreb, 10000, Zagreb, Croatia, vhorvatic@efzg.hr

The main purpose of this work is to propose a new model for feed blend optimization. We propose a set of criteria functions for building a model some of which are fractional and some are linear functions. The proposed methodology has been tested on the example of the feed blend optimization model for growing pigs.

■ TC-05

Tuesday, 12:30-14:00
O4-1

Economic Modeling

Stream: Optimal Control
Invited session

Chair: *Stefan Wrzaczek*, University of Vienna, Argentinierstr. 8, 1. Stock (ORDYS), 1040, Vienna, Austria, stefan.wrzaczek@tuwien.ac.at

1 - Theory of parametric control of macroeconomic systems
Abdykappar Ashimov, Parametric Regulation, Kazakh National Technical University named after K. Satpayev, 22 Satpaev str., 050013, Almaty, Kazakstan, Ashimov37@mail.ru, *Yuriy Borovskiy*, *Bakhyt Sultanov*, *Bakytzhan Aisakova*
The paper presents a theory of parametric control of macroeconomic systems, and its mathematic, algorithmic basis. Effectiveness of the theory has been shown on various classes of models. The difference of this theory from the existing is that it uses mathematic models which have properties of structural stability, and/or stability of a mapping which is defined by model, and/or acceptable values of stability indicators. The theory also applies a dependence of the solution of variational problem on uncontrollable factors for macroeconomic analysis and recommendations for economic policy-making.

2 - Less than exponential growth with non-constant discounting
Francisco Cabo, Universidad de Valladolid, 47011, Valladolid, Spain, pcabo@eco.uva.es, *Guiomar Martin-Herran*, *Maria Pilar Martinez-Garcia*
Due to decreasing returns to scale (DRS), indefinite constant growth rates are not feasible in the Neoclassical Solow-Swan model. Only under the assumptions of null depreciation, constant population and no-discounting, positive but ever-decreasing growth rates are feasible. For a two-sector R&D-endogenous growth model with DRS, we characterized less than exponential growth (LEG), by positive growth rates tending to zero less rapidly than O(-1), hence by unbounded growth. LEG is feasible with non-constant time-preference rates (hyperbolic discounting) and sophisticated consumers.

3 - Optimal Control of Investments in the Capital Generating Sector in the Dynamical Model of a Three-Sector Economy
Veronika Pisarenko, Higher Mathematics, Moscow State Institute of Electronics and Mathematics Higher School of Economics, Bolshoy Trehsvyatitelsky lane, 3, 109028, Moscow, Russian Federation, pisarenkoveronika@gmail.com, *Peter Shourkoff*
The optimal control problem for an economic system whose behavior is described by the dynamical model of a three-sector economy is considered. For the state parameters of the system we take the capital-labor ratio functions in each sector and for the control parameter we take the amount of specific investments in the capital generating sector. The solution of the optimal control problem under consideration is based on the Pontryagin maximum principle. Analytic solutions of the systems of differential equations for the state variables and the conjugate variables are obtained.

4 - Optimal firm growth under the threat of entry
Stefan Wrzaczek, University of Vienna, Argentinierstr. 8, 1. Stock (ORDYS), 1040, Vienna, Austria, stefan.wrzaczek@tuwien.ac.at, *Peter M. Kort*
We consider the dynamics of a switch from a monopolistic to a duopolism. The model will be analyzed with various different assumptions. With the analysis it is possible to learn the optimal behavior before the change in the market structure. Comparing the results to the situation without switch, provides interesting economic insights that go beyond the knowledge from static and two-period models. It is possible to deal with important questions: Is it optimal to increase the capital stock before the market change? Should a firm influence the competitors decisions before the switching time?

■ TC-06

Tuesday, 12:30-14:00
O4-2

Nonsmooth optimization in logistics and production

Stream: Nonsmooth Optimization
Invited session

Chair: *Albert Ferrer*, Dpt. of Applied Mathematics I, Technological University of Catalonia, Av. Doctor Marañon, 44-50, 08028, Barcelona, Catalunya, Spain, alberto.ferrer@upc.edu

1 - Green Horizontal Cooperation with Nonsmooth Objective Functions in Multicriteria Decision Making
Javier Faulin, Department of Statistics and OR, Public University of Navarre, Los Magnolios Builing. First floor, Campus Arrosadia, 31006, Pamplona, Navarra, Spain, javier.faulin@unavarra.es, *Angel A. Juan*, *Elena Perez-Bernabeu*, *Nicolas Jozefowiez*
We propose a multicriteria problem of horizontal cooperation having objective functions with nonsmooth characteristics (the costs cannot be described by functions with derivatives), whose constraints are associated to the control of pollutant emissions. Usually, the objective functions have several components, with penalties linked to the lack of consideration of environmental criteria. We analyze this problem providing suitable solutions which can be applied in a practical case.

2 - Randomized algorithms for solving routing problems with non-smooth objective functions
Albert Ferrer, Dpt. of Applied Mathematics I, Technological University of Catalonia, Av. Doctor Marañon, 44-50, 08028, Barcelona, Catalunya, Spain, alberto.ferrer@upc.edu, *Angel A. Juan*, *Sergio Gonzalez*, *Helena Ramalhinho*
The main idea of this presentation is that combining a heuristic biased randomization can be a natural and efficient way to deal with realistic arc routing problems under more complex scenarios dominated by non-smooth/non-convex objective functions and non-convex regions. Thus, we propose an algorithm which pertains to the class of nondeterministic or stochastic methods and relies on non-uniform and non-symmetric random sampling.

3 - Solving Stochastic Inventory Routing Problems with Nonsmooth Objective Functions
Angel A. Juan, Computer Science, Open University of Catalonia, Rambla Poblenou, 156, 08018, Barcelona, Spain, ajuanp@gmail.com, *Jose Caceres Cruz*, *Scott Grasman*, *Tolga Bektas*
We present an algorithm for solving the Inventory Routing Problem with stochastic demands and stock-outs, which makes the resulting objective function a non-smooth one. The algorithm considers alternative inventory policies for each retailing center, computes their expected inventory costs based on the probabilistic demands of customers, and estimates the routing costs associated with each center-policy combination. This way, alternative inventory policies are sorted for each retailing center. Then, a meta-heuristic is used to find high-quality solutions.

4 - Improved hybrid quasisecant and simulated annealing method for global optimization
Qiang Long, School of Science, Information Technology & Engineering, University of Ballarat, 16 Platypus Dr, Mount Clear, 3350, Ballarat, VIC, Australia, 27131375@qq.com, *Adil Bagirov*
In this presentation, our aim is to design an algorithm for solving global optimization problems subject to box constraints. The proposed is based on the combination of the quasisecant and simulated annealing methods. We apply the simulated annealing method to improve global search properties of the quasisecant method. More specifically, the simulated annealing method is applied to accept or reject points generated by the quasisecant method if none of these points are better than the current iteration. Numerical results are presented to demonstrate the efficiency of the proposed algorithm.

■ TC-07

Tuesday, 12:30-14:00
O4-3

Copositive and Semidefinite Optimization for Coping with Uncertainty

Stream: Copositive and Polynomial Optimization
Invited session

Chair: *Karthik Natarajan*, Singapore University of Technology and

Design, 138682, Singapore, Singapore,
natarajan_karthik@sutd.edu.sg

1 - On Reduced Semidefinite Programs for Order Statistics

Karthik Natarajan, Singapore University of Technology and Design, 138682, Singapore, Singapore, natarajan_karthik@sutd.edu.sg, *Chung Piaw Teo*, *Vinit Kumar Mishra*

In this paper, we derive the tightest upper bounds on the expected maximum value and the expected range of a set of random variales with mean, variance and covariance information using a semidefinite optimization approach. Our main contribution is to show using the theory of positive semidefinite and completely positive matrices, that the standard semidefinite programs to compute the tightest bounds in these instances can be significantly reduced in size, making the formulations more compact and amenable for large scale computation

2 - Procurement with Price and Demand Uncertainty - A Copositive Programming Approach

Chung Piaw Teo, National University of Singapore, 117592, Singapore, Singapore, bizteocp@nus.edu.sg, *Qi Fu*, *Chee Khian Sim*

We consider a single period robust procurement problem of using option contracts with dynamic execution price, and a random spot market to meet the uncertain demand. The exact distribution of demand and spot price is unknown, except for the moments, such as the means, variances and covariances. We show that the problem can be formulated as a copositive programming problem. A closed-form solution for the single contract case is derived, and interestingly, the robust solution is independent of the price-demand correlation. This is joint work with Qi Fu (Macau) and Chee Khain Sim (NUS).

3 - Large Scale Choice Prediction with Correlations Among Alternatives

Xiaobo Li, Engineering Systems and Design, Singapore University of Technology and Design, 20 Dover Drive, 138682, Singapore, Select State/Province, Singapore, li_xiaobo@sutd.edu.sg, *Selin Damla Ahipasaoglu*, *Karthik Natarajan*

The Multinomial Probit choice model accounts for correlations among utilities of alternatives. The utilities are assumed to be multivariate normal with known mean and covariance matrix. Recently, Mishra, Natarajan and Teo (2012) proposed a Cross Moment Model that assumes the mean and covariance information and relaxes the assumption of normality. Choice prediction is done with semidefinite optimization. In this work, we develop new choice prediction methods for the Cross Moment Model. This allows us to handle data sets of much larger size than with semidefinite optimization.

4 - Unsupervised Automatic Categorization using Sparse PCA

Selin Damla Ahipasaoglu, Engineering Systems and Design, Singapore University of Technology and Design, 20 Dover Drive, 138682, Singapore, Select State/Province, Singapore, ahipasaoglu@sutd.edu.sg, *Ngai-Man Cheung*, *Peter Richtarik*, *Martin Takac*

The unsupervised visual object categorization problem attempts to uncover the category information of a given image database without relying on any information on the image content. We develop a novel technique based on Sparse PCA, which uses the first few sparse principal components to pick up object categories. Our experiments show that this technique has great potential in selecting the categories correctly. We solve the Sparse PCA problem with an alternative maximization algorithm, and show that this outperforms the DSPCA algorithm, which is an SDP relaxation of the Sparse PCA problem.

■ TC-08

Tuesday, 12:30-14:00
O3-2

Tutorial - H.A. Le Thi

Stream: Invited Lectures - Keynotes and Tutorials
Tutorial session

Chair: *Jérémie Gallien*, London Business School, NW1 4SA, London, United Kingdom, jgallien@london.edu

1 - Difference of Convex Functions Optimization: Theory, Algorithms and Applications

Hoai An Le Thi, Computer Science, University of Lorraine, Ile du Saulcy,, 57 045, Metz, France, hoai-an.le-thi@univ-lorraine.fr

DC (Difference of Convex functions) Programming and DCA (DC Algorithms), which constitute the backbone of Nonconvex Programming and Global Optimization, were introduced by Pham Dinh Tao in their preliminary form in 1985 and extensively developed by Le Thi Hoai An and Pham Dinh Tao since 1994 to become now classic and increasingly popular (see for example http://lita.sciences.univ-metz.fr/ lethi/). Their popularity resides in their robustness, inexpensiveness, flexibilty, versatility and performance compared to existing methods, their adaptation to specific structures of addressed problems and their ability to solve real-world large-scale nonconvex programs.

DC Programming and DCA address the problem of minimizing a function f which is the difference of two convex functions on the whole finite dimensional Euclidean space X or on a convex set C contained in X. If f = g-h then g-h is a DC decomposition of f and g, h DC components of f. DC Programming is a natural and logical extension of Convex Programming, sufficiently large to cover almost all nonconvex programs but not too in order to use the powerful arsenal of modern Convex Analysis and Convex Optimization. The set of DC functions on X, denoted DC(X), is the smallest vector space containing the "convex cone" C(X) of lower semicontinuous proper convex functions on X. DC(X) is large enough to contain most real-life objective functions and is stable with respect to usual operations in optimization.

DC programming investigates the structure of DC(X), DC duality and local and global optimality conditions for DC programs. A dual DC program, defined with the help of the conjugate functions g*, h* of g and h respectively, is the minimization of h*-g* on X. Relations between local/global solutions of primal and dual DC programs are quite simple. The complexity of DC programs clearly lies in the distinction between local and global solution and, consequently, the lack of verifiable global optimality conditions.

DCA is based on DC duality and local optimality conditions. The philosophy of DCA is to bring back DC(X) to C(X): solving a DC program by as sequence of approximate convex subprograms.

DCA's distinctive feature relies upon the fact that DCA deals with the convex DC components g and h but not with the DC function f itself. Moreover, a DC function f has infinitely many DC decompositions which have crucial implications for the qualities (speed of convergence, robustness, efficiency, globality of computed solutions, ...) of DCA.

DCA is a descent method without linesearch (so very appreciated in large-scale problems) but with global convergence. Remark that with appropriate DC decompositions, DCA permit to recover, as special cases, most standard algorithms in Convex/Noncovex Programming.

These theoretical and algorithmic tools have been successfully used by many researchers and practitioners to model and solve their nonconvex programs in different fields of Applied Sciences.

Extension of DCA to DC programs with DC constraints by using penalty techniques/ linearizing DC constraints (as in DCA for standard DC programs) with updating penalty parameter, exact penalty and error bounds in DC programming, DC relaxation for lower bounding in Branch-and-Bound techniques applied to DC programming, have been constantly investigated during the last decade.

This tutorial on DC programming and DCA will be comprised of four parts. First we outline basic theoretical and algorithmic tools for an easy understanding of the DC Programming and DCA's philosophy, while in the second part we show how to solve several classes of hard problems in Combinatorial Optimization and Operations Research by DC Programming and DCA. The third one is devoted to applications of these theoretical and algorithmic tools for modelling and solving some

real world nonconvex programs in Machine Learning, Image processing, Communication Systems, Finance, Transport-Logistic and Supply Chain Management. Finally, we discuss about some open issues in DC programming and DCA.

■ TC-09

Tuesday, 12:30-14:00
O3-3

Sponsor - FICO 1

Stream: Sponsors
Sponsor session

Chair: *Giovanni Felici*, Istituto di Analisi dei Sistemi ed Informatica, Consiglio Nazionale delle Ricerche, Viale Manzoni 30, 00185, Roma, Italy, giovanni.felici@iasi.cnr.it

1 - Developing optimization applications - Part 1: Modeling techniques for large scale optimization problems
Susanne Heipcke, Xpress team, FICO, 54 rue Balthazar de Montron, 13004, Marseille, France, susanneheipcke@fico.com

In two talks on "Developing optimization applications" we review design choices for optimization applications, comment on trends observed in (end)user expectations and present solutions implemented with Xpress. This first session takes a more technical approach, focusing on modeling and solving aspects. We start with a discussion of design choices, including the choice between different types of modeling systems and architectural issues, and comment on their impact on the project organization. The modeling system chosen for the implementation of an optimization application needs to support the solution techniques that are required for solving a given optimization problem - ranging from the solver choice, to possibilities for implementing or connecting to problem-specific algorithms and solution heuristics, such as may be required by decomposition approaches. Whilst availability of a suitable solver or solving technology certainly is a necessary condition, other considerations should also be taken into account for the choice of the implementation platform, particularly when designing large applications that most likely will remain in use over a longer period of time and may need extensions or modifications to their initial definition. The employed modeling platform should be easy to use and to learn, allowing its user to select and learn about just the required features, and thereby making it possible to move quickly from the prototype stage to final deployment. At the same time, a modeling system is generally expected to provide efficient access to external data sources, as well as interfaces for embedding optimization models or algorithms into other systems. This also implies its availability across different standard operating systems and platforms. Particularly for projects involving experimentation or research, a relevant question to study is 'what happens if I need an unsupported feature?' - that is, how flexible is a system or which open entry points does it provide? Another important aspect of application design are possibilities for structuring of large-scale applications, such as support for the separate development, testing and deployment of different components, resulting in easier maintenance and also providing scope for collaborative development work. We present examples of how these different questions relating to aspects of application design are addressed by the Xpress-Mosel environment: on the language level (including the use of tools like a profiler and debugger); through its open, modular design that makes it possible to select among a set of readily available solver and data handling modules or even to add new external libraries without any modification to the core system; and perhaps most importantly, Mosel's support for distributed and remote computing, including sequential and concurrent decomposition approaches, the use of multiple solvers, and also efficiency and security considerations. Furthermore, we shortly comment on possibilities in Mosel for the interaction with application layers and visualization tools, the user side of which are explored in the second talk of this mini-series.

■ TC-10

Tuesday, 12:30-14:00
G5-1

Content distribution networks

Stream: Telecommunications and Network Optimization
Invited session

Chair: *Maciej Drwal*, Institute of Computer Science, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370, Wroclaw, Poland, maciej.drwal@pwr.wroc.pl

1 - The Dynamic Replica Placement Problem in Content Distribution Networks
Yuri Frota, UFF, Brazil, yuri@ic.uff.br, *Ubiratam De Paula*, *Lucia Drummond*, *Luidi Simonetti*

A Content Distribution Network is an overlay network in which servers replicate contents and distribute client requests in order to reduce the delay, the server and network loads, improving the quality of service perceived by customers. The Replica Placement Problem (RPP) consists in positioning the replicas on servers, respecting the resources available so that the replication and communication costs are minimized. In this work a distributed heuristic is proposed and the results showed that the proposed heuristic presented satisfactory results for the dynamic version of the problem.

2 - Lower and Upper Bounds for the Joint Problem of Request Routing and Client Assignment in Content Distribution Networks
Narges Haghi, Shool of Mathematics, University of Southampton, university Road, SO17 1BJ, Southampton, United Kingdom, nh2w07@soton.ac.uk

A Content Distribution Network is a system of servers containing digital objects that are placed at selected nodes of a telecommunications network. This paper describes a nonlinear integer programming model to solve the joint problem of request routing and client assignment which explicitly considers delays in transmitting objects. The paper also describes a lower bounding procedure for the problem based on Lagrangian relaxation and subgradient optimization, as well as an Iterated Local Search algorithm to generate upper bounds. Results of computational experimentations will be presented

3 - Data replication game between content provider network operators
Maciej Drwal, Institute of Computer Science, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370, Wroclaw, Poland, maciej.drwal@pwr.wroc.pl

Some of the most interesting questions regarding operating principles of the Internet concern their noncooperative nature. Users and network operators share communication, computational and storage resources, with different goals in mind, translated into different notions of network utility. We consider a game-theoretical model of content delivery networks market, where operators decide how to replicate data across their cache servers and how to redirect their subscribers. Algorithm for computing pure Nash equilibria is presented and both lower and upper bounds on Price of Anarchy are proven.

■ TC-11

Tuesday, 12:30-14:00
G5-3

High Performance Computing in Location Problems

Stream: Location Analysis
Invited session

Chair: *Pilar M. Ortigosa*, Departament of Informatics, University of Almería, Ctra. Sacramento s/n, La Cañada de San Urbano, 04120, Almería, Spain, ortigosa@ual.es

1 - Solving a bi-objective competitive facility location and design problem via evolutionary parallel algorithms
Juana López Redondo, Computer Architecture and Technology, University of Granada, Spain, jlredondo@ugr.es, *Aranzazu Gila Arrondo*, *Jose Fernandez*, *Pilar M. Ortigosa*

Recently, a new multi-objective evolutionary algorithm, called FEMOEA, has been proposed to deal with multi-objective problems. However, when the set approximating the Pareto-front must have many points (because a high precision is required), its computational time may be not negligible at all. In those cases, parallelizing the algorithm and run it in a supercomputer may be the best way forward. In this work, a parallelization of FEMOEA, called FEMOEA-Paral, is presented. This work has been funded by grants from the Program CEI from MICINN (PYR-2012-15 CEI BioTIC GENIL, CEB09-0010).

2 - A parallel implementation of a Lagrangean heuristic for huge-scale p-median problems
Anton Ushakov, Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, 134 Lermontov street, Irkutsk, Russian Federation, anton.v.ushakov@gmail.com, *Igor Vasilyev*

Our work is focused on studying huge-scale p-median problems as well as an application of the p-median model to the cluster analysis of huge amounts of data. We propose a parallel algorithm for finding solutions based on the widely known Lagrangean relaxation approach and optimizing the Lagrangean dual function with a subgradient method. We present our computational results obtained for some huge p-median problem instances and synthetically generated clustering problems. The study is partially supported by RFBR, projects No.12-01-31198 mol_a, No.12-07-33045 mol_a_ved, No.12-07-13116 ofi_m_rzd.

3 - Parallelization of a Lagrangean relaxation approach for a flexible discrete location formulation
Pilar M. Ortigosa, Departament of Informatics, University of Almería, Ctra. Sacramento s/n, La Cañada de San Urbano, 04120, Almería, Spain, ortigosa@ual.es, *Juana López Redondo*, *Alfredo Marín*

Flexible discrete location IP models have been studied in literature to approach a wide range of discrete location problems by a common tool. Although the generality of these formulations reduces their effectiveness, the new models can be considered without devoting a new effort to their resolution. Standard commercial IP solvers can solve only small instances. To approach large instances, we propose the use of heuristics and Lagrangean relaxation methods. The algorithm has been parallelized considering the decomposition of the Lagrangian relaxed subproblem into many independent problems.

4 - A Parallel Hybrid Genetic Algorithm for Quadratic Assignment Problem on GPUs
Erdener Ozcetin, Industrial Engineering, Anadolu University, Iki Eylül Kamp., MMF END 107, 26000, Eskişehir, Turkey, eozcetin@anadolu.edu.tr, *Gurkan Ozturk*

In this study, quadratic assignment problem (QAP) is examined to solve by a new approach. Huge amounts of data are being progressed simultaneously by graphics processing units (GPUs). A hybrid genetic algorithm has been proposed to solve the QAP by using GPUs' simultaneously progressing property. This parallel algorithm and the sequential version of it are tested and compared for 59 problems in literature. Best known solutions are obtained for 43 of these problems. Indeed, the proposed parallel algorithm works averagely 17 times and up to 51 times faster than sequentially one.

■ TC-12

Tuesday, 12:30-14:00
G5-4

Freight applications

Stream: Transportation and Logistics
Invited session

Chair: *Ruslan Sadykov*, INRIA Bordeaux - Sud-Ouest, 351 cours de la Libération, 33405, Talence, France, Ruslan.Sadykov@inria.fr

1 - Freight railcar routing problem in Russia
Ruslan Sadykov, INRIA Bordeaux - Sud-Ouest, 351 cours de la Libération, 33405, Talence, France, Ruslan.Sadykov@inria.fr, *Alexander Lazarev*, *Vitaliy Shiryaev*, *Alexey Stratonnikov*

In this problem, we need to 1) chose a profitable set of requests for goods delivery between stations in Russian railroad network, and 2) perform these requests by appropriately routing the set of available railcars. We formulate the problem as a multi-commodity flow problem in a space-time graph, and apply to it the column generation for extended formulations approach, in which columns-routes are disaggregated into arc variables when added to the restricted master problem. Real-life instances with up to 10 millions of arc variables were solved within minutes of computational time.

2 - Freight Railway Operator Timetabling and Engine Routing
Lukas Bach, Aarhus University, Fuglesangs alle 4, 8210, Aarhus V, Arhus, Denmark, luba@asb.dk, *Michel Gendreau*, *Sanne Wøhlk*

We present a model for timetable design at a European freight railway operator, where we chose the time of service for unit train demands among discrete points in time within a time-window. The timetable is periodic at a weekly level and covers a year. The objective in the model is to minimize cost while adhering to constraints considering infrastructure usage, demand coverage and engine availability. The model is solved by a Branch-and-Price algorithm where feasible engine routings are designed in a label setting algorithm in the pricing problem with time-dependent cost and service times.

3 - Scheduling and routing of fly-in safari airplanes
Armin Fügenschuh, Optimierung, Zuse Institut Berlin, Takustraße 7, 14195, Berlin, Germany, fuegenschuh@zib.de, *George Nemhauser*, *Yulian Zeng*

The scheduling and routing of small planes for fly-in safaris is a challenging planning problem. Given a set of flight requests with bounds on the earliest departure and latest arrival times, the planes must be scheduled and routed so that all demands and capacity restrictions on load and fuel are satisfied. Moreover the refueling of the planes, which can only be done in certain locations, must be scheduled. We present a formulation where the time windows are relaxed, and later reintroduced by branching. Numerical results on real-world instances show the computational merits of our approach.

4 - Rosyth — Zeebrugge: a potential intermodal maritime logistics corridor for Scottish freight transportation
Yuhong Wang, Transport Research Institute, Edinburgh Napier University, 10 Collington Road, EH10 5DT, Edinburgh, United Kingdom, y.wang2@napier.ac.uk

The majority of freight originated from Scotland is trucked south to go via Channel Tunnel or ports in Southeast England. As Scotland's only ferry connection to mainland Europe, however, the service between Rosyth and Zeegrugge is struggling with insufficient traffic flows in spite of its efficiency and cost advantages. This paper aims to run a comparative study between the ferry and other transport modes, and identify the critical factors in strengthening the attractiveness of Rosyth — Zeebrugge as a favoured intermodal maritime logistics corridor for Scottish freight transportation.

■ TC-13

Tuesday, 12:30-14:00
G5-5

Traffic congestion charging

Stream: Traffic
Invited session

Chair: *Yingen Ge*, School of Transportation & Logistics, Dalian University of Technology, 116024, China, Liaoning Province, China, y.e.ge@dlut.edu.cn

1 - Modeling effect of car ownership on activity time allocation
Yan Yin, School of Management, Huazhong University of Science and Technology, China, hustyinyan@hust.edu.cn, *Zhi-chun Li*

This paper proposes an activity-based multimodal network equilibrium model to address the interaction between car ownership and individuals' daily activity time allocation. In the proposed model, individuals choose their trip-chain pattern and activity duration to maximize their own utility subject to time and budget constraints. As an application of the proposed model, the optimal private car quota and vehicle license taxes aiming to maximize total social welfare of the system are simultaneously determined using a graphical approach.

2 - A Simulation Based Optimization Method in Determining Time Varying Pricing of Toll Roads
Lei Zhang, Department of Civil and Environmental Engineering, University of Maryland at College Park, 1173 Glenn Martin Hall, University of Maryland, 20742, College Park, Maryland, United States, lei@umd.edu, *Xiang He*, *Xiqun (Michael) Chen*, *Chenfeng Xiong*

A simulation based dynamic traffic assignment model DynusT is used to evaluate system performance in response of different toll scheme implemented on specific toll roads in the network. To help achieve the goal of minimizing total travel time for network users, a surrogate based optimization method is applied to search for the global optima of toll structure. A case study with time varying pricing implemented on 5 segments of a toll road in the state of Maryland, U.S. is conducted to test and analyze the effectiveness and efficiency of the proposed optimization method.

3 - Throughput and waiting times at unsignalised intersections
Hannah Van den Bossche, TELIN, Ghent University, St-Pietersnieuwstraat 41, B-9000 Gent, Ghent, Belgium, hvdnboss@telin.ugent.be, *Dieter Fiems*, *Herwig Bruneel*

As unsignalised intersections are a major source of distress on the road, these junctions cry out for an efficient structural organization. This requires an accurate estimation of throughput and waiting times. We propose a queueing theoretic approach in discrete time. The intersection is modelled as a queue with server interruptions. We assume a preemptive repeat different service discipline to approximate gap acceptance and a finite Markov chain to model road availability. The analysis relies on matrix generating functions (for throughput) and on matrix analytic methods (for waiting times).

4 - Offering more choices to travellers to mitigate undesired boundary effects of traffic congestion charging
Yingen Ge, School of Transportation & Logistics, Dalian University of Technology, 116024, China, Liaoning Province, China, y.e.ge@dlut.edu.cn

We analyze possible impacts of more choices available to travelers on undesired boundary effects of congestion pricing. It is assumed that a multi-step toll is implemented in the city central and that a small shopping and entertainment (S&E) area with a big park & ride side lies just outside the central. A bus line goes from the S&E area to the central and an express train line runs from the suburb to the S&E area first and then goes to the central. A flexible work start time is permitted. Given the settings, we seek ways to mitigate undesired boundary effects of congestion pricing.

■ TC-14

Tuesday, 12:30-14:00
G5-6

Hybrid Metaheuristics

Stream: Matheuristics
Invited session

Chair: *Andreas Reinholz*, Institute of Air Transport and Airport Research, German Aerospace Center (DLR), Linder Hoehe, 51147, Cologne, Germany, andreas.reinholz@gmx.de
Chair: *Vittorio Maniezzo*, dept. Computer Science, University of Bologna, via sacchi 3, 47521, Cesena, – Please Select (only U.S. / Can / Aus), Italy, vittorio.maniezzo@unibo.it
Chair: *Stefan Voss*, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de

1 - MILP based heuristics using Corridor Method to solve rural electrification projects,
Joan Triado, Administració i direcció d'empreses, Universitat Politècnica de Catalunya, Avinguda Diagonal 647, 08028, Barcelona, Catalonia, Spain, triado@eupmt.cat, *Laia Ferrer-Martí*, *Alberto García-Villoria*, *Rafael Pastor*

Isolated electrification systems that use wind and solar energy are a suitable option to provide electricity to rural villages autonomously. This work presents a heuristic to design these systems defining the microgrids and the location of each component. First, a relaxed mixed integer linear programming (MILP) model is solved in order to achieve an initial solution. Second, a local search process to improve this solution is implemented through Corridor Method. A computational experience is carried out and results show the heuristic obtains better solutions than to use Non-relaxed-MILP model.

2 - A Hybrid Approach for the Multi-objective Assignment Problem
Mustapha Ratli, DIM, LAMIH, UVHC LE MONT HOUY, 59313, Valenciennes, France, mustapha.ratli@univ-valenciennes.fr, *Bassem Jarboui*, *Sylvain Lecomte*, *Rachid Benmansour*, *Christophe Wilbaut*

We propose a hybrid approach for multi-objective assignment problem which combines genetic algorithm and mathematical programming techniques. This method is based on the dominance cost variant of the multi-objective genetic algorithm hybridized with exact method. The initial population is generated by solving a series of mono-objective assignment problems obtained by a suitable choice of a set of weights. The crossover operator solves a reduced mono-objective problem where the weights are chosen to identify an unexplored region. Numerical experiments show the efficiency of our approach.

3 - A genetic algorithm- LP combined model to optimize the lifetime of wireless sensor networks
Ayse Cilaci Tombus, Industrial Engineering, Bogazici University, 34000, Istanbul, Turkey, aysecilaci@gmail.com, *Onder Tombus*

In this paper, a genetic algorithm method combined with LP model is proposed to optimize the lifetime of wireless sensor networks. The proposed method is a cluster based approach like LEACH. The method has Set-up and Steady-state phases. In the set-up phase, the clusters are created and are not changed throughout the network. The clusters are not recreated for each round. In each round, there are static clusters with dynamically changing cluster heads. Genetic algorithm is used for selecting best combination of clusters Maximum lifetime of each cluster is found exactly with an LP model.

4 - An integrated Modeling and Optimization Methodology for Rich Vehicle Routing Problems
Andreas Reinholz, Institute of Air Transport and Airport Research, German Aerospace Center (DLR), Linder Hoehe, 51147, Cologne, Germany, andreas.reinholz@gmx.de

We present a methodology for developing powerful Hybrid Metaheuristics for Rich Vehicle Routing Problems (VRP). The methodology starts with a quick and easy implementation that could be improved step by step by adding more complex elements. Problem specific neighborhood generating operators, working on different levels of the problem hierarchy, using specific coding, efficient data structures and accelerated delta function evaluations are introduced to develop competitive solvers. The capability and performance will be shown on both real world problems and benchmark problems from literature

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■ TC-15

Tuesday, 12:30-14:00
G5-2

Metaheuristic Algorithms

Stream: Metaheuristics (contributed)
Contributed session

Chair: *Muhammad Shahid Latif*, Management Sciences and Engineering, Beijing University of Aeronautics and Astronautics, China, mshahidlatif@is.buaa.edu.cn

1 - Batched Hyper-heuristics
Andrew J. Parkes, School of Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG9 1BB, Nottingham, United Kingdom, ajp@cs.nott.ac.uk, *Ender Özcan*

Hyper-heuristics provide a general-purpose software component to help reduce the implementation time needed for effective search methods. However, hyper-heuristics studies have generally used a fixed execution time and also solved each problem instance independently. We consider a batched mode for hyper-heuristics in which a set of instances are to be solved together and within an overall joint execution time. The hyper-heuristic can freely divide the computational effort between the individual instances and also exploit what it learns on one instance to help solve others.

2 - Generating Supply Chain Ordering Policies using Quantum Inspired Genetic Algorithms and Grammatical Evolution
Seán McGarraghy, Management Information Systems, University College Dublin, Quinn Schoolof Business, Belfield, Dublin 4, Dublin, Ireland, sean.mcgarraghy@ucd.ie, *Micheal Phelan*

Evolutionary Algorithms have been used to evolve ordering policies which minimise overall supply chain cost. We extend existing research by applying two more recent evolutionary algorithms to this problem: (a) Grammatical Evolution (GE) using a standard Genetic Algorithm (GA) search engine; and (b) Quantum Inspired GA, used both as a standalone algorithm, and as an alternative search engine for GE. We benchmark these against previous work on the linear Beer Game supply chain, and extend our approaches to arborescent supply chains (without gaming), and capacitated inventory.

3 - Modified electromagnetism-like algorithm for real-parameter optimization
Alkin Yurtkuran, Industrial Engineering Department, Uludag University, Uludag University, Industrial Engineering Department, 16059, Bursa, Turkey, alkin@uludag.edu.tr, *Erdal Emel*

Electromagnetism-like algorithm is relatively new population based meta-heuristic algorithm which simulates the behavior of charged particles in an electrical field. Different studies show that Electromagnetism-like algorithm is a powerful tool to solve continuous optimization problems. In this study modified versions of electromagnetism-like algorithm are proposed in order to improve both the exploitation and exploration ability of the algorithm. Experiments show that proposed algorithm yields remarkable solution quality on benchmark functions.

4 - A Hybrid Quantum Estimation of Distribution Algorithm (Q-EDA) for Flow-Shop Scheduling
Muhammad Shahid Latif, Management Sciences and Engineering, Beijing University of Aeronautics and Astronautics, China, mshahidlatif@is.buaa.edu.cn, *Zhou Hong*

This paper presents a first hybrid approach named Q-EDA for solving PFSSP, a well-known NP hard Problem. The jobs schedule is encoded in terms of angles instead of random keys to make QGA efficient. Further, optimal solutions from QGA and EDA are compare; if the better one is from EDA, it is injected in QGA to switch it towards a more promising solution space, otherwise QGA will keep searching. NEH is also incorporated with EDA for initial solution, rest are produced by standard EDA. The Q-EDA was implemed on different benchmark problems; experiments showned better convergence and results.

■ TC-16

Tuesday, 12:30-14:00
G5-7

Real-world Path Problems in Transportation

Stream: Routing Problems
Invited session

Chair: *Maurizio Bruglieri*, Dipartimento di Design, Politecnico di Milano, Via Durando, 38/a, Milano, Italy, maurizio.bruglieri@polimi.it
Chair: *Alberto Colorni*, Department of Industrial Design, delle Arti e della Comunicazione, Politecnico di Milano, c/o Metid, p.zza Leonardo da Vinci 32, 20133, Milano, Italy, alberto.colorni@polimi.it

1 - Engineering Route-Planning Algorithms for Electric Vehicles
Moritz Baum, Karlsruhe Institute of Technology, Germany, moritz.baum@kit.edu, *Dorothea Wagner*

We consider the problem of route planning for electric vehicles, where one important aspect is the minimization of energy consumption, because of restricted cruising range. However, energy consumption depends on many different parameters, most of which change frequently. Moreover, a query algorithm has to handle certain specific characteristics, such as negative edge weights due to regenerative braking, and constraints induced by the battery capacity. We introduce algorithmic approaches dealing with all these challenges that provide practical query times on large-scale street networks.

2 - Delay Robust Routing in Public Transit Networks
Ben Strasser, ITI Wagner, Karlsruhe Institute of Technology, Am Fasanengarten 5, 76128, Karlsruhe, Germany, strasser@kit.edu, *Julian Dibbelt*, *Thomas Pajor*, *Dorothea Wagner*

Route planning in public transit networks with delays is a challenging task, which involves computing paths that are robust with respect to delays unknown at query time. We model delays using stochastic methods. A major observation is that suboptimal paths can act as backups for optimal paths in case that transfers fail. Optimizing individual paths is therefore not enough. We compute a set of paths that in its entirety minimizes the expected arrival time. We present a practical dynamic-programming based algorithm that computes such sets even on large-scale transit networks.

3 - A multi-objective route planner: a real world application to Milano city
Maurizio Bruglieri, Dipartimento di Design, Politecnico di Milano, Via Durando, 38/a, Milano, Italy, maurizio.bruglieri@polimi.it, *Diego Ciccarelli*, *Alberto Colorni*, *Federico Lia*, *Alessandro Luè*

Our work concerns a vehicle route planner for real-time navigation developed for an Italian firm and tested on real world data of Milano road network. Given the driver GPS position and its wished destination, the route planner allows to find in few seconds a path between them which minimizes at the same time the total travel time, travel cost and risk. Beside the multi-objective optimization and the CPU efficiency, other challenging features faced by the algorithm that supports the route planner are the time-dependency of travel times and costs, and the use of a hierarchical road network.

4 - A Real Life Open Vehicle Routing Problem With an Alternative Cost Structure
Zehra Kamisli Ozturk, Industrial Engineering Department, Anadolu University, Anadolu University, Engineering Faculty Industrial Engineering Department No:126 Iki Eylul Campus, 26555, Eskisehir, Turkey, zkamisli@anadolu.edu.tr, *Erdener Ozcetin*, *Gurkan Ozturk*, *Nergiz Kasimbeyli*, *Refail Kasimbeyli*

The vehicle routing problem is a well known combinatorial optimization problem which is NP-hard. Generally, the objective function is defined as the minimization of the total distance of the vehicles by considering capacity constraints. In this study we consider a real life open vehicle routing problem with an alternative cost structure. Here, cost is determined as a function of farthest location on the route and extra distance of location where is not on the regular route. In order to solve the problem, a genetic algorithm is developed and tested on some real life instances.

■ TC-17

Tuesday, 12:30-14:00
G5-8

Transportation Planning 3

Stream: Transportation Planning
Invited session

Chair: *Christine Vanovermeire*, University of Antwerp, 2000, Antwerp, Belgium, christine.vanovermeire@ua.ac.be

1 - Integrated model for electric vehicles routing and optimal charging
Ons Sassi, LORIA - UMR 7503, University of Lorraine, 54000, Nancy, France, ons.sassi@loria.fr, *Ammar Oulamara*, *Alain Roset*, *Elena Shevchenko*, *Mehdi SErairi*, *Wahiba Ramdane Cherif*

Electric vehicles offer great potential for increasing energy efficiency. In the context of project InfiniDrive that gathers users of captive fleets together with academics and enterprises, the objective is to demonstrate the viability of EVs in industrial context. We propose an ILP formulation for the problem of allocation of EVs to routes and the charging schedule of these EVs, with the aim of maximizing the use of EVs and the minimization of the charging cost. A Cplex solver is used to solve the model and a validation of the proposed model on real instances of the La Poste Group.

2 - A Model for Pollution Routing Problem in Heavy Duty Transportation
Aydin Sipahioglu, Industrial Engineering, Osmangazi University, Meselik, 26480, Eskisehir, Turkey, asipahi@ogu.edu.tr, *Ali Atav*

Pollution Routing Problem (PRP) can be defined as finding the vehicle routes so as to minimize total emission of greenhouse gases. PRP is very important problem especially in heavy duty transportation and it is hard to solve considering pick-up and delivery together. In this study, a mathematical model is offered for PRP with heterogeneous fleet and open vehicle routes. The model is solved to optimality on a group of test problems by modifying taken from the literature. One of the biggest test problems has 20 nodes and 5 vehicles and the other one has 18 nodes and 6 vehicles.

3 - Integration of the cost allocation in the optimization of collaborative bundling
Christine Vanovermeire, University of Antwerp, 2000, Antwerp, Belgium, christine.vanovermeire@ua.ac.be

By bundling orders of partners within the time windows suggested to their 3PLs, a large reduction in cost can be achieved. These benefits can be enlarged by loosening the time window constraints. Using the real cost structure of delivering an order too early or too soon, a partner can give more delivery date options, given that he receives an adequate compensation for moving this order. We create an algorithm that integrates the Shapley value that creates an operational plan and a compensatory cost allocation. We show how such an integrated approach increases the satisfaction of the partners.

4 - On a class of three-dimensional transshipment problems
Archana Khurana, School of Basic and Applied Sciences, Guru Gobind Singh Indraprastha University, Kashmere Gate, 110403, Delhi, Delhi, India, archana2106@gmail.com

In this article we have formulated a three-dimensional linear transshipment problem and studied its variants. Sometimes, because of the budget/political constraints, the total flow of transportation is specified by some external decision maker which thereby results in restricted and enhanced flow in the market. The optimal solution of such problems is obtained by transforming it into an equivalent transportation problem. The algorithm can provide a solution to production-distribution problems having heterogeneous commodities. Numerical examples are also included to support the theory.

■ TC-18

Tuesday, 12:30-14:00
G5-9

Stochastic Modeling and Simulation III

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - Graph partitioning based on driver nodes
Zeev (Vladimir) Volkovich, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il, *Arik Bokser*, *Meital Hafter*

We propose a new graph clustering approach where the driver nodes located in the clusters serve as the clusters' cores. It make possible to refine the partitioning process and automatically estimate the number of clusters. We apply our methodology to clustering of scale-free networks, especially to PPI networks, and compare the results with the solution provided by several known clustering algorithms.

2 - A queuing network for modeling a robotic fulfillment system
Tim Lamballais Tessensohn, Management of Technology and Innovation, Rotterdam School of Management, Zocherstraat 42, 3067 AT, Rotterdam, Netherlands, lamballaistessensohn@rsm.nl

As E-Commerce grows in importance, its influence on warehouse operations becomes stronger as well. This poses a challenge as E-commerce is typically characterized by high fluctuations in demand, small or even single item orders, unpredictable growth and large and varied product assortments. Robotic mobile fulfillment systems, like for example Kiva systems, have been specifically designed to tackle these challenges and enhance warehouse productivity. The aim of our research is to model such a system as a queuing network and to find good approximations to the order throughput times.

3 - Method proposal of computer simulation applied to industry: method for agile development of projects
Fabricio Rodrigues Costa, Nokia Institute of Technology - INdT, +559232365418, +559281065960, Manaus, Amazon, Brazil, fabricio.costa@indt.org.br

The cell phone industry seeks to improve the operational efficiency constantly and ASAP. These improvements are driven by fierce competition. The computer simulation (CS) is an important tool to aid decision-making and therefore can be applied to industry. One major disadvantage of CS is the long time to develop projects. This paper presents a method developed and practiced by us in projects of CS applied to industry. The main objectives of this method are: to develop projects in a short time, develop simulations with reliable results and with different scenarios defined by the customers.

■ TC-19

Tuesday, 12:30-14:00
G5-10

Location Models

Stream: Location, Logistics, Transportation (con-

tributed)
Contributed session

Chair: *Stefan Bock*, WINFOR (Business Computing and Operations Research) Schumpeter School of Business and Economics, University of Wuppertal, Gaußstraße 20, D-42097 Wuppertal, 42097, Wuppertal, NRW, Germany, sbock@winfor.de

1 - Environmental Effects of EVs and Location of Charge Stations
Damla Sener, Industrial Engineering, Koç University, -, Istanbul, Turkey, dasener@ku.edu.tr, *Metin Turkay*

Traffic congestion is one of the most important problems in metropolitan regions. Vehicles running with conventional internal combustion engines have low energy efficiency and release harmful substances to the atmosphere. Analysing the current situation and comparison of cars effect on the environment in assessing the design of transportation support systems such as charging stations. In this work, we analyse the data for Istanbul and develop a MILP problem to design the network of charging stations to satisfy energy requirements.

2 - stochastic network design problem under probabilistic constraints with continuous random variables and efficient methods to solve them.
Olga Myndyuk, Rutcor, Rutgers Center for Operations Research, Rutgers, The State University of New Jersey, 640 Bartholomew Rd, 08854, Piscataway, NJ, United States, olgamyn@eden.rutgers.edu

Single commodity stochastic network design problem is formulated, where the demands at the nodes are continuously distributed random variables. The problem is to find optimal node and arc capacities under some deterministic and probabilistic constraints that ensures the satisfiability of all demandson a high probability level. The large number of feasible inequalities is reduced to a much smaller number. This, in turn, is solved by a combination of inner and outer algorithm providing us with both lower and upper bounds for the optimum on each iteration.

3 - An efficient exact solution approach for the Traveling Repairman Problem on a Line
Stefan Bock, WINFOR (Business Computing and Operations Research) Schumpeter School of Business and Economics, University of Wuppertal, Gaußstraße 20, D-42097 Wuppertal, 42097, Wuppertal, NRW, Germany, sbock@winfor.de

In this talk a first practically applicable exact solution procedure for the well-known Travelling Repairman problem on a line with release and due dates is proposed. Since already the feasibility variant of this problem is strongly NP-hard, optimal solutions are generated by applying a best-first Branch&Bound procedure. It uses various dominance rules and lower bounds in order to limit the computational effort. A comprehensive computational study proves that real-world problem instances comprising more than 100 requests and locations can be solved to optimality in reasonable time.

■ TC-20

Tuesday, 12:30-14:00
G5-11

Air transportation

Stream: Optimization in Public Transport
Invited session

Chair: *Karl Nachtigall*, Faculty of Transport and Traffic Sciences, Institut for Logistics and Aviation, Technical University of Dresden, Hettnerstraße 1, Gerhart-Potthoff-Bau 106a, 01062, Dresden, Sachsen, Germany, karl.nachtigall@tu-dresden.de
Chair: *Steffen Marx*, Fakultät für Verkehrswissenschaften, Technische Universität Dresden, Institut für Luftfahrt und Logistik, Professur f. Verkehrsströmungslehre, 01062, Dresden, Germany, steffen.marx@tu-dresden.de

1 - Creation of conflict-free Taxi Routes for Aircraft with Evolutionary Algorithms
Ingrid Gerdes, Air Transportation, Institute of Flight Guidance, Lilienthalplatz 7, 38108, Braunschweig, Germany, Ingrid.Gerdes@dlr.de, *Meilin Schaper*

Flight operations for aircraft are influenced by tools like arrival and departure managers, which create time constrained flight trajectories, but there is a lack of surveillance for ground operations. Therefore, DLR develops TRACC, a surface management system supporting trajectory based ground operations. It is able to create conflict-free "4D"-taxi routes using evolutionary algorithms, where especially the arrival time at the departure runway is optimized. TRACC creates the controller commands, controls deviations from the planned routes and analyses the impact on the ground taxi system.

2 - Optimized Capacity Management at Airports
Carla Müller-Berthel, Faculty of Transportation and Traffic Sciences "Friedrich List", Institute of Logistics and Aviation, Technical University of Dresden, Chair of Traffic Flow Science, Hettnerstraße 1, 01069, Dresden, Sachsen, Germany, carla.mueller-berthel@tu-dresden.de, *Karl Nachtigall*

Operation rules define the capacity management for the runway system of an airport through demand-depending flow regulations. Through operation rules the overall capacity becomes distributed among the airport elements that squeeze air traffic flows. We investigate the problem to find an optimized sequence of operation rules resulting in the most efficient capacity usage. In this paper we present optimization and solution models that deliver an optimized sequence of operation rules for a generic airport. Results for real-world data are presented and the models and methods assessed.

3 - Robust Relative 4D Trajectory Planning by Wind Networking
Daniel Delahaye, French Civil Aviation University, 7 avenue Edouard Belin, 31055, Toulouse, France, delahaye@recherche.enac.fr

The goal of this work is to take advantages of uncertainties by constraining aircraft in time only when it is necessary. To reach this goal, aircraft measure their local weather parameters and broadcast them to the other aircraft. Having such distributed weather information, each aircraft is able to compute an enhanced local maps of wind and temperature which could be shared with other aicraft. By sharing those information, aircraft are able to know if the other aircraft are planned to be on time at a given point and decide if they have to adjust their own planning.

4 - A decision support system for the seasonal flight scheduling by using linear optimization and transport demand modeling
Steffen Marx, Fakultät für Verkehrswissenschaften, Technische Universität Dresden, Institut für Luftfahrt und Logistik, Professur f. Verkehrsströmungslehre, 01062, Dresden, Germany, steffen.marx@tu-dresden.de, *Karl Nachtigall*

A decision support for the seasonal flight scheduling can help to create better strategic flight plans. The classical planning workflow in airlines starts with determination of transport demand and following optimization of all typical planning processes. The problem is, it exists no feedback between transport demand modeling and schedule optimization. Our basic approach handles the effects of the optimized flight schedules on transport demand by an iterative optimization process.

■ TC-21

Tuesday, 12:30-14:00
G6-1

Scheduling in the Presence of Uncertainty

Stream: Scheduling
Invited session

Chair: *Alena Otto*, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de
Chair: *Rami Atar*, Technion, 32000, Haifa, Israel, atar@ee.technion.ac.il

1 - Due Date Assignment in Dynamic and Stochastic Single Machine Environments with Family Setups
Zehra Duzgit, Industrial Engineering, Bogazici University & Istanbul Bilgi University, Francalacı street No:5/3, Arnavutkoy-Besiktas, 34345, Istanbul, Turkey, zehra.duzgit@bilgi.edu.tr, *Ali Tamer Unal*

We consider a due date assignment problem in dynamic and stochastic single machine environments with family setups. A due date is to be assigned to the jobs immediately at their arrival. We propose a two stage assignment procedure. The first stage determines a batching structure. The second stage assigns due dates to arriving jobs. In this setting, we analyze the delivery performance and competitive power of the system under the proposed due date assignment policy.

2 - Multi-project scheduling under mode duration uncertainties
Gündüz Ulusoy, Industrial Engineering, Sabancı University, FENS, Orhanlı, Tuzla, 34956, Istanbul, Turkey, gunduz@sabanciuniv.edu, *Emre Arda Sisbot*, *Can Akkan*

The multi-mode multi-project resource constrained project scheduling problem under mode duration uncertainty is investigated. The objectives are minimizing the overall makespan and the sum of absolute deviations of scheduled and early start times of activities found through simulation. First, each project is reduced to a macro-activity with macro-modes. Macro-modes are represented as random variables by generating disruption cases via simulation. A multi-objective genetic algorithm is employed for scheduling. Macro-activities are reconverted into projects. Computational study is reported.

3 - Three new state space collapse results for the multiclass G/G/1 queue
Rami Atar, Technion, 32000, Haifa, Israel, atar@ee.technion.ac.il

I will present asymptotic optimality results, in diffusion and moderate deviation scales, for the multiclass G/G/1 queue with various combinations of the following elements: scheduling/admission control, finite buffers, reneging, holding/rejection/reneging costs. In all cases the limiting dynamics is one-dimensional, and asymptotic optimality is achieved by switching from one priority discipline to another depending on the workload level. I will also mention models we couldn't solve.

4 - Heavy-traffic analysis of a multi-class queue with relative priorities
Ane Izagirre, LAAS, 7 avenue Coronel Roche (group SARA), 31077, Toulouse, France, ane.izagirre@laas.fr

We study the steady-state queue-length in a multi-class single-server queue with relative priorities in a heavy-traffic regime. We first establish a state-space collapse for the scaled queue length, that is, in the limit the scaled queue length vector is distributed as the product of an exponentially distributed r.v. and a deterministic vector. As a consequence, we obtain that the scaled number of customers reduces as classes with smaller mean service requirement obtain larger weights. We simulate a system with two classes of customers to numerically verify some of the analytical results.

■ TC-22

Tuesday, 12:30-14:00
G6-2

Dynamic scheduling problems

Stream: Scheduling II
Invited session

Chair: *Stanislaw Gawiejnowicz*, Faculty of Mathematics and Computer Science, Adam Mickiewicz University, Umultowska 87, 61-614, Poznan, Poland, stgawiej@amu.edu.pl

1 - Scheduling with a due-window for acceptable lead-time
Gur Mosheiov, School of Business, Hebrew University, 91905, Jerusalem, Israel, msomer@huji.ac.il

Due-dates are often determined during sales negotiations in two stages: (i) in the pre-sale stage, customers provide a time interval of their preferred due-dates, (ii) in the second stage, the parties agree on the delivery penalties. The contract reflects penalties of both stages: earliness/tardiness penalties of the due-dates (with respect to the agreed upon due-window), and earliness/tardiness penalties of the actual delivery times (with respect to the due-dates). We model this setting, and introduce an efficient (pseudo-polynomial) dynamic programming algorithm for this NP-hard problem.

2 - Minimizing the makespan on single-machine scheduling with deterioration effect and partial machine maintenance
Wen-Hung Kuo, Department of Information Management, National Formosa University, Taiwan, whkuo@nfu.edu.tw, *Dar-Li Yang*

A machine can restore to its original state after the complete maintenance. However, a machine sometimes is only maintained to an available state to save time and then it is put back to a production system. Such maintenance is called "partial maintenance". However, a machine in such an available state is not as efficient as that after complete maintenance. Therefore, it is a trade-off between to adopt partial maintenance or to adopt complete maintenance in scheduling problems. In this paper, we will discuss such a situation in a single-machine scheduling problem.

3 - Scheduling linear jobs by two agents to minimize the weighted sum of two criteria
Stanislaw Gawiejnowicz, Faculty of Mathematics and Computer Science, Adam Mickiewicz University, Umultowska 87, 61-614, Poznan, Poland, stgawiej@amu.edu.pl, *Cezary Suwalski*

We consider two-agent job scheduling on a single machine. Each job has a ready time, a linear time-dependent processing time and a weight or a due-date. Both agents construct partial schedules with their own jobs and are evaluated by their own optimality criterion: the total weighted completion time or the maximum lateness. The goal is to find a complete schedule with minimal weighted sum of the criteria. We prove that the problem is NP-hard, show its properties and propose for it an exact algorithm and a meta-heuristic. We also report the results of computational evaluation of the algorithms.

■ TC-23

Tuesday, 12:30-14:00
G6-3

Fuzzy Goal Programming

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Mariano Jimenez-Lopez*, Economía Aplicada I, University of the Basque Country, Plaza de Oñati 1, 20018, San Sebastian, Spain, mariano.jimenez@ehu.es

1 - MRP modelling with fuzzy lead times
Manuel Díaz-Madroñero, Research Centre on Production Management and Engineering, Universitat Politècnica de València, Escuela Politécnica Superior de Alcoy, Plaza Ferrándizy Carbonell, 03801, Alcoy, Spain, fcodiama@cigip.upv.es, *Josefa Mula*, *Mariano Jimenez-Lopez*

We propose a fuzzy multi-objective integer linear programming approach to model a material requirement planning (MRP) problem with fuzzy lead times. We incorporate to the crisp MRP model the possibility of occurrence of each one of the possible lead times. Then, an objective function that maximizes the possibility of occurrence of the lead times is considered. By combining this objective with the initials of the MRP model, decision makers can play with their risk attitude of admitting lead times that improve the other objectives but have a minor possibility of occurrence.

2 - A Novel Approach For Multiobjective Programming Problems with Fuzzy Objective Functions
Monga K Luhandjula, Decision Sciences, University of South Africa, Muckleneuk Campus, 0003, Pretoria, Gauteng, South Africa, luhanmk@unisa.ac.za

Many Optimization problems invove the challenging task of integrating simultaneously conflicting goals and imprecise data. In this paper we consider multiobjective programming problems where the picture is made complicated by the presence of fuzzy objective functions. The main idea behind our approach is to take advantage of an Embedding Theorem for fuzzy numbers in a way to put the fuzzy problem into equivalent deterministic terms. A Galerkin like scheme is described to tackle the resulting deterministic optimization problem involving infinitely many objective functions.

3 - A proposal for a firm's ranking taking into account their efficiency
Trinidad Casasus, Matematicas para la Economia y la Empresa, Universitat de Valencia, AVDA, TARONGERS, S/n, 46022, VALENCIA, Valencia, Spain, trinidad.casasus@uv.es, *Vicente Liern*, *Maria Leonor Pla Ferrando*, *Juan Carlos Perez*

We calculate the efficiency of a set of firms and analyse some methods to obtain an order. The data that are managed are often affected of uncertainty and models using Fuzzy DEA methodology are very useful to study that efficiency. Also, it is not enough to know if a firm uses in an efficient way its resources, it is also necessary to establish a classification of the DMUs that could appear as a first approximation to the study of their competitiveness. We will apply our proposal to the evaluation and classification of a group of textile firms in the zone of Alicante, Spain.

4 - A new approach to jointly address fuzzy and standard goal programming
Mariano Jimenez-Lopez, Economía Aplicada I, University of the Basque Country, Plaza de Oñati 1, 20018, San Sebastian, Spain, mariano.jimenez@ehu.es, *Amelia Bilbao-Terol*, *Mar Arenas-Parra*

In fuzzy goal programming (FGP) the threshold of goal membership functions cannot be surpassed, which may result in infeasible problems. To avoid this drawback it is usual to set pessimistic thresholds, resulting targets that do not reflect the opinion of decision maker. A new goal programming (GP) variant in which thresholds can be surpassed is proposed. The objective values not exceeding the thresholds are positively valued, according to their membership degree to the fuzzy goal, like in FGP approach, whereas those that exceed the threshold are penalized, like in standard GP approach.

■ TC-24

Tuesday, 12:30-14:00
G6-4

Flexible Resources in Project Scheduling

Stream: Project Management and Scheduling
Invited session

Chair: *Rainer Kolisch*, TUM School of Management, Technische Universitaet Muenchen, Arcisstr. 21, 80333, Muenchen, Germany, rainer.kolisch@wi.tum.de

1 - Flexible Resource-Constrained Project Scheduling: Discrete-Time Models
Anulark Naber, TUM School of Management, Technische Universität München, Arcisstr. 21, 80333, München, Bavaria, Germany, anulark.naber@wi.tum.de, *Rainer Kolisch*

This research addresses a generalized resource-constrained project scheduling (RCPSP) that allows flexible resource profiles where resource usages may vary from period to period. Activities' resource usages, durations and schedules must be simultaneously determined to minimize the project makespan. Besides those of RCPSP, constraints on total work/resource content required, bounds on resource usage, the minimum number of periods with constant profiles, and coordination of multiple resources are also imposed. Several discrete-time models are proposed and computationally compared.

2 - Scheduling resource-constrained projects with flexible project structure
Carolin Kellenbrink, Institut für Produktionswirtschaft, Universität Hannover, Königsworther Platz 1, 30167, Hannover, Germany, carolin.kellenbrink@prod.uni-hannover.de

In projects with a flexible project structure, the activities that have to be scheduled and implemented are not completely known beforehand. Instead, scheduling the project includes the decision whether to carry out particular activities at all. In such projects, the project structure is therefore ex ante partially unknown. However, established approaches for the resource-constrained project scheduling problem (RCPSP) assume that the project structure is given in advance. In this talk, the RCPSP is hence extended by a highly general model-endogenous decision on this flexible project structure.

3 - A new planning model for the resource-constrained multi project scheduling problem with flexible resource usage
Torben Schramme, DS&OR Lab Paderborn, University of Paderborn, Warburger Straße 100, 33098, Paderborn, Germany, schramme@dsor.de, *Leena Suhl*

The resource-constrained project scheduling problem (RCPSP) has been discussed in literature for decades, although there is still a gap between the needs of practical project scheduling on the one side and available project scheduling methods on the other side. Especially methods dealing with flexible resource usage for activities together with multiple projects in one plan are still rare and not practicable. We will present a planning model which incorporates these features and makes further aspects possible and we will show first approaches to solve this model under different objectives.

4 - On the comparison of FLM and SA for determining the optimal timings of control points in a project
Narjes Sabeghi, Applied Mathematics, Ferdowsi University of Mashhad, Faculty of Mathematical Sciences, No10,ladan10,vakilabad BLV,Mashhad,Iran, Mashhad, Iran, Islamic Republic Of, narjes_sabeghi@yahoo.com, *Hamed Reza Tareghian*, *Erik Demeulemeester*

In this paper after representing the method based on facility location model (FLM) for determining the fixed number of project control points, we tried to compare the results of this method with the results of some other methods like equal intervals (EI) and a heuristic method like simulated annealing (SA). Comparison is done in both static and dynamic view.

■ TC-25

Tuesday, 12:30-14:00
G9-1

Machine Learning

Stream: Artificial Intelligence, Fuzzy systems (contributed)
Contributed session

Chair: *Heinrich Rommelfanger*, Economics and Business Administration, Goethe University, Niebergallweg 16, 65824, Schwalbach a. Ts., Hessen, Germany, Rommelfanger@wiwi.uni-frankfurt.de
Chair: *Peter Tarabek*, Department of Transportation Networks, University of Zilina, Slovakia, peter.tarabek@fri.uniza.sk

1 - Obtaining input data for microscopic optimization models
Peter Tarabek, Department of Transportation Networks, University of Zilina, Slovakia, peter.tarabek@fri.uniza.sk, *Matej Cebecauer*

Typical limitation of solving many existing optimization problems in spatially large systems is the use of coarse data on customers. This paper describes the ways of acquiring high-resolution input data to improve the quality of the solutions obtained by solving various tasks

such as location problems at microscopic level. We propose to use OpenStreetMap (OSM) as a primary data source. To improve quality and completeness of the data in OSM we introduce methods for acquiring the data about the infrastructure as well as building types and position from various drawn maps and satellite images.

2 - Relaxing inference through constraint driven optimization
Enza Messina, DISCo - Department of Informatics, Systems and Communication, Università degli Studi di Milano Bicocca, viale Sarca 336, 20126, Milano, Italy, messina@disco.unimib.it, *Elisabetta Fersini*

Much of the valuable information to support decision making processes originates in text-based documents and, in order to become actionable knowledge, need to be extracted and transformed in a structured form. This problem, known as Named Entity Recognition, can be addressed by using Conditional Random Fields (CRF). To enhance the performance of CRF we formulate the inference process as an ILP model where useful knowledge - automatically extracted from data - is introduced as constraints, leading to a relaxation of the original decoding problem usually solved by the Viterbi algorithm.

3 - Analysis of Intrusion Detection in Control System Communication based on One-class Classifiers
Takashi Onoda, System Engineering Lab., CRIEPI, 2-11-1, Iwado Kita, Komae-shi, 201-8511, Tokyo, Japan, onoda@criepi.denken.or.jp

In this paper, we introduce an analysis report of outlier detection using SVM (Support Vector Machine) for intrusion detection in control system communication networks. In control systems, a large amount of normal communication data is available, but there have been almost no cyber attacks. We applied these two methods to intrusion detection in an experimental control system network, and compared the differences in the classification. Our experiments clarified that sequence information in control system communication is very important for detecting some intrusion attacks.

4 - Bayesian Learning with Genetic Algorithms and Fuzzy Membership Functions for Gaussian Approximation of Bayesian Neural Networks
Ozan Kocadağlı, Department of Statistics, Mimar Sinan F.A. University, 12345, Istanbul, Turkey, ozankocadagli@msgsu.edu.tr

In the nonlinear systems, the pre-knowledge about an exact functional structure between inputs and outputs is mostly either unavailable or insufficient. The artificial neural networks can determine the functional structure. Traditional neural networks suffer from the approximation and estimation errors and the Bayesian neural networks provide a natural way to alleviate this issue. We propose a new approach and compare it with the traditional neural networks in terms of their estimation and prediction performances over an artificial data set of instances.

■ TC-26

Tuesday, 12:30-14:00
G9-7

Network Design

Stream: Combinatorial Optimization I
Invited session

Chair: *Markus Leitner*, Institute of Computer Graphics and Algorithms, Vienna University of Technology, Favoritenstraße 9-11, 1040, Vienna, Austria, leitner@ads.tuwien.ac.at

1 - Scheduling fiber replacement in WDM networks
Daniel Karch, TU Berlin, Germany, karch@math.tu-berlin.de, *Andreas Bley*, *Fabio D'Andreagiovanni*

In recent years, Wavelength Division Multiplexing (WDM) has become a reference technology adopted in optical networks, since it allows sharing an optical fiber among multiple connections, by assigning each connection a distinct wavelength. We consider the migration of a network to a new technology. During the upgrade of a network component, connections using it are temporarily disrupted. It is thus important to schedule the migration of the network such that the downtime is minimized. We give an IP-based model for the WDM-FRS problem, and discuss some of the problem's basic properties.

2 - Grammar and Constrained Network-Based Column Generation for the Tour Scheduling Problem
Maria-Isabel Restrepo, Mathematics and Industrial Engineering, Ecole Polytechnique de Montreal, 7 cote sainte catherine apt 305, H2V1Z9, Montreal, Quebec, Canada, maria-isabel.restrepo-ruiz@polymtl.ca, *Bernard Gendron*, *Louis-Martin Rousseau*

We present a methodology based on Column Generation to solve personalized Tour Scheduling Problems. The subproblems consist first, in the generation of daily shifts by using Grammars. Daily shifts are later used to construct a Directed Acyclic Graph where tours are found by solving a Shortest Path Problem with Resource Constraints. The model is flexible enough to handle multiple work activities, different days-off patterns and several work rules.

3 - ILP Models for the single PON Access Network Design Problem
Maria João Lopes, Departamento de Métodos Quantitativos para a Gestão e Economia, Instituto Universitário de Lisboa (ISCTE - IUL) and CIO, Av. das Forcas Armadas, 1649-026, Lisboa, Portugal, mjfl@iscte.pt, *Luís Gouveia*, *Amaro de Sousa*

A PON is an optical access network connecting a Central Office to a set of terminals using optical fibres and splitters, installed on intermediate nodes. For each PON we have to define where to install splitters and how to connect all elements through fibres. There are costs associated with intermediate nodes, splitter types and fibre connections. We consider a single PON and define the minimum cost design problem in the context of densely populated urban areas, proposing different discretized formulations and valid inequalities for this problem.

4 - The k-Architecture Connected Facility Location Problem
Markus Leitner, Institute of Computer Graphics and Algorithms, Vienna University of Technology, Favoritenstraße 9-11, 1040, Vienna, Austria, leitner@ads.tuwien.ac.at, *Ivana Ljubic*, *Markus Sinnl*, *Axel Werner*

In the design of fiber optic access networks three main deployment architectures have been considered: (i) fiber-to-the-home, (ii) fiber-to-the-building, and (iii) fiber-to-the-curb. We consider a variant of the connected facility location problem that allows to model mixed deployment strategies, since they often provide the best compromise between costs and bandwidth. Integer programming models are presented and computationally compared on realistic instances from three German towns. We also discuss natural extensions leading to bi- multi-objective variants of the problem.

■ TC-27

Tuesday, 12:30-14:00
G9-8

Combinatorial problems of multi-model line balancing and model sequencing II

Stream: Combinatorial Optimization II
Invited session

Chair: *Alexandre Dolgui*, IE & Computer Science, Ecole des Mines de Saint Etienne, 158, cours Fauriel, 42023, Saint Etienne, France, dolgui@emse.fr
Chair: *Mikhail Y. Kovalyov*, United Institute of Informatics Problems, National Academy of Sciences of Belarus, Surganova 6, 220012, Minsk, Belarus, kovalyov_my@yahoo.co.uk

1 - A decomposition-based algorithm for two-sided assembly line balancing problem with strong precedence constraints
Xiaofeng Hu, School of Mechanical Engineering, Shanghai Jiao Tong University, 800 Dong Chuan Road, Shanghai, China, wshxf@sjtu.edu.cn, *Wenjuan Zhang*
A decomposition-based algorithm is proposed to solve a two-sided assembly line balancing problem (TALBP). Based on the precedence features, the strong precedence constraint is defined and used to decompose the TALBP into a set of sub-problems. Each sub-problem is solved by an optimal sub-solution using branch-and-bound algorithm. These sub-solutions are then joined and adjusted to draw the final solution for the TABLP. Experiments have been conducted. The results show the proposed algorithm can effectively solve TABLP with strong precedence constraints.

2 - Two Sided Assembly Line Balancing: A Case Study
Fatma Selen Madenoğlu, Department of Industrial Engineering, Dokuz Eylül University, Faculty of Engineering, Izmir, Turkey, Dokuz Eylül University, Faculty of Engineering, Department of Industrial Engineering, 35160, Izmir, Turkey, selen.madenoglu@deu.edu.tr, *Lale Özbakır*, *Adil Baykasoğlu*
This paper presents a case study to address the two-sided assembly line balancing problem of a real company. A mathematical programming model is presented to formally describe the problem with precedence, zoning and synchronism constraints. The aim of the mathematical model is to minimize the cycle time. The result obtained from the mathematical model is compared with the existing layout via simulation. The results demonstrate how efficiently the two sided assembly line is for the practitioner.

3 - Models Sequencing Optimization for an Automated Fully Flexible Assembly System (F-FAS)
Maurizio Faccio, Department of Innovation in Mechanics and Management(DIMEG-Padova), University of Padova, Via Venezia 1, Padova, Italy, maurizio.faccio@unipd.it, *Giulio Rosati*, *Finetto Christian*
Sequencing optimization is historically related to the case assembly lines. It is possible to consider a particular single station system where the models sequencing optimization is a critical problem: The Fully Flexible Assembly System (F-FAS; Rosati et al., Assembly Autom. 1-2, 2013), an answer in case of high flexibility/low volumes scenarios.The system relies on a fully-flexible feeder, responsible for the parts delivery for assembly. Since in the F-FAS the feeding process is stochastic in nature, the defined sequence of model to assembly is critical in the complete order execution time.

4 - Searching for a maximal dominating cycle in undirected graphs
Fabio Salassa, DAUIN, Politecnico di Torino, Italy, fabio.salassa@polito.it, *Andrea Grosso*, *Wim Vancroonenburg*
Consider an undirected graph G = (V;E); a dominating cycle is a cycle C in G that covers all nodes of the graph. A node i of V is covered if it either lies on C or is adjacent to a node on C. We deal with the problem of detecting a cycle C* that cover as many nodes as possible. By exploiting a MIP solver an exact relax & cut algorithm is developed. The main idea is to iteratively introduce into the MIP model, as constraints, all disjoint cycles generated by the relaxation at the previous iteration. The pool of disjoint cycles is also increased by heuristically generated high quality cycles.

■ TC-29

Tuesday, 12:30-14:00
G9-3

Queueing Systems

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Iddo Eliazar*, Holon Institute of Technology, 58102, Holon, Israel, eliazar@post.tau.ac.il
Chair: *Uri Yechiali*, Department of Statistics and Operations Research, Tel Aviv University, 69978, Tel Aviv, Israel, uriy@post.tau.ac.il

1 - The Traffic Policeman Problem: Two Finite-Buffer Queues with Alternating Server
Efrat Perel, Tel Aviv University, 69978, Tel Aviv, Israel, fgnaamati@gmail.com, *Konstantin Avrachenkov*, *Uri Yechiali*
A policeman regulates two streams of traffic crossing an intersection. When one direction has the right-of way and the accumulating number of cars in the other direction reaches a threshold, the right-of-way is transferred to the latter direction, and vice versa. Consequently, we study a polling-type system of two finite-buffer queues served by a single server with threshold-based switching policy determined by the state of the queue which is not being served. We provide a probabilistic analysis of the system and investigate various performance measures.

2 - The Israeli Queue with Priorities
Nir Perel, Tel Aviv University, 69978, Tel Aviv, Israel, perelnir@gmail.com, *Uri Yechiali*
The 'Israeli Queue' is an N-queue polling system with unlimited-size batch-service, where the next queue to be served is the one with the most senior customer. We consider a 2-class, single-server, preemptive priority queueing model in which the high priority customers form a classical M/M/1 queue, while the low priority customers form the Israeli Queue. We present a probabilistic analysis of the model using both Probability Generating Functions and Matrix Geometric methods, and calculate various performance measures. Special cases are analyzed and numerical results are presented.

3 - The Asymmetric Inclusion Process: A Showcase of Complexity
Iddo Eliazar, Holon Institute of Technology, 58102, Holon, Israel, eliazar@post.tau.ac.il, *Shlomi Reuveni*, *Uri Yechiali*
The Asymmetric Inclusion Process (ASIP) is a model of tandem queues with unlimited batch service: when service is completed at queue k, all particles present at that queue move simultaneously to queue k+1. In this talk we establish that the ASIP is a showcase of complexity. We show that the ASIP's different performance measures display a rich span of behaviors ranging from 'mild' to 'wild' types of randomness: Gaussian load, Gaussian draining time, Rayleigh inter-exit times, Inverse-Gaussian coalescence times, and Power-Law occupation probabilities and occupation fluctuations.

4 - Occupation Probabilities and Catalan Numbers in the Asymmetric Inclusion Process
Uri Yechiali, Department of Statistics and Operations Research, Tel Aviv University, 69978, Tel Aviv, Israel, uriy@post.tau.ac.il, *Shlomi Reuveni*, *Iddo Eliazar*
We investigate occupation probabilities in the Asymmetric Inclusion Process (ASIP) and show that they obey a discrete two-dimensional boundary value problem. Solving this problem we find explicit expressions for the probability that site k is occupied by x particles (x=0,1,2,...). The numbers of Catalan's triangle are shown to naturally arise in the context of these occupation probabilities.

■ TC-30

Tuesday, 12:30-14:00
G9-10

Advances in Discrete and Global Optimization IV

Stream: Discrete and Global Optimization
Invited session

Chair: *Marco Lübbecke*, Operations Research, RWTH Aachen University, Kackertstraße 7, 52072, Aachen, Germany, marco.luebbecke@rwth-aachen.de

1 - Data transfer optimization in a system of collaborative systems
Ronan Bocquillon, Génie Informatique, Heudiasyc UMR CNRS 7253, Université de Technologie de Compiègne, Centre de Recherches de Royallieu - BP 20529, 60205, COMPIEGNE CEDEX, France, ronan.bocquillon@hds.utc.fr, *Antoine Jouglet*

Systems of systems are collections of systems which interact between themselves to achieve complex functions. These systems profit from contacts, arising when two entities are close enough, to share data. Such exchanges allow them to collaborate and route information from their sources to their recipients. We assume reliable predictions can be made about contacts, and thus study a problem aiming at profiting from this knowledge to determine a clever store-carry-and-foward routing. We will formally describe our problem and then propose dominance-rule-based resolution schemes.

2 - Strategies for improvement in the waiting line system in a call center using discrete simulation
Ever Angel Fuentes Rojas, Programa de Ingeniería Industrial, Universidad Libre, CRA 13 C 165 86 CASA 51, BOGOTA, Colombia, ever.fuentes@gmail.com, *Jeyson Andres Martinez Gamboa*

In recent decades, the demand for call center services has experienced significant growth which requires the application of tools and methodologies for planning of resources in a context where markets are constantly changing and customers are more demanding. It seeks to provide a methodology for evaluating the efficiency of resource planning through discrete event simulation. It relies on different tools like SPSS ® and FLEXIM. It was validated in a call center in the form of outsourcing, attending four types of companies, with twelve types of services and 350 agents in three daily shifts.

3 - A branch-and-price algorithm for rearranging a matrix to doubly bordered block-diagonal form
Michael Bastubbe, Operations Research, RWTH Aachen University, Kackertstr. 7, 52072, Aachen, Germany, bastubbe@or.rwth-aachen.de, *Martin Bergner*, *Alberto Ceselli*, *Marco Lübbecke*

In this talk we present an exact approach to the optimization problem of rearranging the rows and the columns of a matrix to doubly bordered block-diagonal form for a given number of blocks and some given balance condition on the blocks such that the total number of border rows and border columns is minimized. We present a branch-and-price algorithm which at first solves the pricing problem heuristically by exploiting its special structure. If the heuristic solution does not yield variables with promising reduced costs the pricing problem is solved exactly by an IP.

4 - Improving an approach of robustness scheduling for one machine problem
Boukedroun Mohammed, math, Etudiant, mohfou, mohfou, Algeria, medbkedroun@yahoo.fr

We present an improving of a robust scheduling for one machine problem based on interval structure and dominating partial orders, based on the improvement of these scheduling approach. In the separation of the tree's nodes by the algorithm of Carlier for determining optimal sequence and optimal solution, but we use jobs vertices and no vertices separation of production; the bound Lmax and the separation of nodes is based on nodes having the best bound to the last one. This is used for netting the tree's nodes.

■ TC-31

Tuesday, 12:30-14:00
G9-11

Methods and Models for Supply Chain Analytics

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Michael Katehakis*, Rutgers University, 08854, Piscataway, NJ, United States, mnk@rci.rutgers.edu

Chair: *Apostolos Burnetas*, Operations, Case Western Reserve University, 10900 Euclid Ave, 44106, Cleveland, OH, United States, atb4@weatherhead.cwru.edu

1 - Approximate solution for the inventory system with yield uncertainty and the lead time
Wen Chen, IROM, The University of Texas, United States, wen.chen@utexas.edu

The paper discusses a procurement dynamic problem. The firm can replenish its inventory from an unreliable supplier with positive leadtime (L). The problem involves a large state space of in-transit order. The paper treats two realistic versions of inventory problem, full backordering inventory system and lost-sales inventory system. We construct simple myopic approximations for both inventory systems which decompose L-dim problem to L different subproblems at every planning horizon.

2 - Investment and Pricing in a Supplier-Buyer Chain with Persistent Price Effects
Panagiotis Kyriazis, Management Science and Technology, Athens University of Economics and Business, Athens, Greece, kyriazis@kfs.gr, *Apostolos Burnetas*, *George Ioannou*

We consider a single product supplier —buyer chain where the supplier sets the wholesale price and the buyer the retail price, faced with a downward linear demand curve. We analyze the two-period pricing problem, under the assumption that the first period retail price affects the market size in the second period, and derive the equilibrium pricing policy. We also study the game where the two parties decide on individual investments in the first period, which increase the market size.

3 - Homogeneous Quasi-Skip-Free processes with "quasi" product form distribution
Dwi Ertiningsih, Leiden University, Niels Bohrweg 1, Rijnsburgerweg 124-E17, 2333CA, Leiden, Zuid Holland, Netherlands, dwiertiningsihd@math.leidenuniv.nl, *Flora Speksma*, *Laurens Smit*

We study QSF (Quasi-Skip-Free) processes, which are a generalization of QBD (Quasi-Birth-Death) processes, where jumps to higher phases are allowed. Under homogeneity and irreducibility assumptions we show that the stationary distribution has a product form as a function of the phase. We will study various applications such as the embedded G/M/1 and phase type batch service queues.

4 - Explicit Solutions and Other Properties of Successively Lumpable Quasi Skip Free Processes
Laurens Smit, Leiden University, Netherlands, lsmit@math.leidenuniv.nl, *Flora Speksma*

We consider Quasi-skip-free processes (QSF), a generalization of the quasi-birth-and-death processes. We use a simple condition under which a QSF is successively lumpable (SL-QSF) and the steady state distribution can be calculated explicitly and rapidly. These processes have applications in many areas of applied probability including queuing theory, reliability and the theory of branching processes. We discuss a procedure to decompose QSFs into separate SL-QSFs and we extend the method of successive lumping to calculate discounted rewards in a QSF with a fixed policy.

■ TC-32

Tuesday, 12:30-14:00
G8-1

Behavioral Supply Chain Management

Stream: Supply Chains
Invited session

Chair: *Steef van de Velde*, Technology & Innovation, RSM Erasmus University, PO Box 1738, 3000 DR, Rotterdam, Netherlands, svelde@rsm.nl
Chair: *Michael Becker-Peth*, Seminar für Supply Chain Management und Management Science, Universität zu Köln, Albertus Magnus Platz, 50923 , Köln, NRW, Germany, michael.becker-peth@uni-koeln.de

1 - Behavioral Aspects of Project Portfolio Selection — Why people choose projects poorly
Thomas Fliedner, TUM School of Management, Technische Universitaet Muenchen, 80333, Muenchen, Germany, thomas.fliedner@wi.tum.de, *Sebastian Schiffels*, *Rainer Kolisch*

We address the question of how people behave in the context of Portfolio Decision Analysis problems. We set up an experimental study based on the knapsack problem to investigate human performance in project selection and to study the selection process. Our results demonstrate consistent sub optimization for all subjects under different treatments. Based on subjects' final portfolio selection and portfolio development we identify decision heuristics which explain much of the observed behavior. The selection process of most subjects is consistent with a biased use of these heuristics.

2 - Designing Incentive Schemes for Truthful Demand Information Sharing
Lisa Scheele, Supply Chain Management, University of Cologne, Albertus-Magnus-Platz, 50923, Köln, Germany, lisa.scheele@uni-koeln.de, *Marco Slikker*, *Ulrich Thonemann*

Motivated by structurally biased demand forecasts in practice, we study a forecast sharing situation between a (better informed) sales and an operations department. Our objective is to incentivize truthful forecasts by applying payment schemes that penalize forecast errors. We formalize the setting as a signaling game with behavioral utility functions grounded in theories of lying aversion and loss aversion. By means of laboratory experiments we estimate the behavioral parameters of our model in order to design and validate forecast-error-based incentive schemes for truthful forecast sharing.

3 - Contract Specific Reference Prices in Supply Contracts
Michael Becker-Peth, Seminar für Supply Chain Management und Management Science, Universität zu Köln, Albertus Magnus Platz, 50923 , Köln, NRW, Germany, michael.becker-peth@uni-koeln.de

Although theoretically similar, different contracts induce different ordering behavior of human decision makers. In this study we analyze the effect of reference prices under different supply contracts. We show that reference prices can explain the observed ordering behavior.

4 - Bullwhip-effect as a measure of bounded rationality in supply chain management
Javier Pereira, Escuela de Ingeniería Informática, Universidad Diego Portales, Avenida Ejercito 441, Santiago, Chile, javier.pereira@udp.cl, *Claudio Fuentes*, *Fernando Paredes*

It has been shown that any ordering method (pull, push and hybrid) could minimize the bullwhip-effect in a supply chain, if the right context is chosen. We suggest that the Tversky and Kahneman's bounded rationality theory may be used to explain the bullwhip-effect as systematic error from the supply chain manager, who fails to properly match a situation with the currently best ordering strategy. We explore situations where heuristic judgment (representativeness, availability and adjustment and anchoring) is used as an analysis grid, revealing different bias inducing the bullwhip-effect.

■ TC-33

Tuesday, 12:30-14:00
G8-3

Managing Inventory and Capacity

Stream: Supply Chain Risk Management
Invited session

Chair: *Emre Berk*, Department of Management, Faculty of Business Administration, Bilkent University, 6800, Ankara, Turkey, eberk@bilkent.edu.tr

1 - Models to estimate degree of repair in Repairable Systems
Ernie Love, Segal Graduate School of Business, Simon Fraser University, 500 Granville Street, Vancouver, Canada, V6C 1W6, Vancouver, British Columbia, Canada, love@sfu.ca

The purpose of this research is to estimate the repair effects in a repairable system. The failure/repair structure is modeled in a Kijima virtual age framework. Covariate data was also used to compare proportional hazards, accelerated life and Trend-Renewal frameworks in estimating the failure/repair process. Data from a cement kiln is used for comparative testing.

2 - Ordering and Financing Policies of Capital-Constrained Retailer under Transshipment
Zou Xuxia, School of Management, Huazhong University of Science and Technology, Rm 507, School of Management, HuaZhong University of Science and Technology, 1037, LuoYU Rd, 430074, Wuhan, Hubei Province, China, xuxia.zou@mail.hust.edu.cn

This paper studies the impact of capital constraint on a retailer having multiple outlets. The retailer is financed by a bank; transshipment between outlets is allowed. The results show that when demand is normally distributed and bank loan interest rate is exogenous, the retailer's profits increase with a decrease in demand correlation while its optimal ordering quantity and bank profits increase with an increase in demand correlation. When the interest rate is endogenous, a bank prefers a higher loan rate and will benefit from the transshipment; however, the retailer's profit decreases.

3 - A Unifying Framework for One for One Perishable Inventories
Emre Berk, Department of Management, Faculty of Business Administration, Bilkent University, 6800, Ankara, Turkey, eberk@bilkent.edu.tr

In this talk, I present a unifying framework for the one-for-one perishable inventory system. As such, it generalizes the existing models to the case of exogeneous random lead times. Some properties of the models are established and the operating characteristics are derived. Implications for different objectives are also discussed.

4 - Value stream mapping and a conwip system design
Şenim Özgüler, Department of Industrial Engineering, Yildiz Technical University, Yıldız Teknik Üniversitesi Beşiktaş Kampüsü, 34349, İstanbul, Turkey, senimozgurler@hotmail.com, *Semih Onut*, *M. Bülent Durmusoglu*

In today's competitive environment, for adaptation, companies need to respond customer demands and to provide high quality low priced products. Lean manufacturing is a systematic approach for waste identification and elimination; it obtains a competitive advantage over others. Value stream mapping is a visualization tool of lean manufacturing; it helps to identify wastes in the system. In this paper, value stream mapping study has been carried out in a tractor factory. Firstly, current state is examined, and then a CONWIP system design is suggested for the future state improvements.

■ TC-34

Tuesday, 12:30-14:00
G8-4

Sustainability: Closed loop supply chains and design

Stream: Supply Chain Planning
Invited session

Chair: *Hans-Otto Guenther*, Production Management, TU Berlin, Strasse des 17. Juni 135, 10623, Berlin, Germany, hans-otto.guenther@tu-berlin.de

1 - The impact of information and lead-times in a closed loop supply chain
Takamichi Hosoda, Aoyama Business School, Aoyama Gakuin University, 4-4-25, Shibuya, 1508366, Shibuya-ku, Tokyo, Japan, hosoda@gsim.aoyama.ac.jp, *Stephen Disney*

We investigate the impact of advance notice of the product returns on the performance of a closed loop supply chain with lead-times. A proportion of the sold products to the market are returned to an external remanufacturer. After a lead-time the used products are converted into "as-good-as-new" products to be used, together with new products, to satisfy market demand. We demonstrate that the lead-times and parameters describing the return rate have a significant impact on the manufacturer's performance.

2 - Optimising Value Recovery from Product Returns in Closed-loop Supply Chains (CLSC) through Linear Programming Models
Wei Qu, Nottingham University Business School, United Kingdom, wei.qu07@gmail.com, *Luc Muyldermans*

We explore a LP model to maximise value recovery from product returns and to investigate the optimal recovery policy with consideration of fundamental CLSC constraints of component durability, return quality and product life cycle. The recovery options include remanufacturing and reusing in the primary market, refurbishing and selling in the secondary market and scrapping. We explore key sensitivities of the optimal value recovery with respect to the changes in various parameters. We also discuss the managerial uses of the model for product recovery decision-making by numerical examples.

3 - Finite planning horizon inventory decision-making models for manufacturing systems with inspection, sorting and product recovery
Konstantina Skouri, Mathematics, University of Ioannina, Ioannina, 45110, Ioannina, Greece, kskouri@uoi.gr, *Lakdere Benkherouf*, *Ioannis Konstantaras*

This paper studies a manufacturing/remanufacturing system where new items and remanufacturing ones satisfy a time varying demand over a finite planning horizon. Used products are kept in recoverable inventory until the start of a combined inspection and recovery process. Remanufactured items are assumed as-good-as new ones while refurbished items are sold to a secondary market at a reduced price. The aim is the determination of the optimal ordered, remanufactured quantities and inventory level of recoverable items, which minimize the cost over the planning horizon.

4 - "Minimize Time-to-Sustainability" as new optimization approach for sustainable development of supply chains
Matthias Kannegiesser, Production Management, TU Berlin, Danziger Str., 35, 10435, Berlin, Deutschland, Germany, mkannegiesser@yahoo.com, *Hans-Otto Guenther*

Sustainability in supply chains is increasingly important: companies need to improve the environmental and social impact as well as staying economically competitive. We propose "Minimize-Time-to-Sustainability" as new sustainability optimization approach for supply chain network design. The approach minimizes the time, until sustainability target values for defined indicators such as costs or CO2 are met steady state in a supply chain network. We present framework and model formulations and show, how the approach can be applied based on a case from the automotive industry.

■ TC-35

Tuesday, 12:30-14:00
G8-2

OR Applications in Industrial Manufacturing Systems

Stream: Manufacturing and Warehousing
Invited session

Chair: *Wichai Chattinnawat*, Industrial Engineering, Chiang Mai University, Department of Industrial Engineering, Faculty of Engineering, Chiang Mai University, 239 Huay Kaew Road, Muang District, Chiang Mai, 50200, 50200, Chiang Mai, Thailand, chattinw@eng.cmu.ac.th

1 - Modeling, simulation and optimization of the main line of a filling beer company
Lucila Ramos, Instituto de Desarrollo Tecnológico para la Industria Química, Ruta Nacional 168 - Paraje "El Pozo", 3000, Santa Fe, Argentina, ramos.lucila@gmail.com, *Natalia Basán*, *Carlos Mendez*, *Mariana Cóccola*

This paper introduces advance techniques of modeling and simulation in order to represent the activities involving in a beer filling line located in the second largest beer company in Argentina. To optimally manage design and operational activities in such packaging system, a discrete simulation model is developed. The resulting model can be used to evaluate model sensitivity to determine the impact of specific operational parameters on the performance of the line logic. The results, obtained through the proposed method, conclude that significantly growth in production level can be achieved.

2 - Assignment Problem of Injection Machines in an Electronic Equipment Manufacturer
Selin Kara, Industrial Engineering, Yildiz Technical University, Turkey, sskara80@gmail.com, *Engin Pekel*, *Yagmur Ercins*, *Mustafa Kemal Çelik*

Injection is one of the methods used in plastic material production. In injection machines producing plastic part, assignment of appropriate injection mold and using suitable row material and dye in terms of part that is going to be produced are substantial. Producing different products in the same machine increases machine setup times and this leads production time to inflate. As a result of this, injection molds should be assigned to machines in an appropriate tonnage. The Purpose of this study is to minimize charge and discharge injection molds during manufacturing.

3 - Multistage Inspection System Design of Hard Disk Drive Actuator-Pivot Bearing Manufacturing Process
Wichai Chattinnawat, Industrial Engineering, Chiang Mai University, Department of Industrial Engineering, Faculty of Engineering, Chiang Mai University, 239 Huay Kaew Road, Muang District, Chiang Mai, 50200, 50200, Chiang Mai, Thailand, chattinw@eng.cmu.ac.th

This research aims to design and improve the quality monitoring scheme of pivot bearing used for an HDD actuator manufacturing process. The traditional monitoring has focus heavily on the incoming material inspection and 100% in-process sampling inspection. This research investigate the effectiveness of the monitoring scheme by designing the integrated acceptance sampling scheme of the incoming material and an economical control scheme for pivot bearing inspection based on integrated network of the multistage process.

4 - A Framework for the Computer-Aided Planning and Optimization of Manufacturing Process Chains in the Context of Functionally Graded Components
Marcus Petersen, Product Engineering, Heinz Nixdorf Institute, Fuerstenallee 11, 33102, Paderborn, Germany, marcus.petersen@hni.uni-paderborn.de, *Jürgen Gausemeier*

Functional gradation denotes a continuous distribution of properties over the spatial dimensions of a component. These distributions are tailored with respect to later applications and require complex manufacturing processes. Therefore, a framework for the planning and optimization of manufacturing process chains for those components is presented. The framework is divided into three modules — the Component Description for the integration of graded properties into CAD models, the Expert System for the synthetization of alternative process chains and the Model-based Process Chain Optimization.

■ TC-36

Tuesday, 12:30-14:00
G7-1

Cutting and Packing 1

Stream: Cutting and Packing
Invited session

Chair: *Francisco Parreño*, MAthematics, Universidad de Castilla-La Mancha, 02002, Albacete, Spain, Francisco.Parreno@uclm.es

1 - Constructive Heuristic for the 3D Container Loading Problem
Xiaozhou Zhao, School of Management, University of Southampton, University of Southampton, SO17 2ER, Southampton, United Kingdom, xiaozhou.zhao@gmail.com, *Julia Bennell*, *Kathryn Dowsland*, *Tolga Bektas*

The paper aims to develop effective heuristics for 3D regular packing problem where there are multiple identical or non-identical large items. In this presentation we investigate problems with weakly heterogeneous small items and one or more identical large item. Our research focuses on the impact of priority orders. Different existing box sorting strategies are combined into sets and tested on benchmark data. In a similar manner, we test different sets of heuristics for their impact on the various problem instances. Extensive numerical results on benchmark problem instances will be presented.

2 - Biased Random Key Genetic Programming based Heuristics for a on-line 3D Cutting Problem
José Fernando Gonçalves, LIAAD, INESTEC, Faculdade de Economia do Porto, Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-464, Porto, Portugal, jfgoncal@fep.up.pt

This paper addresses a cutting problem where 3D rectangular items are presented to a decision maker (DM) one at a time, sequentially, and must be cut from a large 3D stock object chosen by the DM before the next item is known. The heuristics are generated by a biased random key based Genetic Programming algorithm. The analysis of the heuristics generated is based on an average-case performance. Computational experiments demonstrate that the approach performs well. Supported by Fundação para a Ciência e Tecnologia (FCT) project PTDC/EGE-GES/117692/2010.

3 - An adaptive algorithm for container loading problem with load-bearing constraints.
Maria Teresa Alonso Martínez, Department of mathematics, University of Castilla-La Mancha, Edificio Infante Don Juan Manuel, Avda.de España s/n, 02071, Albacete, Spain, mariateresa.alonso@uclm.es, *Ramon Alvarez-Valdes*, *Francisco Parreño*, *Jose Tamarit*

In the work we address the problem of maximizing container volume utilization while respecting a set of practical constraints: full support of boxes, allowed orientations and load-bearing capacity. We have developed different heuristics for solving the problem and we have combined them into a GRASP algorithm. The algorithm is composed of a constructive phase with a reactive method for selecting the heuristics which are best for each instance, and an improving phase in which several improvement methods are applied. An extensive computational study shows the efficiency of the proposed procedure.

■ TC-37

Tuesday, 12:30-14:00
G7-4

Multicriteria Decision Making and Its Applications IV

Stream: Multicriteria Decision Making
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Nina Kajiji*, Computer Science and Statistics, University of Rhode Island, and The NKD Group, Inc., USA, Kingston, RI, United States, nina@nkd-group.com

1 - Selecting Forecasting Techniques via TOPSIS: A Case in the Retail Sector
Bahadir Gulsun, Yildiz Technical University, Turkey, bahadir@yildiz.edu.tr, *Onur Yilmaz*, *Nilay Giray*

In this study, we consider a case of demand forecasting for different types of goods. We seek for the most suitable forecasting technique in our case via TOPSIS method. Minitab software is employed to use different forecasting techniques for demands of soft drinks, butter, bread and biscuits for twelve months, using data of sales for the previous twelve months. As a result, we show that different techniques present the most accurate forecasts depending on the type of demand. We use TOPSIS to determine the best forecasting method for soft drinks demand according to various criteria.

2 - Dynamic Hedging with Nonlinear Multicriteria Combinatorial Optimization for VaR Control and Adaptive Sharpe Ratios
Nina Kajiji, Computer Science and Statistics, University of Rhode Island, and The NKD Group, Inc., USA, Kingston, RI, United States, nina@nkd-group.com, *Gordon Dash*

A new mixed-integer nonlinear multicriteria goal program (MINLGP) with branch and bound and separable programming constraints is introduced an applied to an efficient portfolio within a dynamically hedged trading environment. We find similar Sharpe ratios for rebalanced multicriteria portfolios that are hedged and equally weighted compared to those that are hedged and efficiently diversified. However, using a percentile risk measure (VaR) the hedged optimally diversified portfolio outperforms its non-hedged and naively diversified counterpart.

3 - AHP methodology applied to industrial location: a Brazilian perspective
José Fabiano Serra Costa, UERJ - Rio de Janeiro State University, Rua São Francisco Xavier, 524 sl 6028-B — Maracanã, 20559-900, Rio de Janeiro, RJ, Brazil, fabiano@ime.uerj.br, *Aline Borges*, *Thais Machado*

The purpose of this work is to help a textile Brazilian company, specialized in jeans production, with a study on the conditions to installing a plant considering three possible regions, where the most important textile companies of the country are located. In the study, the Hierarchy Analysis Process — a multicriteria methodology to decision support - is used, and results show a slight tendency to Rio de Janeiro state when compared to Santa Catarina state, both presenting significant advantage over Rio Grande do Norte state.

4 - Oil and gas facility vulnerability assessment: An Analytic Network Process approach
Makbule Kandakoglu, Department of Information Technologies, Turkish Petroleum Corporation, Sögütözü Mahallesi 2. Cad. No:86 Cankaya, 06100, Ankara, Turkey, mcubuk@tpao.gov.tr, *Ahmet Kandakoglu*

Oil and gas facilities are potential targets for the terrorists to draw the attention of public and government, and to create a huge impact on the society and economy. Assessing the vulnerabilities of these facilities arising from this threat is critical and time consuming. Therefore, this paper proposes an analytic network process (ANP) based vulnerability assessment approach that considers the possible interdependencies among the assessment factors. Finally, this approach can be used as a starting point for a more formal and adequate risk assessment and management in combating the terrorism.

■ TC-39

Tuesday, 12:30-14:00
G7-3

Analytic Network Process

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Ahmet Kandakoglu*, Scientific Decision Support

Department, Turkish Air Force Command, Bakanliklar, 06100, Ankara, Turkey, akandakoglu@hvkk.tsk.tr

1 - An ANP Based Recommendation Framework with an Application in the Semantic Technology Domain
Filip Radulovic, Artificial Intelligence, Universidad Politécnica de Madrid, Ontology Engineering Group, Facultad de Informatica, UPM, Avda. Montepríncipe, s/n, 28660, Boadilla del Monte, Spain, filiprd@gmail.com, *Raúl García-Castro*

In this work we present a theoretical recommendation framework based on the Analytic Network Process. The proposed recommendation framework provides an algorithm for the automatic comparison of alternatives based on the results of their evaluation instead of on expert or user opinions. Furthermore, such framework gives the users a possibility to specify quality requirements, hence adapting the recommendations to users' needs. We also present a software support for the recommendation framework, with a Web application for the recommendation of the software in the Semantic Technology domain.

2 - Evaluation of Green Supply Chain Performance
Özer Uygun, Industrial Engineering, Sakarya University, Turkey, ouygun@sakarya.edu.tr, *Hasan Kacamak*, *Gülay Odabaşı*

According to environmental regulations and companies' politics on environment, firms have to enhance their skills on green management activities. In this study a model is proposed for evaluating green supply chain (GSC) performance of companies in terms of green design, green purchasing, green transformation, green logistics and reverse logistics. The cause-effect interaction among main criteria is derived by DEMATEL method. Then the ANP method is used for obtaining the weights of the sub-criteria. Finally, TOPSIS method is applied for evaluating the GSC performance of alternative companies.

3 - A Systematical Approach for Evaluation and Ranking of R&D Projects
Hasan Kacamak, Computer and Information Sciences, Sakarya University, Sakarya Universitesi Esentepe Kampusu, Department of Computer and Information Sciences Serdivan, 54187, Sakarya, Turkey, hkacamak@sakarya.edu.tr, *Özer Uygun*, *Fuat Simsir*, *Esra Kurt Tekez*

Project selection requires considering many criteria which makes the decision process a harder problem. Since the budget of the state institutions that fund R&D projects is limited and usually there are many submitted projects, the project selection decision making process is significant in order to allocate the budget effectively. In this study a systematical approach is proposed for project evaluation and ranking using an integrated multi-criteria decision making techniques. The criteria are based on the Turkish Scientific and Technical Research Institute's project selection procedures.

4 - A new fuzzy group decision making framework for renewable energy resource selection problem
Sezin Guleryuz, Department of Industrial Engineering, Galatasaray University, Galatasaray University, Industrial Engineering Department, 34357, Ortaköy—Istanbul, Turkey, sezinguleryuz@yahoo.com, *Gulcin Buyukozkan*

The high complexity of socioeconomic environments often makes it difficult for a single decision maker (DM) to consider all the important aspects of some decision problems. Therefore, a group decision making (GDM) process is often preferred to avoid the bias and minimize the partiality in the decision process. This paper develops a new GDM approach based on integrated linguistic interval fuzzy preference relations and analytic network process. To demonstrate the potential of the proposed approach, a case study is given for selecting the most appropriate renewable energy alternative in Turkey.

■ TC-40

Tuesday, 12:30-14:00
Y12-1

DEA Theory III

Stream: DEA and Performance Measurement
Invited session

Chair: *Cinzia Daraio*, Department of Computer, Control and Management Engineering Antonio Ruberti, University of Rome "La Sapienza", Via Ariosto, 25, Roma - ITALY, 00185, Rome, Italy, daraio@dis.uniroma1.it

1 - DEA Models for Estimating Efficiency When Inputs (Outputs) Are Not Substitutes
Darold Barnum, Information & Decision Sciences; Management, Univ of Illinois at Chicago, 1028 North Euclid Ave., 60302-1322, Oak Park, IL, United States, dbarnum@uic.edu, *John Gleason*

DEA is frequently applied to fixed proportion technologies (technologies that involve nonsubstitutable inputs and/or nonsubstitutable outputs). However, DEA theory requires substitutability. In this paper, we identify the consequences of nonsubstitutability on conventional DEA efficiency estimates. We develop adapted efficiency indicators that add constraints to CCR and BCC models so they yield valid efficiency estimates when some or all of the inputs (outputs) are not substitutable for each other. We compare the results of conventional and constrained DEA models with airline data.

2 - Directional Elasticity of Scale for Research Institutes via DEA
Wenbin Liu, Kent Business School, canterbury, United Kingdom, w.b.liu@kent.ac.uk

The classic elasticity of Scale is defined assuming the inputs are changed proportionally. However for many research institutes, the changes of inputs are far from proportional. This work introduces the notion of directional elasticity of scale for production functions, and then further extends it into the DEA framework to utilize the empirical production functions. Methods of computing the directional elasticity of scale are developed with a case study.

3 - Returns to Scope: A Metric for Production Synergies Demonstrated for Hospital Production
Andrew Johnson, Department of Industrial & Systems Engineering, Texas A&M University, 77843, College Station, TX, United States, ajohnson@tamu.edu, *Brandon Pope*

Knowledge of the production function's scope properties can provide insights for firms choosing their operating strategy and policy-makers considering industry structure. We introduce returns to scope which is distinct from scale properties and does not rely on price information. We use simulated data and hospital production data from the 2008 National Inpatient Sample of AHRQ's Healthcare Cost and Utilization Project. We find that smaller hospitals experience negative returns to scope (productivity losses) from the joint production of minor and major diagnostic procedures.

4 - Consolidating Productivity Stylized facts at the micro level: a General Framework
Cinzia Daraio, Department of Computer, Control and Management Engineering Antonio Ruberti, University of Rome "La Sapienza", Via Ariosto, 25, Roma - ITALY, 00185, Rome, Italy, daraio@dis.uniroma1.it

We propose a general formulation of the production process to measure productivity stylized facts. It is based on conditional frontier models, a more general alternative to regression-based models. We propose to assess productivity stylised facts by keeping into account the heterogeneity of units and provide a unifying framework for various streams of literature. Our framework is useful for consolidating productivity stylized facts at the micro level, deriving economic regularities and letting empirical evidence contribute to the advancements of economic theory.

■ TC-41

Tuesday, 12:30-14:00
Y12-5

DEA Applications XII

Stream: DEA and Performance Measurement II
Invited session

Chair: *Eliane Gomes*, Brazilian Agricultural Research Corporation, Parque Estação Biológica, W3 Norte final, Asa Norte, 70770901, Brasília, DF, Brazil, eliane.gomes@embrapa.br

1 - A new approach to determine input/output variables in data envelopment analysis
Olcay Alpay, Statistics, Sinop University, Faculty of Arts and Sciences, Department of Statistics, 57000, Sinop, Turkey, olcayb@sinop.edu.tr, *Elvan Akturk Hayat*

Determination of the input/output variables is an important issue in data envelopment analysis (DEA). Researchers often refer to expert opinions in defining these variables. In this study, we propose a new approach to determine the input/output variables. Copula functions are used for modeling the dependency structure of the variables with each other. In this study, we use the local dependence function which analyzes the point dependency of variables of copulas to define the input/output variables and we construct a simulation study to test the efficiency in data envelopment analysis.

2 - An Enhanced Russell Measure Approach for Solving the Discontinuity of the Super-efficiency Measure in the Presence of Infeasibility
Ya Chen, School of Management, University of Science and Technology of China, No. 96, Jinzhai Road, 230026, Hefei, China, ychen10@mail.ustc.edu.cn, *Yongjun Li*, *Liang Liang*

Recently, many researchers try to solve the infeasibility of the super-efficiency model. However, few examine the discontinuity of such a super-efficiency measure. This paper considers such the issue based on enhanced Russell measure (ERM). Two super-efficiency DEA models are proposed in the presence of infeasibility. Then, this paper proposes a two-step process and a corresponding algorithm to calculate the super-efficiency scores, and has proven that the resulted super-efficiency measure is continuous. Finally, we illustrate the proposed approach through an example of the US cities.

3 - How car dealers adjust prices to reach the product efficiency frontier in the spanish automobile market
Eduardo Gonzalez, Business Administration, University of Oviedo, Av Cristo s(n, 33071, Oviedo, Asturias, Spain, efidalgo@uniovi.es, *Juan Ventura*, *Ana Cárcaba*

Competitive analysis is concerned with the ability of firms to deliver products with superior product/price ratio. We assess product efficiency in the Spanish automobile market, overcoming some limitations in the literature: 1) dealership discounts, 2) list of attributes, 3) sample size. Our data set comprises more than 2000 car versions with more than 60 product attributes. Official and discounted prices are considered to obtain DEA scores of product efficiency. The results show how dealers of inefficient models adjust prices (below the official price) in order to move towards the frontier.

4 - Comparisons of Groups based on non-Archimean DEA Measures of Performance and Fractional Regression Models
Eliane Gomes, Brazilian Agricultural Research Corporation, Parque Estação Biológica, W3 Norte final, Asa Norte, 70770901, Brasília, DF, Brazil, eliane.gomes@embrapa.br, *Geraldo Souza*

We consider the use of the non-Archimedean infinitesimal epsilon in DEA-CCR models. The application of interest is defined by the performance measure of the Brazilian Agricultural Research Corporation research centers. We characterize an assurance region for the non-Archimedean element and suggest a value for it. Types of DMUs are compared using fractional regression models and quasi maximum likelihood inference. We conclude that the research centers aimed at studying specific agricultural products are dominant.

■ TC-42

Tuesday, 12:30-14:00
Y12-3

Socio-economics for Security Decisions

Stream: Decision Processes
Invited session

Chair: *Javier Cano*, Rey Juan Carlos University, Spain, javier.cano@urjc.es

1 - Adversarial and Non-Adversarial Risk Analysis for Security over Multiples Sites
Javier Cano, Rey Juan Carlos University, Spain, javier.cano@urjc.es, *David Rios-Insua*

We discuss security resource allocation over multiple sites that need to be protected. We frame the problem through a combination of risk analysis and adversarial risk analysis models. The Defender needs to decide her best portfolio of countermeasures to protect its installations from several possible threats.

2 - Effective Enforcement Strategy in the Implementation of Security Regulations
Woohyun Shim, Information Engineering & Computer Science, University of Trento, Via Sommarive 14, 38123, Trento, TN, Italy, woohyun@disi.unitn.it, *Fabio Massacci*

This study investigates strategies for the effective implementation of a regulation, taking account of possible responses from the regulated firms. To be effective, a regulation should have an enforcement scheme that can provide the firms with incentives to allocate their resources to comply with the regulation. Using a principal-agent model, we provide a theoretical framework for analysing government enforcement strategies in the context of security regulations. Using a case study on airport security, we then propose strategies that can improve the effectiveness of an enforcement scheme.

3 - Modeling an Emerging Terrorist Threat against Airport Security Scenario
Alessandro Pollini, Deep Blue, Piazza Buenos Aires 20, 00198, Rome, Italy, Italy, alessandro.pollini@dblue.it, *Alessandra Tedeschi*, *Javier Cano*

We analyze new emerging terrorist threats against airport installations and systems, such as bio- and cyber-attacks, which jeopardize passengers' security and increase risk perception. Airport authorities aim at mitigating their effects by implementing several technical, procedural and organizational countermeasures. We give advice for devising a multi-objective security contingency plan within the Adversarial Risk Analysis framework.

4 - Allocating Resources to Secure the Performance of Complex Networks
Ahti Salo, Systems Analysis Laboratory, Aalto University School of Science and Technology, P.O. Box 11100, Otakaari 1 M, 00076, Aalto, Finland, ahti.salo@aalto.fi, *Jussi Kangaspunta*, *Juuso Liesiö*

In this paper, we model critical transportation systems as complex networks which consist of nodes and edges. The performance of a network is measured by the extent to which the transportation objectives are achieved if some network nodes are incapacitated. We develop methods to identify (i) those nodes which are most critical to network performance in multiple disruption scenarios and (ii) those portfolios of actions which are cost-effective in securing the performance of the network across these scenarios.

■ TC-43

Tuesday, 12:30-14:00
Y12-2

Mathematical Economics and Optimal Control

Stream: Mathematical Economics
Invited session

Chair: *Alexander Zaslavski*, Technion, 32000, Haifa, Israel,

ajzasl@techunix.technion.ac.il

1 - On a unifying model for noncooperative games
Erik Balder, Department of Mathematics, Universiteit Utrecht, PO Box 80 010, 3508 TA UTRECHT, 3508, Utrecht, Netherlands, E.J.Balder@uu.nl

A general model is presented for noncooperative games. Specializations include Bayesian games with incomplete information, games with a continuum of players, anonymous games and finite games. General results about equilibrium existence and purification will be presented, including their consequences for those specializations.

2 - Invariant sets, equilibrium points and their approximations
Elza Farkhi, School of Math. Sciences, Tel-Aviv University, Haim Levanon Str., 69978, Tel Aviv, Israel, elza@post.tau.ac.il

The set of equilibrium points of a set-valued map F is the set of fixed points of the Euler map G=I+hF, where h is a scalar. If the map F is upper semi-continuous and weakly dissipative (one-sided Lipschitz with a negative constant), this set is a non-empty compact subset of an invariant set of a differential inclusion with F in the right-hand side. Methods and rates of approximation of the invariant sets and the fixed points are discussed in the case of weakly dissipative and Lipschitz-dissipative mappings.

3 - Optimal control of the management of a renewable resource in a risky environment: an application to fisheries.
Patrice Loisel, UMR MISTEA, INRA, 2 place Viala, 34060, Montpellier, France, patrice.loisel@supagro.inra.fr

The exploitation of a natural resource can be disturbed by a random environment. We assume that the growth of a natural resource is deterministic but is subject to random jumps at random times. We consider a continuous time optimal control in infinite horizon problem. The obtained first-order optimality conditions reveal, as in the pure deterministic case, the existence of a turn-pike. Application to fisheries management is presented including a study of the dependence of the turn-pike with respect to growth parameters and economic characteristics of the manager.

4 - Optimal spatially distributed harvesting
Vladimir Veliov, Institute of Mathematical Methods in Economics, Vienna University of Technology, ORCOS, Argentinierstr. 8/119, 1040, Vienna, Austria, veliov@tuwien.ac.at

The talk will present some new models and results about optimal utilization of spatially distributed renewable resources. A typical model involves a distributed control system on an one- or two-dimensional domain. The talk will focus on a model of periodic harvesting on a circular domain, for which theoretical and numerical results will be presented. The talk is based mainly on a joint work with A. Belyakov, A. Davydov, A. Platov and V. Veliov.

■ TC-44

Tuesday, 12:30-14:00
Y12-4

Networks and Industrial Organization

Stream: Dynamical Systems and Game Theory
Invited session

Chair: *Telmo Parreira*, University of Minho, 4000, Braga, Portugal, telmoparreira@hotmail.com
Chair: *Alberto Pinto*, Mathematics, University of Porto, Portugal, aapinto1@gmail.com

1 - Local market structure in a Hotelling town
Telmo Parreira, University of Minho, 4000, Braga, Portugal, telmoparreira@hotmail.com, *Alberto Pinto*

We consider the problem of spatial price competition à la Hotelling in a network, where the firms are located at the nodes and the consumers are uniformly distributed along the edges. We find suficient conditions to guarantee that a Hotelling town network has a unique optimum local price strategy that determines a local market structure and that is the unique Nash price equilibrium. We introduce the idea of n-space bounded information, where the firms have limited knowledge of the network and we prove that a firm can compute approximately its own Nash price and profit, depending upon n.

2 - Double Best Response algorithm for network formation
Vsevolod Korepanov, ICS of RAS, Russian Federation, kvsevolodo@mail.ru

Let there be a set of nodes that can form one-sided links with each other. An edge (two-sided link) between two nodes exists if both nodes agree with it. Each node have an cost's on each one-sided link, but have a bigger reward for each other node associated with it a chain of edges node. The problem of decentralized algorithm for effective network formation is considered. The double-best response algorithm is suggested. This algorithm can take place with nodes that are rational and it is better then simple best response.

3 - Two-levels approach to location problems with capacity considerations
Matej Cebecauer, Department of Transportation Networks, University of Žilina, Plavisko 138, 03401, Ruzomberok, Slovenská republika, Slovakia, matej.cebecauer@gmail.com

When solving location problems in the domain of public systems we are dealing with spatially large areas. Consequently, numbers of possible candidate locations and serviced customers are huge what makes difficult the use of classical approaches. Typical solution is the use of spatial aggregations. In this paper we show an alternative approach based on two-levels procedure. First, we solve the location problem at the macroscopic level obtaining primary division of the service area into regions. In the second step,we solve the location problem at the microscopic level separately for each region.

4 - Cost Structure of Friendliness in Nash Networks
Banchongsan Charoensook, ALHOSN University, United Arab Emirates, b.charoensook@alhosnu.ae

This paper extends the two-way flow model of Bala and Goyal (2000) to a case in which agents are heterogeneous in their link formation costs, aiming to shed light on the reality that an agent who is relatively more friendly or attractive than other agents spends lower efforts contacting other agents, and other agents also spend lower efforts contacting him. Nash networks in this model have similar, but not identical, shape to those in the model of Sarangi et al. (2011). This confirms that partner heterogeneity plays a relatively more important role in influencing the shape of Nash networks.

■ TC-45

Tuesday, 12:30-14:00
Y10-3

New Mathematical Models in Energy Markets I

Stream: Mathematical Models in Macro- and Microeconomics
Invited session

Chair: *Miray Hanım Yıldırım*, Institute of Applied Mathematics, Middle East Technical University; Department of Industrial Engineering, Çankaya University; European Commission, Joint Research Centre, Institute for Energy and Transport, Institute of Applied Mathematics Middle East Technical University, 06531, Ankara, Turkey, e160106@metu.edu.tr
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Estimation of the impact of forward contracts on producers' market power
Ekaterina Daylova, Lomonosov Moscow State University, Russian Federation, e.dajlova@gmail.com, *Alexander Vasin*

Reduction of large producers' market power is an important problem for many markets of homogeneous goods. Forward contracts are considered as an efficient instrument to reduce the market power, in particular, for electricity markets. In our model the spot price depends on a random factor. We take into account the presence of risk-neutral arbitrageurs. We describe a strategic model of agents' interaction in a two-stage market and determine their optimal behaviour. We derive conditions under which the subgame perfect equilibrium exists and estimate reduction of producers' market power.

2 - Efficiency of Mechanisms in Wholesale Electricity Markets
Alexander Vasin, Operations Research, Lomonosov Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su

I consider several types of auctions (uniform price, pay-as-bid, Vickrey) and discuss mathematical models for evaluation of the market power in these auctions. I consider Cournot equilibrium and supply function equilibrium concepts in this context. I compare theoretical results, computational experiments and empirical data in order to determine the optimal schemes for day ahead and real time auctions in electricity markets.

3 - A two-stage stochastic transmission planning model for multivariate wind farms and load
Heejung Park, Electrical and Computer Engineering, The University of Texas at Austin, United States, tohjpark@gmail.com, *Ross Baldick*

We present a stochastic transmission system planning model with production from wind farms represented as a multivariate random variable. The sequential approximation method is used to iteratively solve a two-stage stochastic program until a given tolerance is satisfied for the model. Thirty-six wind farms and load are represented by multivariate random variables and a linearized DC power flow is used in an optimal load flow. To investigate the impact of the production of the wind farms in different locations, we simulated a simplified Electric Reliability Council of Texas (ERCOT) case.

4 - A New Robust Electricity Market Model under Uncertainties
Miray Hanım Yıldırım, Institute of Applied Mathematics, Middle East Technical University; Department of Industrial Engineering, Çankaya University; European Commission, Joint Research Centre, Institute for Energy and Transport, Institute of Applied Mathematics Middle East Technical University, 06531, Ankara, Turkey, e160106@metu.edu.tr, *Gerhard-Wilhelm Weber*

Energy policies for sustainable development resulted in reforms, revolutions, and restrictions in energy markets. Regarding these, electricity markets, with the highest priority among the energy markets, are being evolved since the beginning of the last decade. Therefore, in this study, we present a new electricity market model that reflects the recent reforms and restrictions. The model is developed for the markets under perfect competition and handles uncertainties. The model is also demonstrated for a sample electricity network in order to distinguish the effect of reforms and restrictions.

■ TC-46

Tuesday, 12:30-14:00
Y10-1

Cooperation and Competition

Stream: Game-theoretical Models in Operations Research
Invited session

Chair: *M[a] Gloria Fiestras-Janeiro*, Universidade de Vigo, 36310 , Vigo, Spain, fiestras@uvigo.es

1 - Degree of Difficulty in Competitions: A Fundamental Problem in Contest Design
Yigal Gerchak, Dept of Industrial Engineering, Tel-Aviv University, 69978, Tel-Aviv, Israel, ygerchak@eng.tau.ac.il, *Marc Kilgour*

In various types of contests, the contestants chose a degree of difficulty. We analyze a contest where the succesful contestant who selected the highest degree of difficulty wins. The prize is a linear function of the degree of difficulty. After analyzing non-competitive policy, we analyze a strictly competitive zero-sum scenario. Finally, we analyze a scenarion which combines features of the two. Then we consider the situation from the point of view of the contest designer, who determines the prizes based on its own utility of the achievement.

2 - Competition for Cores in Remanufacturing
Serra Caner Bulmus, Operations, University of Groningen, Nettelbosje 2, 9747 AE, Groningen, Netherlands, s.caner@rug.nl, *Xiang Zhu*, *Ruud Teunter*

We study competition between an original equipment manufacturer (OEM) and an independent remanufacturer (IO) where they compete not only for sales but also for collecting returned products through their acquisition prices. We consider a two-period model and find that the acquisition price of the OEM only depends on its own cost structure; the OEM may manufacture less in period 1 to protect its market share; and when there is a lower willingness to pay for remanufactured items, remanufacturing becomes less profitable.

3 - Information Sharing in a Supply Chain with a Common Retailer
Weixin Shang, Computing and Decision Sciences, Lingnan University, SEK212/3, Simon and Eleanor Kwok Building, Lingnan University, Tuen Mun, Hong Kong, Hong Kong, shangwx@ln.edu.hk

We consider a supply chain with two competing manufacturers selling substitutable products through a common retailer. The retailer decides whether to share a private imperfect demand signal with any of the two manufacturers. We consider two cases where the manufacturers face either economies or diseconomies of scale in production. We show how production economies/diseconomies, competition intensity and information contracting influence the firms' equilibrium decisions as well as their profits.

4 - The Impact of Supply Chain Structure on Wholesale Prices
Alper Nakkas, SKK Graduate School of Business, Seoul, Korea, Republic Of, nakkas@skku.edu

We represent trade limitations between manufacturers and retailers via a supply chain network and find that similar supply chain structures may lead to different equilibrium outcomes as a result of tension between the bargaining power created by differences in retail valuations and critical supply chain positions.

■ TC-47

Tuesday, 12:30-14:00
Y10-2

Customer-centered Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Michael Mohaupt*, Dresden University of Technology, Germany, michael.mohaupt@mailbox.tu-dresden.de

1 - Disclosing Uncertainties in Revenue Management
Daniel Kadatz, Information Systems, Freie Universität Berlin, Germany, daniel.kadatz@gmail.com, *Catherine Cleophas*

Recent literature shows a rapidly increasing interest in integrating risk-aversion in revenue management (RM) systems. The majority of research refers exclusively to risks that are connected to variations in demand. However, further risks and uncertainties can be observed when looking into RM process details. This presentation gives an overview of uncertainties in RM systems and considers the question of how to quantify their effect and, if possible, their probability. A categorization of sources and possible measurements for uncertainty analysis will be provided along with first results.

2 - Dynamic Pricing for retail, based on customer behaviour

Alexander Börsch, TU Chemnitz, Germany, alexander.boersch@mathematik.tu-chemnitz.de

One main task for every retailer is to find a good price for his products. Approaches to develop pricing strategies based on the reaction of customers to different prices and discounts respectively will be shown. Therefore the price elasticity of demand is an important part of the model. Since the price alone is not enough to explain customer behaviour, other factors will also taken into account like seasonality or the prices of competitors. Several mathematical optimisation methods will be used to build the complex model to explain the dependencies between price and demand.

3 - Upselling Or Upsetting? Determinants Of A Successful Upsell Option

Wibke Heidig, Center for Customer Insight, University of St Gallen, 9010, St Gallen, Switzerland, wibke.heidig@unisg.ch, *Daniel Wentzel*, *Torsten Tomczak*

In many industries, consumers are offered the opportunity to revise their initial decision in return for a superior but more expensive service option. This revenue management technique is referred to as upselling. Upselling bears a financial potential for industries with fixed capacity decisions in the long run because it allows them to increase inventory utilization during low demand periods. Instead of using forecasting models, this work aims to develop a framework for a decision process and to experimentally clarify when/why consumers accept such offers from a consumer behavior perspective.

4 - Customer Value-based Revenue Management in Manufacturing

Michael Mohaupt, Dresden University of Technology, Germany, michael.mohaupt@mailbox.tu-dresden.de, *Andreas Hilbert*

In manufacturing, providers are interested both in a revenue maximizing allocation of their limited production capacity (as goal of revenue management) and the establishment of long-term profitable business relations with their clients (as goal of customer relationship management). Confronted with these partly diametric objectives at strategic level, we define, formalize and analyze the decision-making problem of accepting or denying customers' requests of heterogeneous worthiness. In addition, revenue potentials of a customer value-based booking control policy are evaluated via simulation.

■ TC-48

Tuesday, 12:30-14:00
Y11-1

Financial Mathematics and OR 1

Stream: Financial Mathematics and OR
Invited session

Chair: *Mei-Ting Tsai*, Department of Business Administration, National Chung Hsing University, 250, Kuo Kuang Road, 402, Taichung, Taiwan, mtsai@dragon.nchu.edu.tw
Chair: *Busra Temocin*, Middle East Technical University, Turkey, btemocin@metu.edu.tr

1 - A Study of a Green Procurement Portfolio for Retailers Using a Real Options Approach

Mei-Ting Tsai, Department of Business Administration, National Chung Hsing University, 250, Kuo Kuang Road, 402, Taichung, Taiwan, mtsai@dragon.nchu.edu.tw, *Chung-Han Lee*

Green procurement is an important practice of green retailing. A significant challenge of adopting green procurement to retailers is that there exists a gap between customers' willingness and their actions which is known as the value-action gap. The value-action gap makes the demand for green products uncertain and complicates the retailers' procurement decisions. Therefore, this study aims to design green procurement contracts and develop the contracts pricing models to help retailers making correct procurement decisions under the demand uncertainty.

2 - Analysis of Dynamics of Cluster Structure for Financial Market Networks

Anton Kocheturov, Laboratory of Algorithms and Technologies for Networks Analysis, National Research University Higher School of Economics, 136, Rodionova street, 603093, Nizhny Novgorod, Nizhny Novrorod region, Russian Federation, antrubler@gmail.com

In course of recent 15 years networks become a powerful tool for analysis of financial markets. In this work we analyze cluster structures in the market graph arising from the correlation matrix of stocks traded on the stock markets of the USA and Russia. We discovered some stable characteristics and dependencies in the dynamics of the cluster structures. We found that during the crisis periods stock clusters become unstable but pairs of stocks change their clusters together. Besides the process of cluster destabilization for large number of clusters begin early then the crisis period.

3 - A martingale approximation result for a special class of stochastic volatility models

Zsanett Orlovits, Department of Differential Equations, Mathematical Institute, Budapest University of Technology and Economics, Egry József utca 1., 1111, Budapest, Hungary, orlovits@math.bme.hu

A basic effort of this research is to develop strong approximation results for a special class of stochastic volatility models, namely for the so-called GARCH models. Using a uniform strong law of large numbers for the log-likelihood function and applying the theory of stochastic approximation method we get an improved error bound for the martingale approximation of the estimation error. The advantage of this approach is that, under some suitable conditions, a more precise characterization of the estimation error-process can be obtained.

■ TC-49

Tuesday, 12:30-14:00
Y11-2

Stochastic control

Stream: Actuarial Sciences and Stochastic Calculus
Invited session

Chair: *Duan Li*, Systems Engineering & Engineering Management Dept., The Chinese University of Hong Kong, Shatin, NT, Hong Kong, dli@se.cuhk.edu.hk

1 - Optimal control problem of stochastic switching system with delay

Charkaz Aghayeva, Industrial Engineering, Anadolu University, 2 Eylul cam., Faculty of Engineering,, dep. of Industrial Engineering, Eskishehir, Turkey, c_aghayeva@anadolu.edu.tr

The present work is devoted to the optimal control problem of stochastic switching system with delay. The contribution of this paper is to present a stochastic maximum principle for a switching optimal control problems with constraints. It provide necessary conditions of optimality in the form of a maximum principle for stochastic switching systems, in which the dynamic of the constituent processes takes the form of delay stochastic differential equations. The restrictions on the transitions for the system are described through functional equality constraints on the end of each subsystems.

2 - Short-Time Work As A Stochastic Control Process Of Labour Input Under Uncertainty

Kilian Niedermayer, Research Data Centre (FDZ), IAB Nuremberg, Regensburger Straße 104, 90478, Nuremberg, Germany, kilian.niedermayer@gmx.net

Short-time work (STW) saved the German economy in the 2009 recession. Theory on a firm's decision processes is still insufficient. This model exhibits STW from an investment point of view. Under uncertainty, implemented by a Geometric Brownian Motion, a firm optimizes its labor input by variations of the amount of labor force and working hours. Given its strategy, the firm chooses transaction or remanence cost. Utilizing stochastic control, the firm continuously maximizes its future profits. The framework yields numerical results on the respective extent of labor hoarding vs. layoffs.

3 - The Application of H-J-B Method in stochstic modelation for volatility with persistence: The Mexican Case Index

Guillermo Sierra, Metodos Cuantitativos, Universidad de Guadalajara CUCEA, Periferico Sur 799, Nucleo Los Belenes, 45100, Zapopan, Jalisco, Mexico, gsierraj@yahoo.com.mx

The application of the Range Rescalate method in some financial variables and their volatility's estimators showed a behavior, different from independence case. This paper proposes to model one underlying financial asset and its volatility with the stochastic process knowing like fractional Brownian motion. Using The H-J-B method we get the Black Scholes equation generalized and propose a solution for the case with stochastic volatility. Besides, we get the behavior of implicit volatility in European options with characteristics long memory, in particular, for the Mexican case.

■ TC-50

Tuesday, 12:30-14:00
Y11-3

Advanced Revenue Management

Stream: Advanced Inventory Control and Pricing Strategies
Invited session

Chair: *Alf Kimms*, Mercator School of Management, University of Duisburg-Essen, Lotharstr. 65, LB 125, 47057, Duisburg, Germany, alf.kimms@uni-due.de
Chair: *Robert Klein*, Chair of Analytics & Optimization, University of Augsburg, Universitätsstr. 16, 86135, Augsburg, Germany, robert.klein@wiwi.uni-augsburg.de

1 - A Solution Method for Network Revenue Management Games

Waldemar Grauberger, Mercator School of Management, University of Duisburg-Essen, Germany, waldemar.grauberger@uni-due.de, *Alf Kimms*

We present a model for the revenue management network seat inventory control problem under competition based on the well-known deterministic linear program (DLP). Since the resulting game would be too large to solve with an existing algorithm, we use the model within a new algorithm that—given a starting strategy—computes a solution for this game. Results of a computational study are presented as well.

2 - Optimizing Conditional Value-at-Risk in Dynamic Pricing

Jochen Gönsch, Department of Analytics & Optimization, University of Augsburg, Universitätsstraße 16, D-86159, Augsburg, Germany, jochen.goensch@wiwi.uni-augsburg.de

The perspective of a risk-averse decision maker is particularly appropriate when regarding rare events or acting as part of a volatile and fast changing environment. This talk presents an approach for risk-averse dynamic pricing based on stochastic dynamic programming where the Conditional Value-at-Risk (CVaR) serves as risk measure. The CVaR is an important example from the class of coherent risk measures. To the best of our knowledge, this is the first dynamic pricing model using a time-consistent formulation of the CVaR suitable for evaluation of multi-period revenue streams.

3 - Optimal Brochure Pricing in the Tour Operating Industry

Claudius Steinhardt, Chair of Analytics & Optimization, University of Augsburg, Universitätsstraße 16, 86159, Augsburg, Germany, claudius.steinhardt@wiwi.uni-augsburg.de, *Alexander Baur*, *Robert Klein*

In this talk, we consider the decision problem of optimally determining hotel room prices to be published in a tour operator's brochure. We propose a linear mixed integer programming-based approach which incorporates demand-side behavior by including a general attraction model whose parameters can be obtained from past booking data. Furthermore, we present four different real-world scenarios of model-based decision support, showing how the brochure pricing problem can be integrated into the manual decision making process, given the requirement of using standard optimization software.

4 - Network revenue management of online display-ad allocation

Kalyan Talluri, University of Pompeu Fabra, Barcelona, Spain, kalyan.talluri@upf.edu, *Sumit Kunnumkal*

The online display ad allocation problem is concerned with the assignment of web pages to a pool of advertisers who specify the types and quantities for their ads. In this paper we model the problem as a stochastic dynamic program, in the spirit of network revenue management, with an objective of maximizing the expected revenues from the dynamic online matching.

■ TC-51

Tuesday, 12:30-14:00
Y11-4

Risk Analysis and Assessment 1

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *Alberto A. Álvarez-López*, Quantitative Applied Economics II, UNED (Spanish National University of Distance Education), Paseo Senda del Rey, 11, 28040, Madrid, Spain, aalvarez@cee.uned.es

1 - The conceptual approach to risk-management and its specification for decision-making in conditions of uncertainty

Tatiana Zolotova, Chair f Applied mathematics, Financial University at the Government of the Russian Federation, Shherbakovskaja str., 38, 105187, Moscow, Russian Federation, tgold11@mail.ru

The conceptual model of risk-management including the submodel of an estimation of system effectiveness and the submodel of an estimation of the risk of its functioning is offered. This model is applied to the problem of decision-making in conditions of uncertainty, when there is only information about the range of external factors values. The approach to a choice of the optimum control is based on the ideas of vector optimization, i.e. a combination of Wald, Hurwicz, Savage, Laplace criteria. The research has shown that the combined criteria possess the basic properties of initial criteria.

2 - Related certainty problems in a decision model under uncertainty

Alberto A. Álvarez-López, Quantitative Applied Economics II, UNED (Spanish National University of Distance Education), Paseo Senda del Rey, 11, 28040, Madrid, Spain, aalvarez@cee.uned.es, *Inmaculada Rodríguez-Puerta*, *Mónica Buendía*, *Francisco Sebastiá-Costa*

We study a quite general model of decision under uncertainty in which a risk-averse agent maximizes a random wealth. Related to this, we construct two certainty problems that capture some of its aspects. The first problem shares the point at which the optimum is attained. The second problem is obtained by writing the corresponding expectations instead of the random variables. In both cases, we study properties of the solution and derive some relevant results for the original model (e.g. comparative-static effects). We also give some applications to different decision models under uncertainty.

3 - Option Portfolio with Multiple Criteria Decision Making

Jing-Rung Yu, Information Management, National Chi-Nan Univ., 470 Univ. Road, 545, Pu-Li, Nan-Tau, Taiwan, jennifer@ncnu.edu.tw, *Paul Chiou*, *Hsiu-Wen Pai*, *Shin-Ruei Huang*

An option portfolio model that takes into account various hedging ratios, transaction costs, trading volume is proposed. We combine Horasanli (2008) model with multiple objective programming and simultaneously set the target interval of risks, return and transaction cost in solving an optimal option portfolio. A numerical example shows that the proposed model can fit in actual transaction to construct option portfolio. The portfolio generated by our model is more flexible than Horasanli's model and can better adjust the range of risk neutralization.

4 - Multi-objective Risk Simulation Using Stratified Importance Sampling

İsmail Başoğlu, Department of Industrial Engineering, Boğaziçi University, Boğaziçi University South Campus, Department of Industrial Engineering, Bebek, 34342, İstanbul, Turkey, ismailbsgl@gmail.com, *Wolfgang Hörmann*, *Halis Sak*

We present a simulation algorithm that estimates tail loss probabilities for linear asset portfolios under the t-copula model combining importance sampling with optimal stratification. Based on the combined method, an efficient procedure for multiple tail loss probabilities is developed. For this purpose, a heuristic determines sample allocation fractions in the strata such that the maximum relative error is minimized. This idea and heuristic is applicable to minimize the maximum relative error of an arbitrary multi-objective simulation.

■ TC-52

Tuesday, 12:30-14:00
B13-1

Energy forecasting III

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Lio Goncalves*, ENGENHARIAS, UTAD, APARTADO 1013, 5001-801, VILA REAL, Portugal, lgoncalv@utad.pt

1 - Anomalous Data Detection for Short Term Load Forecasting

Royden Fernandes, Indian Institution of Technology Bombay, PowerAnser Labs, Dept. of Electrical Engg., IIT Bombay, Powai,, 400076, Mumbai, Maharashtra, India, royden@ee.iitb.ac.in, *Yogesh Bichpuriya*, *Somasekara Rao Manda*, *Shreevardhan Soman*

Short-term load forecasting is important for efficient functioning of electricity distribution companies. The forecasting methods involve estimation of model parameters. Presence of anomalous days can lead to wrong estimation of model parameters which in turn leads to erroneous forecast. Hence, detection of anomalous days is crucial for meaningful forecasting. This paper proposes new methods called probabilistic, distance, auto-associative ANN and hybrid methods for detecting and correcting anomalous data. Performance of the proposed methods will be demonstrated with real life data.

2 - Electricity demand forecasting by using data mining techniques — the case study of a brazilian electric power utility

Raimundo Ghizoni Teive, Univali, Brazil, rteive@univali.br

This paper proposes a computational model, based on Data Mining techniques, for estimating the load profile and power demand for industrial consumers of an electrical distribution utility, considering the industrial activities in a segregated way. The definition of typical load curves by minimum clusters was possible by using association rules (Supervised Association Generator algorithm) and the k-means clusterization algorithm. The predicted demand growth was obtained by using a RBF Artificial Neural Network, whose input variables were defined by Principal Components Analysis technique.

3 - An Adaptive Time Series Approach to Electricity Price Forecasting

Yogesh Bichpuriya, Indian Institution of Technology Bombay, PowerAnser Labs, Dept. of Electrical Engg., IIT Bombay, Powai,, 400076, Mumbai, Maharashtra, India, bichpuriya@ee.iitb.ac.in, *Royden Fernandes*, *Shreevardhan Soman*

Electricity market players, especially GENCOs and DISCOMs, need to be able to accurately forecast price (along with demand). In this work, time series based methods are developed. Detection of outliers and influential observations is also very critical. Measures for the same are proposed and validated. Market participants' behaviour changes over the time say due to technological advancements or regulatory changes. Hence, we propose adaptive scheme, which is responsive to market dynamics and automatically tunes its parameters with minimal manual intervention.

4 - Wind power forecasting using an artificial intelligence method

Lio Goncalves, ENGENHARIAS, UTAD, APARTADO 1013, 5001-801, VILA REAL, Portugal, lgoncalv@utad.pt, *Paulo Salgado*

The increased integration of wind power into the electric grid poses new challenges due to its intermittency and volatility. Hence, good forecasting tools play a key role in dealing with these challenges of balancing supply and demand in any electricity system. In this paper it is proposed an artificial intelligence method that uses historical time series of wind speed and wind power generation to forecast wind power. The method is validated using wind power data from Portugal's Electric Grid, REN.

■ TC-53

Tuesday, 12:30-14:00
B13-2

Parallel Computing Models and Risk Analysis in Energy Planning

Stream: Stochastic Modeling in Energy Planning
Invited session

Chair: *Somayeh Moazeni*, Dept of Operations Research and Financial Engineering, Princeton University, Sherrerd Hall, Charlton Street, 08544, Princeton, New Jersey, United States, somayeh@princeton.edu

1 - Applying High Performance Computing to Multi-Area Stochastic Unit Commitment for Renewable Energy Integration

Anthony Papavasiliou, Mathematical Engineering, CORE, Catholic University of Louvain, Voie du Roman Pays 34, 1348, Louvain la Neuve, Belgium, anthony.papavasiliou@uclouvain.be

We present a parallel implementation of a Lagrangian relaxation algorithm for solving stochastic unit commitment. We present a scenario selection algorithm inspired by importance sampling and validate its performance by comparing it to a 1000-scenario stochastic formulation that we solve through parallelization. We examine the impact of narrowing the duality gap on the performance of stochastic unit commitment and compare it to the impact of increasing the number of scenarios. We report results on running time and discuss the applicability of the method in an operational setting.

2 - A best-deterministic approach to stochastic unit commitment

Boris Defourny, Department of Operations Research and Financial Engineering, Princeton University, Sherrerd Hall, Charlton St, 08544, Princeton, NJ, United States, defourny@princeton.edu, *Hugo Simao*, *Warren Powell*

We present an algorithm for solving approximately a two-stage stochastic unit commitment problem in the presence of uncertain wind energy. The algorithm has two phases. In the first phase, candidate first-stage decisions are generated by solving in parallel deterministic unit commitment models which differ by their planning scenario. In the second phase, the first-stage solutions are ranked by solving for each of them the two-stage model with fixed first-stage decision, which makes the stochastic model separable across scenarios.

3 - Risk-Averse Energy Storage Management: A Parallel Stochastic Programming Approach
Somayeh Moazeni, Dept of Operations Research and Financial Engineering, Princeton University, Sherrerd Hall, Charlton Street, 08544, Princeton, New Jersey, United States, somayeh@princeton.edu, *Warren Powell*, *Belgacem Bouzaiene-Ayari*

This talk discusses a stochastic energy storage optimal dispatch problem in the presence of a stochastic renewable energy source, non-stationary stochastic electricity price and load evolutions to explain seasonality effects, and price impact of trading electricity with the grid. We propose a parallel computational stochastic programming technique based on the direct policy search and a novel parallel derivative free optimization to derive an optimal real-time transmission policy among wind, electricity, and the storage, to satisfy the electricity load and minimize the expected cost and risk.

4 - Risk hedging optimal capacity in the European hub-based natural gas market network
Parviz Darvish, Operations Management, ESSEC Business school, Avenue Bernard Hirsch, BP 50105, Cergy, 95021, Cergy Pontoise cedex, Val d'Oise, France, parviz.darvish@essec.edu

Decision-making in the hub-based natural gas market in Europe is crucial in terms of properly allocating reliable capacities due to the market's susceptibility to risk. This work addresses ex ante decisions concerning the optimal production and transportation capacities on the NG futures market subject to uncertainty in the final spot market demand, while fulfilling the Nash equilibrium condition. To this end, we used stochastic (scenario based) nonlinear programming and the (CVaR) concept to arrive at a quantitative measure of the optimal circumstances and to hedge against that uncertainty.

■ TC-54

Tuesday, 12:30-14:00
B14-1

Mathematical Optimisation in Power Systems II

Stream: Energy, Environment and Climate
Invited session

Chair: *Nikita Zhivotovskiy*, Faculty of Control and Applied Mathematics, Moscow Institute of Physics and Technology, Russian Federation, nikita.zhivotovskiy@phystech.edu
Chair: *Maria Teresa Vespucci*, Dept. of Management, Economics and Quantitative Methods, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, maria-teresa.vespucci@unibg.it

1 - Optimal Underground Pumped Hydroelectric Storage Design
Amir José Daou Pulido, Chair of Energy Systems and Energy Economics, Ruhr - Universität Bochum, IB 4 - 32, Universitätsstr. 150, 44801, Bochum, Germany, daoupulido@lee.rub.de, *Hermann-Josef Wagner*, *Marco K. Koch*

Optimal design of utility scale energy storage systems has been strongly researched in the last decades. However, there are few studies addressing Underground Pumped Hydroelectric Storage (UPHS). In Germany, UPHS has become an interesting technology for both energy system flexibility and mining sector. We propose an optimization model for UPHS design, i.e., reservoirs, waterways and turbo machinery configuration. The model aims to find the UPHS design that maximizes long-term profit, given a certain power market development scenario.

2 - Transmission Network Expansion Problem in the case of the Danish transmission network.
Rolf Wognsen, Mathematics, Aarhus University, Ny Munkegade 118, DK-8000, Aarhus C, Denmark, rrw@imf.au.dk

The Transmission Network Expansion Problem (TNEP) addresses the problem of broadening and strengthening an existing electrical generation and transmission network to optimally serve a electricity market. The literature distinguishes many different formulations of and solution approaches to the TNEP. This paper gives an overview on these approaches and classifies them according to the objective, type of model, security constraints, solution method, etc. Emphasis will be given to the case of the Danish network, which requires a greater level of survivability than most methods and papers address.

3 - The need for electricity storages in the German energy system considering net restrictions
Sonja Babrowski, Chair of Energy Economics (IIP), KIT, Germany, sonja.babrowski@kit.edu, *Patrick Jochem*, *Wolf Fichtner*

Due to the increasing share of renewable energy the need for electricity storages arises. To estimate the need and the best allocation for daily storage systems in Germany until 2040 we implemented storage extension options at over 300 possible allocations in the existing long-term energy system model PERSEUS-NET. The investment and dispatch model minimizes the system costs and includes a DC approach of the transmission grid. First results show that storages are either allocated in northern Germany close to future off-shore wind parks or close to bottlenecks within the transmission grid.

4 - Capacitated minimum spanning trees in the planning of windfarm connection network
Adelaide Cerveira, DM & CIO, UTAD, 5000, Vila Real, Portugal, cerveira@utad.pt, *José Baptista*, *Eduardo Pires*

The current demand for clean energy sources associated with the rising costs of fossil fuels have led to a large increase in the global production of electricity from wind energy. This study presents a mathematical formulation to find the best electrical configuration to interconnect the wind farm turbines, reducing both the installation costs and the energy losses. This problem concerns to a Capacitated Minimal Spanning Tree Problem (CMSTP) with additional constraints. The proposed model is applied to real case studies and the computation results are reported.

■ TC-55

Tuesday, 12:30-14:00
B14-2

Decision Making and Decision Support Systems I

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Rudolf Vetschera*, Dept. of Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, rudolf.vetschera@univie.ac.at
Chair: *Mikhail Kuznetsov*, Moscow Institute of Physics and Technology, Russian Federation, mikhail.kuznecov@phystech.edu

1 - Pattern analysis in the study of science, education and innovative activity in Russian regions
Alexey Myachin, National Research University Higher School of Economics, Moscow, Russian Federation, a_miachin@mail.ru, *Fuad Aleskerov*, *Lyudmila Egorova*

We describe the method of pattern analysis and the results of its application to the problem of analyzing the development of science, education and the success of innovative activity in the Russian Federation. We examine characteristics of the regions of Russia such as the level of socio-economic conditions and the potential and efficiency of science, education and innovative activity. Also we obtain a classification of regions by the similarity of the internal structure, construct trajectories of regional development over time, and find groups of regions carrying out similar strategies.

2 - Representability Theorems of Pareto-Scalar Choice Model and Its Applicability as a Screening-Choice Procedure

Yetkin Çınar, Faculty of Political Sciences, Ankara University, Faculty of Political Sciences, Cebeci, 06590, Ankara, Turkey, ycinar@ankara.edu.tr, *Fuad Aleskerov*

Pareto rule is often used as a screening procedure in multicriterial choice problems to eliminate dominated alternatives at an initial stage. Then a narrowed choice set can be presented for the second stage, in which the alternatives extremal with respect to scalar criterion are chosen. We call this model as 'Pareto-scalar'. We introduce new representability conditions of the model and show that it satisfies Condordance condition, but not all choice functions from that domain can be constructed by this model. Since this procedure is often used, some illustrative examples are given, as well.

3 - Information levels in additive group decision models under incomplete information: Bridging the cardinal-ordinal gap

Rudolf Vetschera, Dept. of Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, rudolf.vetschera@univie.ac.at, *Luis C. Dias*, *Paula Sarabando*

Aggregation of cardinal values in groups requires individuals to assign utility scores to alternatives. We report on a computational study to quantify the effect of different levels of preference information (exact cardinal values, rankings of differences between alternatives and rankings of alternatives), and of the imposition of different constraints on members' weights in an additive group utility function on outcomes at the group level. Outcome dimensions analyzed refer to the structure of the group (necessary and possible) preference relations and the strength of impact of individuals.

4 - How to measure non-monotone noise?

Irena Milstein, Faculty of Management of Technology, Holon Institute of Technology, 52 Golomb St., 5810201, Holon, Israel, irenam@hit.ac.il, *Arie Ben David*, *Rob Potharst*

Most real-world ordinal data sets do include non-monotone examples even when theory dictates monotonicity (e.g., due to noise). Non-monotone noise may be determined as the ratio between the number of non-monotone pairs and the total number of pairs in a data set. Using the real-world ordinal data sets in the data mining literature (ESL, ERA, LEV, and SWD), we check the actual non-monotone noise. We expect that the values of non-monotone noise will be rather low (between 1% and 3%) since high values of noise may imply that a pattern, if exists in the data, may be distorted by noise.

■ TC-56

Tuesday, 12:30-14:00
B15-3

Optimization Modeling II

Stream: Software for OR/MS
Invited session

Chair: *Robert Fourer*, AMPL Optimization, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com
Chair: *Bjarni Kristjansson*, Maximal Software, Ltd., Boundary House, Boston Road, W7 2QE, London, United Kingdom, bjarni@maximalsoftware.com

1 - pyCMPL and CMPLServer

Mike Steglich, University of Applied Sciences Wildau, Germany, mike.steglich@th-wildau.de

pyCMPL is the CMPL API for Python and is indented to define sets and parameters within a Python script, to commit it to a CMPL object, to start and control the solving process and to analyse the solution in Python. pyCMPL can be used with a local CMPL installation or a CMPLServer, which is an XML-RPC-based web service for CMPL. After an overview of the main functionalities of pyCMPL, the scripting of CMPL objects in Python will be demonstrated through using several examples. Furthermore, it will be shown how pyCMPL and CMPLServer can be used to create distributed optimization applications.

2 - Recent Enhancements in GAMS

Toni Lastusilta, GAMS Software GmbH, P.O. Box 40 59, 50216, Frechen, Germany, tlastusilta@gams.com

From the beginning in the 1970s at the World Bank till today, GAMS, the General Algebraic Modeling System, has evolved continuously in response to user requirements, changes in computing environments and advances in the theory and practice of mathematical programing. We will outline several recent enhancements of GAMS supporting efficient and productive development of optimization based decision support applications. Furthermore, some advanced features are discussed.

3 - Discrete-Event Simulation with SAS Simulation Studio

Ed Hughes, SAS Institute, 20143, Milano, Italy, Ed.Hughes@sas.com

Discrete-event simulation is a useful paradigm for modeling the behavior and performances of complex systems under different scenarios created by varying operating conditions and resources. We will highlight key elements of discrete-event models with a diverse set of customer examples from areas such as Service Center Staffing, Clinical Trial Operations planning, Sentencing Policy assessment and Medical Care unit operations. We will demonstrate the use of SAS Simulation Studio, a SAS/OR component that provides a graphical interface for building and analyzing discrete-event simulation models.

4 - Extensions to AMPL for Optimisation Under Uncertainty

Christian Valente, OptiRisk Systems, OptiRisk R&D House, 1 Oxford Road, UB9 4DA, Uxbridge, Middlesex, United Kingdom, christian@optirisk-systems.com, *Gautam Mitra*, *Victor Zverovich*

We describe a set of language extensions to AMPL for representing robust optimisation problems and various classes of stochastic programming problems. We not only describe syntax and semantics of the extensions but also discuss solver requirements, reformulation techniques and connection between the modelling system and external solvers. In particular, we show that direct representation (as opposed to deterministic equivalent) of some of the modelling constructs not only makes the models easier to understand but also facilitates the use of specialised solution algorithms.

■ TC-57

Tuesday, 12:30-14:00
B15-4

Competition, Advance Selling, and NPD

Stream: Operations/Marketing Interface
Invited session

Chair: *Kathryn E. Stecke*, University of Texas at Dallas, United States, KStecke@utdallas.edu

1 - Competing Though Cooperatives

Sudheer Gupta, Faculty of Business, Simon Fraser University, 500 Granville Street, V6C 1W6, Vancouver, BC, Canada, sudheerg@sfu.ca, *Omkar Palsule-Desai*

We analyze a model where several small producers, that lack scale and resources, form a cooperative and delegate decisions to a marketing agent, in order to compete with a dominant producer in a differentiated products market. The agent designs a procurement contract, secures quantities and sets prices. We show how different contracts affect network size, cost structure and pricing. Equilibrium outcomes balance incentives within the cooperative with competitive dimensions. We discuss conditions under which competing through cooperatives in presence of institutional voids is effective.

2 - Advance Selling without Showing the Price? The Roles of Anecdotal Reasoning and Capacity
Tingliang Huang, Department of Management Science and Innovation, University College London, Management Science and Innovation, Gower Street, University College London, WC1E 6BT, London, Select State, United Kingdom, t.huang@ucl.ac.uk, *Ying-Ju Chen*

Motivated by the recent practice, we study the advance selling strategy without showing the price (which may be coined as "probabilistic pricing"). We postulate that customers have boundedly rational expectations via anecdotal reasoning to anticipate the firm's pricing strategy. This bounded rationality thus induces the firm to strategically randomize prices to create intentional uncertainty for customers' decision making, even in the absence of demand and valuation uncertainties.

3 - Supply Chain Coordination under Competition
Guillermo Gallego, Industrial Engineering and Operations Research, Columbia University, 500 West 120th Street, 10027, New York, NY, United States, ggallego@ieor.columbia.edu, *Masoud Talebian*

We study contracts between suppliers with fixed capacities and a single retailer. Suppliers present contracts and the retailer decides how much to buy and how much to sell, assuming a deterministic demand function. Under mild assumptions we show that in equilibrium suppliers use sophisticated contracts, although this may harm some of them relative to simple wholesale pricing. We characterize the set of equilibrium contracts, and show that all Nash equilibria result in a coordinated chain with a unique profit split such that each supplier gains her marginal profit contribution to the chain.

4 - Knowledge Creation in a Three-Stage New Product Development Process
Cheryl Gaimon, Scheller College of Business, Georgia Tech, 800 W. Peachtree St. NW, 30308, Altanta, GA, United States, cheryl.gaimon@scheller.gatech.edu, *Janice Carrillo*, *Wenli Xiao*

We consider the evolution of knowledge during a three-stage new product development project. The development team at each stage pursues activities to increase the levels of prototyping, pilot line, and ramp-up knowledge. Since development teams are co-located and highly interactive, knowledge transfer occurs continuously. As a result of knowledge transfer, the ability of the recipient team to generate new knowledge is enhanced. The objective is to maximize the net revenue earned when the product is released to the marketplace (expressed as a function of knowledge) less development costs.

■ TC-58

Tuesday, 12:30-14:00
B15-6

OR and Real Implementations II

Stream: OR and Real Implementations
Invited session

Chair: *Belarmino Adenso-Diaz*, Engineering School at Gijon, Universidad de Oviedo, Campus de Viesques, 33204, Gijon, Spain, adenso@epsig.uniovi.es

1 - A Condition-Based Maintenance Policy for a Continuously Deteriorating Multi-Unit System with Aperiodic Inspections
Minou Olde Keizer, Operations, University of Groningen, Nettelbosje 2, 9747 AE, Groningen, Netherlands, m.c.a.olde.keizer@rug.nl

In condition-based maintenance (CBM) a certain condition, e.g., vibration, is monitored to estimate the moment of failure. Maintenance is then performed right before that moment. We consider an advanced, existing, CBM optimization approach in which the (aperiodic) inspection moments and condition thresholds are jointly optimized. A discrete time two-unit series system is considered, where the long run average maintenance cost per time unit is minimized. We analyze an adapted version of the system where two units operate in parallel, and provide new insights on CBM for systems with redundancy.

2 - Strategic workforce planning for the Australian Defence Force
Tarek Elgindy, Mathematics, Informatics and Statistics, CSIRO, Private Bag 33, Clayton South, 3169, Melbourne, Victoria, Australia, tarek.elgindy@csiro.au, *Mark Horn*, *David Sier*

We present a mixed integer programming model for optimizing personnel placement in hierarchical workforce organizations, subject to operational constraints. The model includes penalty costs for deviations from personnel targets, and real costs associated with personnel employment, promotions, separations and entries into the workforce, which are optimized in a multistage model. Solutions are obtained efficiently through decomposition into loosely-linked components, exploiting the hierarchical structure. The model has been used to assist in personnel planning for the Australian defence force.

3 - The optimal maintenance strategy based on a dataset of historical failures
Bram de Jonge, Operations, University of Groningen, P.O. Box 800, 9700 AV GRONINGEN, 9700 AV, Groningen, Netherlands, b.de.jonge@rug.nl, *Ruud Teunter*, *Warse Klingenberg*, *Tiedo Tinga*

Given a dataset of historical times until failure of a machine, it is common practice to base the maintenance strategy on the maximum likelihood estimation of the parameters of, for example, the Weibull distribution. If the Weibull distribution has an increasing failure rate there is always an optimal maintenance age. However, a new approach of taking into account the uncertainty in the estimated parameter values shows that in many cases where the maximum likelihood estimation suggests an increasing failure rate, it is optimal to perform no preventive maintenance at all.

4 - "Real options versus static expectations - a comparison of two approaches for the long term modelling of electricity generation under fuel price uncertainty
Daniel Ziegler, Chair for Management Sciences and Energy Economics, University Duisburg-Essen, Universitaetsstrasse 12, 45117, Essen, Germany, daniel.ziegler@uni-due.de, *Christoph Weber*

We present two extensions of classic electricity system models with enhanced capabilities to deal with stochastic influences and associated optionalities. In the first approach we iteratively apply Bender cuts for estimating follow-up costs of investment decisions. The second model replaces the assumption of perfect foresight by a planning calculus with bounded rationality. We apply the models to the German system with the purpose to span a range of possible future developments for electricity prices going beyond deterministic fundamental analyses or scenario techniques.

■ TC-59

Tuesday, 12:30-14:00
B15-5

Machine Learning in eCommerce and Marketing

Stream: Machine Learning and Its Applications
Invited session

Chair: *Dirk Van den Poel*, Department of Marketing, Ghent University, Hoveniersberg 24, B-9000, Ghent, Belgium, Dirk.vandenpoel@UGent.be
Chair: *Nikita Ivkin*, Faculty of Management and Applied Mathematics, Moscow Institute of Physics and Technology (State University), Institutskiy Pereulok, 9, 141700, Dolgoprudny, Moscow Region, Russian Federation, ivkinnikita@gmail.com

1 - Considering the Effective Ad Promotion Tool by the Cohort Analysis
Chen Yuan Rao, Web Applied Technology, The Kyoto College of Graduate Studies for Informatics, 7 Monzen-cho Tanaka Sakyo-ku Kyoto, 606-8225, Kyoto, Kyoto, Japan, rao_chenyuan@yahoo.co.jp, *Jin Chen*, *Hong Rong Cai*, *Feng Zhu*, *Hong Seung Ko*

Ad promotion strategy of customer acquisition in online business environment is the key factor to increase the sales. Especially, picking up the Ad promotion tool for acquiring customers effectively is very important to successfully develop the marketing strategy concerned. Therefore, it is necessary to reconsider Ad promotion tools based on the cost performance and the efficiency in the customer acquisition. Consequently, we analyze various Ad promotion tools through cohort analysis, and then we suggest an effective Ad promotion tool in the future.

2 - Click-Through Prediction for Sponsored Search Advertising in Web Search Engines
Alexander Mafusalov, Yandex, 16 Leo Tolstoy St., Moscow, Russian Federation, mafusalov@yandex-team.ru

Since most of search engines use the pay-per-click model for sponsored search, it is important to predict accurately the probability that a user will click on a banner (click-through rate or CTR). In the Yandex sponsored search there are two advertising s blocks. The CTR of a banner highly depends on the block it is shown in. If a banner has sufficient history in terms of impressions and clicks then the CTR can be estimated from this data. The problem considered is to predict CTR for banners with short history in one block more accurately using its history from other block.

3 - Cross-sell models in a non-profit organisation: The use of text mining data
Jeroen D'Haen, Marketing, Ghent University, Belgium, jeroen.dhaen@ugent.be, *Dirk Van den Poel*

In this research we use data mining techniques in a non-profit setting. These techniques offer great potential as, even in a non-profit sector, there is fierce competition. The non-profit organization at hand offers a range of products in different categories. Products of one category are always bought by members as a sort of membership fee. The goal is to compose a cross-sell model that predicts the buying probability in the other categories. We use product features as input for the model and include text mining data as a data augmentation technique.

4 - Web Service-based Data Mining Systems
Olga Kurasova, Vilnius University, Institute of Mathematics and Informatics, Akademijos St. 4, 08663, Vilnius, Lithuania, Olga.Kurasova@mii.vu.lt, *V. Marcinkevicius.*, *Viktor Medvedev*

A comparative analysis of data mining systems based on web services is presented in the research. For several decades, the research has been focused on developing data mining techniques and their applications. After rapid development of web services, an attention turns to creation of web services for data mining. In the last decade, there are developed some data mining systems based on web services. The systems are compared according some criteria in the investigation. Drawbacks are highlighted and ways of their elimination are suggested in order to improved web services for data mining.

■ TC-60

Tuesday, 12:30-14:00
B15-7

Data Mining in Early Warning Systems 3

Stream: Data Mining in Early Warning Systems
Invited session

Chair: *Elcin Kartal Koc*, Statistics, Middle East Technical University, Department of Statistics, No:234, 06800, Ankara, Turkey, kartalelcin@gmail.com
Chair: *Inci Batmaz*, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr

1 - Human Factors Management in UAV Operations: Case Study of Software Instrument Table
Dusan Starcevic, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Serbia, starcev@fon.rs, *Mlađan Jovanović*, *Mlađan Jovanović*

Today's modern UAV aircraft operators rely on vast amount of data that has to be presented in real-time. The meaning of this data is difficult to assess in its raw format. Therefore, we need sophisticated methods to interpret and present data to the user in a suitable format. This paper addresses the problem of adapting immense amount of visualization data to the operator in an aircraft cockpit based on the ideas from the multimodal human-computer interaction.

2 - Trajectory Mining
Alexandra Vlachaki, Electrical and Computer Engineering, National Technical University of Athens, Greece, alexandravlahaki@hotmail.com

GPS technology has enabled the collection of large volumes of data about moving objects such as animals or vehicles. Storing, processing, querying and mining these data efficiently and effectively raises important research challenges and has many real-world applications. This paper reviews the state-of-the-art in this area and focuses on developing algorithms for the analysis of moving object trajectories. More specifically, the problems addressed include mining moving object clusters and finding nearest neighbors in large sets of historical trajectories.

3 - Forecasting Product Returns Using Marginal Failure Count Data
Prasanna Akella, Hewlett-Packard, India, prasanna.akella@hp.com, *Sathya Dheep K K*

The most critical input for whole units and spare parts inventory optimization across the service network is an accurate product failure forecast. Using shipments and marginal failure count data, we developed two complementary product failure forecasting approaches - One, based on Non-Homogenous Poisson Process approximation of failure rates, solved by Expectation-Maximization algorithm and the other through intelligent iterative linear optimization. These innovative models improve forecast accuracy significantly thereby improving customer satisfaction and profitability of the business.

4 - Two levels model for forecasting retail sales data with holiday effects
Suhartono Suhartono, Statistics Department, Institut Teknologi Sepuluh Nopember, Department of Statistics, Kampus ITS Keputih Sukolilo, 60111, Surabaya, East Java, Indonesia, gmsuhartono@gmail.com

This research proposes a calendar variation model for forecasting retail sales data with the Eid ul-Fitr effect. The proposed model was developed based on ARIMAX and regression methods. Monthly men's jeans and women's trousers sales in a retail company were used as case study. In general, two levels of calendar variation model yields two models, to reconstruct the sales pattern already occurred, and to forecast the effect of increasing sales. The results of forecast accuracy comparison are presented.

■ TC-62

Tuesday, 12:30-14:00
R18-1

Theory of Integer Nonlinear Optimization (COST TD1207)

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Alberto Del Pia*, Mathematics, IFOR, ETH Zurich, Kalkbreitestrasse 136, 8003, Zurich, Switzerland, alberto.delpia@gmail.com

1 - Mirror-Descent Methods in Mixed-Integer Convex Optimization
Michel Baes, IFOR, ETH, HG.G.22.1, Ramistrasse 101,, 8092, Zurich, Switzerland, michel.baes@ifor.math.ethz.ch, *Christian Wagner*, *Robert Weismantel*

In this paper, we address the problem of minimizing a convex function over a convex set, with the extra constraint that some variables must be integer. We study a new algorithmic approach to this problem, postponing its hardness to the realization of an oracle. For problems with two integer variables, we show with a novel geometric construction how to implemented the oracle efficiently. Our algorithm can be adapted to find the second best point of a purely integer convex optimization problem in two dimensions, and more generally its kth best point.

2 - Graver-based steepest descent augmentation
Raymond Hemmecke, TU München, Germany, hemmecke@tum.de, *Jon Lee*

Separable convex IPs can be solved via polynomially many augmentation steps if only best possible augmentation steps along a Graver basis directions are performed. In contrast to this, we consider in this talk the augmentation along applicable Graver basis directions with a best ratio of cost improvement/unit length. We show that for linear objectives the number of augmentation steps is bounded by the number of elements in the Graver basis of the problem matrix and we thus end up with stongly polynomial-time algorithms for the solution of N-fold LPs and ILPs.

3 - Nonlinear Integer Programming is Fixed Parameter Tractable
Shmuel Onn, Davidson Faculty of IE & M, Technion - Israel Institute of Technology, Technion City, 32000, Haifa, Israel, onn@ie.technion.ac.il

I will overview our theory of Graver bases methods for solving nonlinear integer programming problems in polynomial time, mention a recent result showing that these problems are moreover fixed parameter tractable, and describe an application to nonlinear network problems.

4 - Integer quadratic programming in the plane
Alberto Del Pia, Mathematics, IFOR, ETH Zurich, Kalkbreitestrasse 136, 8003, Zurich, Switzerland, alberto.delpia@gmail.com, *Robert Weismantel*

We give a polynomial time algorithm for the problem of optimizing a quadratic polynomial over the integer points in a two dimensional polytope given by an outer description.

■ TC-63

Tuesday, 12:30-14:00
R18-2

Cognitive Approach in Control Sciences I

Stream: Operational Research and Control Problems
Invited session

Chair: *Nina Abramova*, Lab of Cognitive Modelling and Situation Control, Institute of Control Sciences, 65 Profsoyuznaya Street, Moscow GSP-4, Russia, 117997 , Moscow, Russian Federation, abramova@ipu.ru

1 - About some advances in the cognitive approach to cognitive mapping
Nina Abramova, Lab of Cognitive Modelling and Situation Control, Institute of Control Sciences, 65 Profsoyuznaya Street, Moscow GSP-4, Russia, 117997 , Moscow, Russian Federation, abramova@ipu.ru

The proposed review of results in the research field of cognitive mapping demonstrates advances achieved due to the cognitive approach that is to accounting for human cognitive sphere. It represents (i) the discovered human-induced risk factors that are significant for validity of modeling but "invisible' in the tradition of control sciences, (ii) proposals on identifying such factors and their overcoming. The results concern both modeling of specific situations and quality of up-to-date theoretical models for their cognitive mapping.

2 - False transitivity of causal influences in cognitive maps and some criteria of its detection and diagnosing
Svetlana Kovriga, Lab of Cognitive Modeling and Situation Control, Institute of Control Sciences of the Russian Academy of Sciences, 65, Profsouznaya st., 117997, Moscow, Moscow, Russian Federation, sv.kovriga@mail.ru, *Nina Abramova*

One of the nontrivial human-induced risks is the risk of false transitivity of causal influences, leading to invalid results of cognitive mapping of ill-structured situations. Some mechanisms of generation of false transitivity, connected with use by experts of vagueness and ambiguous concepts for expression causal influences at cognitive maps are shown. For protection against such risks some criteria of their detection and diagnosing are proposed. Capabilities of criteria in detecting risks of false transitivity of causal influences in cognitive maps are shown in examples of applied maps.

3 - Modeling of the regions development on the basis of cognitive methods and system dynamics
Galina Gorelova, Taganrog Institute of Technology, Russian Federation, annuchka15@gmail.com, *Anna Maslennikova*

Forecasting of the development of complex social and economic systems and its interaction, decision making, management, requires the prior simulation because the experiment with the real system is not allowed. Implemented approach, combining the ideas of system dynamics and the possibility of cognitive modeling, developed in the Southern Federal University. Conducted simulation modeling of regional systems of southern Russia. Analyzed interregional cooperation of the macroregions of Russian Federation.

4 - Using SODA for structuring the problematic of monitoring system innovation projects for brazilian companies
Rocio Gutierrez, Brasilia, SENAI Departamento Nacional - Confederação Nacional da Indústria, SBN QUADRA 1 BLOCO C ED. ROBERTO SIMONSEN 3o ANDAR, 70040-903, BRASILIA, BRASILIA, Brazil, rociosgutierrez@gmail.com, *Igor de Lima Matos*

Nowadays, innovation is a constant concern of companies around the world as a way to generate competitive advantages. In this context, innovation grants are used by some companies for developing new products or processes. Among these grants, there is in Brazil the Edital SENAI de Inovação that has approved innovation projects in all Brazilian territory. Our objective is to propose improvements for the monitoring process of these projects by structuring the problematic situation, according to the Decision maker perspective, using Strategic Options Development and Analysis methodology

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■ TC-64

Tuesday, 12:30-14:00
R18-3

Dynamic Optimization

Stream: Dynamic Optimization
Invited session

Chair: *Amir Nakib*, Laboratoire LISSI, Universite Paris-Est Creteil, 61 avenue du General de Gaulle, 94010, CRETEIL, France, nakib@u-pec.fr

1 - Groundwater Management under Uncertainty: Structural Properties of Discrete-Time Models
Chandra Kiran Krishnamurthy, Economics, Umeå University, Sweden, bkckiran@gmail.com

We consider a very general discrete-time set up of groundwater management, with stochastic recharge to the aquifer. The agent is assumed to make a decision prior to the realization of recharge, making uncertainty regarding groundwater stock central to the decision on extraction. The stock-dependent cost of extraction is generalized to accommodate more physically realistic scenarios. Using lattice-theoretic methods, for three different extraction cost functions, we provide a fuller characterization of structural properties of the decision rules.

2 - Simulation Optimization Based Hybrid PSO Application of Optimal Vehicle Allocation Problem in Automated Materials Handling
Chao-Jung Huang, Department of Industrial Engineering and Engineering Management, National Tsing Hua University, Taiwan, No. 101, Section 2, Kuang-Fu Road, Hsinchu, Taiwan 30013, R.O.C., Hsinchu, Taiwan, c8903013@cc.chu.edu.tw, *James T. Lin*

The AMHS in semiconductor industry plays a vital role to reduce the wafer cycle times and to enhance the fab productivity. Due to the complexity of the manufacturing process and the stochastic, we formulated it as a simulation optimization problem and proposed a conceptual framework to handle the problem. We use an effective PSOOCBA for simulation optimization of vehicle allocation in AMHS. This paper compared the PSOOCBA with PSO and exhaustive method. The results demonstrate the superiority of PSOOCBA in terms of searching quality and robustness.

3 - Real-time sub-optimal trajectory planning on an electronic flight bag.
Massimiliano Nolich, DIA, University of Trieste, Italy, mnolich@units.it, *Maria Pia Fanti*, *Stefano Mininel*, *Gabriella Serafino*, *Gabriella Stecco*, *Walter Ukovich*

In this talk we present a Decision Support System (DSS) module that is executed on an EFB and that can perform real-time sub-optimal planning of the aircraft path. The optimization is performed using multi-objective functions that can include monetary costs, for example fuel costs and overflying charge, and environmental costs, for example pollutant productions and noise emissions. The main objective of this DSS is to provide a tool that helps the pilot to guide the aircraft in a safe and low cost trajectory path, reducing the workload affecting him/her.

4 - Robust strategies for facility location under uncertainty
Nalan Gulpinar, Warwick Business School, The Warwick University, UK., CV4 7AL, Coventry, United Kingdom, Nalan.Gulpinar@wbs.ac.uk, *Mahdi Noorizadegan*

This paper considers a stochastic facility location problem in which multiple capacitated facilities serve customers with a single product. Customer demand is assumed to be uncertain. We study robust approximations to the problem in order to incorporate information about the random demand distribution in the best possible, computationally tractable way. Finally, we present numerical experiments that illustrate the performance of the different robust formulations.

■ TC-65

Tuesday, 12:30-14:00
R18-5

Management Science

Stream: Emerging Applications in Portfolio Selection and Management Science
Invited session

Chair: *George Mavrotas*, Chemical Engineering, National technical University of Athens, Zografou Campus, 15780, Athens, Greece, mavrotas@chemeng.ntua.gr

1 - A quantitative approach to determine the optimal table occupancy in casinos
Xiaoming Liu, FBA, University of Macau, University of Macau, Macau, NA, MACAU, China, xmliu@umac.mo, *Davis Fong*, *Jason Gao*

We present a quantitative framework to determine the optimal number of customers at any type of casino gaming table (table occupancy) when the casino is not too crowded. Using baccarat tables in Macau as an example, we demonstrate how casino managers can apply this methodology based on the real situation in their casinos. We show theoretically that once the optimal occupancy for each type of table (a combination of the game and the lower limit) is known, a casino can achieve near-optimal average hourly profits as long as the occupancy of most tables is close to the optimal.

2 - The optimal stopping rule for the full information duration problem with random horizon
Mitsushi Tamaki, Business Administration, Aichi Univeristy, 370 Kurozasa Miyoshi, 470-0296, Nishikamo, Aichi, Japan, tamaki@vega.aichi-u.ac.jp

In the classical full information duration problem as a variation of the secretary problem, a fixed number n of i.i.d. random variables are observed sequentially and we find a stopping rule that maximizes the expected duration of holding a record. We introduce uncertainty about the number N of the available observations. N is assumed to have a prior distribution. The structure of the optimal rule is examined and a necessary and sufficient condition for it to be monotone is given. When N is uniform on (1,2,...,n), some asymptotic results, as n tends to infinity, are derived

3 - Optimal expenditure problem as a partially observable Markov decision process under stochastically increasing and concave
Toru Nakai, Faculty of Education, Chiba University, Yayoi 1-33, Inage-Ku, 263-8522, Chiba, Japan, t-nakai@faculty.chiba-u.jp

An optimal expenditure problem is formulated as a partially observable Markov decision process, in which a state is closely related to an evaluation of a certain public service. Such a problem is treated in Nakai(2010), where some monotonic properties are obtained. We treat this problem as a Markov decision process with concave and submodular function. A state changes according to a transition rule with stochastically increasing and concave. A dynamic programming formulation implies a recursive equation about the optimal value. The purpose is to observe some properties of an optimal policy.

4 - Multi-objective project portfolio selection: Assessing the robustness of selected portfolios
George Mavrotas, Chemical Engineering, National technical University of Athens, Zografou Campus, 15780, Athens, Greece, mavrotas@chemeng.ntua.gr, *John Psarras*, *Olena Pechak*, *Eleftherios Siskos*

In multi-objective project portfolio selection we aim at an efficient portfolio that corresponds to the preference of the decision maker that is usually expressed by a set of weights. In our work we examine how sensitive is the final portfolio in variations of the weight coefficients. We gradually enlarge the domain of the weights and use Monte Carlo simulation and Optimization to produce the corresponding portfolios. The process is terminated when the selected portfolio is no longer supported by the majority of the iterations. We apply the method to an illustrative example with 100 projects.

■ TC-66

Tuesday, 12:30-14:00
R18-4

Optimization for Sustainable Supply Chain Design

Stream: Optimization for Sustainable Development
Invited session

Chair: *Ernesto D.R.S Gonzalez*, DECOM, UFOP, Brazil, research.ernesto@gmail.com

1 - MRP optimization model for a production system with remanufacturing
Fernanda Raupp, DEI, PUC-Rio, Brazil, fraupp@puc-rio.br

Science and technology practitioners have been studying how to take economical, social and environmental advantage of industrial residuals and discarded products. In this sense, we present a Material Requirements Planning (MRP) optimization model for a production system that, besides manufacturing new units of the main assembling component, it recovers selected units of the component that are returned. We prove that this lot-sizing problem is NP-hard. We also show computational experiments with the model using a optimization solver, as well as we analyze some possible industrial scenarios.

2 - Quick Response and inventory management in the apparel industry: the fast fashion in Minas Gerais
Priscilla Ribeiro, Industrial Engineering, Ouro Preto Federal University, Rua Rio Grande do Norte 619, apto 1303, 30130130, Belo Horizonte, Minas Gerais, Brazil, priscri@ig.com.br, *Andre Golobovante*

We identify how Brazilian companies from the apparel industry have sought to maintain competitiveness and sustainability with growth of a fast fashion strategy. Fast fashion requires high inventory turnover, frequent insertion of new products and supply chain agility through quick response (QR) and inventory management. We conducted two case studies. One of the companies has adopted the fast fashion strategy. We describe how it meets the requirements of fast fashion and stays competitive with QR.

3 - A Novel Mixed Integer Linear Programming Model for the Strategic Planning of a Reverse Supply Chain Network
Ernesto D.R.S Gonzalez, DECOM, UFOP, Brazil, research.ernesto@gmail.com, *Nelson Maculan*

In this paper we address a classical three-layer remanufacturing supply chain network design problem that covers sourcing, reprocessing and remanufacturing activities, in which strategic decisions regarding the number, location of reprocessing units and the flow of returns through the logistics network are made. First, we propose an alternative mixed-integer linear programming (MILP) formulation for this problem and a theoretical proof of equivalence between the models is provided. Second, computational results show that the proposed formulation outperforms the classical formulation.

4 - Sustainable Large-Scale Mining Network Design
Bruno Pimentel, Vale Institute of Technology, Brazil, bruno.pimentel@gmail.com

We present preliminary results of our ongoing research aiming at establishing a mathematical programming framework to support sustainable mining supply chain whole lifecycle design. A stochastic, multistage mixed integer model is proposed to balance economic (net present value), environmental (water and energy consumption, pollutant emissions and biodiversity) and societal (gross domestic product per capita, basic service infrastructure and local economy development). It is our belief that such an approach could deliver significant long-term value to industry and local communities alike.

■ TC-68

Tuesday, 12:30-14:00
R19-2

Stochastic Models

Stream: Discrete Optimal Control
Invited session

Chair: *Hitoshi Hohjo*, Department of Mathematics and Information Sciences, Osaka Prefecture University, 1-1 Gakuen-Cho, Naka-Ku, Sakai, 599-8531, Osaka, Japan, hojo@mi.s.osakafu-u.ac.jp

1 - The decision-making of retailers and customers in a competitive inventory problem
Hitoshi Hohjo, Department of Mathematics and Information Sciences, Osaka Prefecture University, 1-1 Gakuen-Cho, Naka-Ku, Sakai, 599-8531, Osaka, Japan, hojo@mi.s.osakafu-u.ac.jp

We consider a competitive inventory problem including customers' decision-making. We deal with it as a non-cooperative game among two retailers and n customers. Though a price in a retailer is deterministic, another one is a discrete random variable. Each retailer decides his ordering quantity maximizing his payoff related to purchasing, selling, holding products and shortages. Each customer chooses his own action maximizing his utility under consideration to his reference price, satisfaction and transferring to purchase a product. Our goal is to find Nash equilibrium for (n+2)-players.

2 - Commodity Procurement and Dynamic Pricing for Demand Stabilization
Kimitoshi Sato, Graduate School of Finance, Accounting and Law, Waseda University, 103-0027, Tokyo, Japan, k-sato@aoni.waseda.jp, *Katsushige Sawaki*

We deal with decision making of the procurement and pricing of a product produced by a manufacture with a two-echelon system. The manufacture buys a commodity in the spot market. A retailer wishes to stabilize the demand for product by adjustment of the price. We formulate a model to analyze the effect of a dynamic pricing (DP) on the peak demand. Then, we discuss the procurement decision in the discrete-time stochastic model that the demand for the commodity occurs in connection with the DP model. We show that the stabilization in downstream provides significant benefits for the supply chain.

3 - An asymptotic analysis for multiserver retrial queues with two types of non-persistent customers
Tuan Phung-Duc, Mathematical and Computing Sciences, Tokyo Institute of Technology, Japan, tuan@is.titech.ac.jp

We consider multiserver retrial queues where a blocked customer has two opportunities for abandonment: at the moment of blocking or at the departure epoch from the orbit. In this queueing system, the number of customers in the queue (servers and buffer) and that in the orbit form a level-dependent quasi-birth-and-death (QBD) process whose stationary distribution is expressed in terms of a sequence of sparse rate matrices. We derive a Taylor type expansion for non-zero elements of the rate matrices and tail asymptotic formulae for the stationary distribution of the QBD process.

4 - Ordering policies for two products with demand substitution
Odysseas Kanavetas, Department of Mathematics, University of Athens, Greece, okanav@math.uoa.gr, *Apostolos Burnetas*

We consider the problem of ordering for two products with stochastic demand and partial demand substitution. Successive demands arrive at random times, thus the order of arrivals affects the ending inventory and/or shortages. We define an equivalent queueing model, compute steady state performance measures, and analyze monotonicity and submodularity properties of a suitable average profit function. Finally, we consider extensions to the case of unknown parameters and suggest adaptive ordering policies.

■ TC-70

Tuesday, 12:30-14:00
R19-4

EURO Journal on Decision Processes 2

Stream: Journals
Sponsor session

Chair: *Ahti Salo*, Systems Analysis Laboratory, Aalto University School of Science and Technology, P.O. Box 11100, Otakaari 1 M, 00076, Aalto, Finland, ahti.salo@aalto.fi

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■ TC-71

Tuesday, 12:30-14:00
R16-1

Health Care Management (Disease Policy Modelling I)

Stream: Health Care Management
Invited session

Chair: *Paul Harper*, School of Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, Wales, United Kingdom, harper@cardiff.ac.uk

1 - Applications of Spatial, Mathematical and Simulation Models to Construct Efficient and Equitable Allocation System for Liver Transplantation
Monica Gentili, University of Salerno, P.te Don Melillo, Fisciano, 84084, Salerno, Italy, mgentili@unisa.it, *Naoru Koizumi*, *Rajesh Ganesan*, *Nigel Waters*, *Chun-Hung Chen*

This study combined Geographic Information Systems, mathematical programming models and Discrete Event Simulation to analyze geographic equity and efficiency of the US liver allocation system. The main objectives of the study were: (i) to identify key factors determining geographic disparity; (ii) to identify optimal locations of existing and new liver transplant centers; (iii) to identify new allocation boundaries and (iv) to test whether the mathematically produced liver allocation system can perform better than the actual system. The results of our analyses will be presented and discussed.

2 - Modelling Adolescent Smoking Behaviours with Social Network Analysis
Angelico Fetta, Maths, Cardiff University, United Kingdom, angelico_fetta@hotmail.com, *Paul Harper*, *Vincent Knight*, *Janet Williams*

Research on link predictions for social networks, whereby we desire to predict future links that will be added to the network, has been greatly advanced in recent years following a surge in quantifiable data. Our research explores the importance of school-based social networks on adolescent smoking cessation rates, aiming to predict both network and behavioural outcomes. Utilising agent based simulation techniques, game theoretic approaches and validating against a cohort of British adolescents - a rigorous investigation is presented.

3 - OR modelling to evaluate long term outcomes in stroke thrombolysis
Leonid Churilov, Florey Institute of Neuroscience and Mental Health, Melbourne Brain Centre, 245 Burgundy St, 3084, Heidelberg, VIC, Australia, leonid.churilov@gmail.com, *Mahsa Keshtkaran*, *Atte Meretoja*

Although intravenous thrombolytic therapy for ischaemic stroke is more effective when delivered early after symptom onset, in-hospital delays of >60 mins are common. We quantified the disability adjusted life years patients gain from faster treatment. Each minute reduction in the average delay provided 1.3 days of extra healthy life. That effect varied with the patients' life-expectancy and exceeded 2 days per minute for young and severe patients. We discuss the challenges encountered in the process of model building and validation.

4 - Location of HIV/AIDS testing laboratories
Honora Smith, Academic Unit of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, honora.smith@soton.ac.uk, *Maria Battarra*

The National Health Laboratory Service of South Africa has been reorganising its nationwide network of laboratories where HIV/AIDS testing takes place, in response to increased demand for services in recent years. We propose several location models for location of test equipment, including a variation on a classical set covering model and a hub location model for testing of different sample types. Results have already proved useful in the decision-making process to improve situations of poor coverage.

■ TC-72

Tuesday, 12:30-14:00
R16-2

Approaches to Quality Problems in Health Care

Stream: OR in Health & Life Sciences (contributed)
Contributed session

Chair: *Dimitrios Andritsos*, Operations Management and Information Technology, HEC Paris, 1 rue de la Liberation, 78351, Jouy-en-Josas, France, andritsos@hec.fr

1 - Does following the rules help reduce resource usage? Exploring the impact of pay-for-performance programs.
Dimitrios Andritsos, Operations Management and Information Technology, HEC Paris, 1 rue de la Liberation, 78351, Jouy-en-Josas, France, andritsos@hec.fr, *Christopher Tang*

Within the context of cardiac care, we empirically examine whether hospital processes of superior quality also attain lower resource usage, which we measure while taking into account patient readmissions. We find that patients whose initial hospitalization occurs at a hospital with high process quality, spend on average less time in an acute care setting and hence consume less resources. Moreover, the effect of process quality appears to be direct. We then examine whether the structure of the cardiac department, moderates the observed effects of process quality on resource usage.

2 - Evaluation of service quality of public hospitals using multiple criteria decision making
Ahmet Aktaş, Industrial Engineering Department, Karadeniz Technical University, Karadeniz Technical University Industrial Engineering Department, 61080, Trabzon, Turkey, a.aktas@ktu.edu.tr, *Selçuk Çebi*, *İzzettin Temiz*

Evaluation of service quality (SQ) of hospitals has been ignored by health care providers in Turkey. For this, some regulations are being done by Turkish Government. One of them is to classify hospitals based on their SQ. However, the current classification procedure is not based on an analytical method. Therefore, in this paper, service quality index (SQI) has been developed to present a scientific basis for classification by using multiple criteria decision making tools with respect to existing measures in the literature. A case study is presented to test applicability of the method.

3 - Benchmarking Clinical Practice in Surgery Services: Assessing Mortality Looking Beyond Traditional Rates
Ricardo A. S. Castro, Faculdade de Engenharia, Universidade do Porto, Portugal, ricardo.alves.castro@fe.up.pt, *Pedro Oliveira*, *Maria Portela*, *Ana Camanho*, *João Queiroz e Melo*

This study proposes two new measures to assess surgical quality, regarding the life/death outcome, enabling an enhanced benchmarking of surgical units. Relying only on surgery risk and patients' final state, the measures are the area under the ROC curve and a corrected average risk for the living patients. The validity of these measures is verified with a simulation based on random sampling and an exploratory study of a cardiothoracic service providing real data. The results provided insightful information to the director of this service, with practical utility to hospital management.

4 - A Decision Model Combining DEMATEL with Fuzzy Multiple Objective Programming for Medical Supplier Selection
Mehtap Dursun, Industrial Engineering, Galatasaray University, Turkey, mdursun@gsu.edu.tr, *Zeynep Sener*, *E. Ertuðrul Karsak*

Recently, with the growth of medical device use, medical supplier selection has become crucial in order to achieve customer satisfaction in healthcare industry. This paper proposes a decision approach based on decision making trial and evaluation laboratory (DEMATEL) method and fuzzy multiple objective programming (FMOP) for supplier selection in healthcare. Fuzzy numbers are employed to quantify the imprecision and uncertainty inherent in supplier data. The importance level of each decision criterion, which is considered as an objective in the FMOP framework, is obtained using DEMATEL.

■ TC-73

Tuesday, 12:30-14:00
R16-3

OR in Forestry II

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *Miguel Constantino*, University of Lisbon,

FCUL-DEIO-CIO, Bloco C2 Piso 2 Campo Grande, 1749-016, Lisbon, Portugal, miguel.constantino@fc.ul.pt

1 - Efficient solutions for a harvest scheduling problem in Cuba.

Monica Hernandez, Applied Economics (Mathematics), University of Malaga, Campus El Ejido s/n, 29071, Malaga, Spain, m_huelin@uma.es, *Trinidad Gomez*, *Julian Molina*, *Rafael Caballero*, *Maria Amparo Leon*

Cuba is making great efforts to reduce the pressure its natural forests are under by increasing the number of productive plantations to meet the country's timber requirements. In this work we use multiobjective programming to solve a forest management problem in the island that focuses on the economic factors, while taking into account aspects related to environmental protection. We also incorporate spatial constraints. The model results a complex problem necessitating the use of metaheuristics to solve it. In this context, we have used an adaptation of the evolutionary method SSPMO.

2 - Enhancing forest wildfire resistance with mixed integer programming

Miguel Constantino, University of Lisbon, FCUL-DEIO-CIO, Bloco C2 Piso 2 Campo Grande, 1749-016, Lisbon, Portugal, miguel.constantino@fc.ul.pt, *Liliana Ferreira*, *Jose Borges*, *Jordi Garcia_Gonzalo*

An MIP approach is proposed to address wildfire risk in forest management planning at landscape level. It introduces a wildfire resistance index that takes into account both stand characteristics and its spatial context. Several factors may influence neighbors' contribution to increase or decrease the resistance to fire of one given stand. The model aims the selection of management prescriptions to maximize the soil expected value of a forest, ensuring some level of resistance. A Portuguese forest area was used as a test case.

3 - Combining column generation and VNS for a forest harvest scheduling problem

Isabel Martins, Departmento de Matemática, Instituto Superior de Agronomia, Centro de Investigação Operacional, Tapada da Ajuda, 1349-017 , Lisbon, Portugal, isabelinha@isa.utl.pt, *Filipe Alvelos*, *Miguel Constantino*, *Ricardo Magalhães*

We apply a general combination of column generation (CG) and metaheuristics (MH) (named SearchCol - MH search by CG) to a forest harvest scheduling problem with maximum area restrictions. In the present application VNS is the MH used. In SearchCol the subproblem solutions generated by column generation, define a restricted space which can be effectively explored by meta-heuristics. We describe two Dantzig-Wolfe decompositions of the bucket formulation and develop different SearchCol algorithms for which we present computational results.

■ TC-74

Tuesday, 12:30-14:00
R16-4

EDDA Finalists

Stream: Prizes
Invited session

Chair: *Christian Raack*, Optimization, Zuse Institute Berlin, Takustr. 7, D-14195, Berlin, Germany, raack@zib.de

1 - New Directions in Robustness Analysis and Preference Modeling in Multiple Criteria Decision Aiding

Milosz Kadzinski, Institute of Computing Science, Poznan University of Technology, 60-965 , Poznan, Poland, milosz.kadzinski@cs.put.poznan.pl

We propose a set of novel decision aiding methods based on two prevailing preference models: additive value function and outranking relation. The introduced approaches take into account preference information of a new type and conduct robustness analysis of the suggested recommendation in an innovative way. The presented methods promote alternate phases of preference elicitation and robustness analysis as a versatile tool for approaching real-world decision problems.

2 - Quality-driven Efficiency in Healthcare

Nikky Kortbeek, Quality and Process Innovation / Stochastic Operations Research, Academic Medical Center / University of Twente, Drienerlolaan 5, P.O. Box 217, 7500AE, Enschede, Netherlands, n.kortbeek@utwente.nl

During the upcoming decades, healthcare organizations face the challenge to deliver more patient care, of higher quality, and with less financial and human resources. The goal is to help and guide healthcare professionals make their organizations future-proof. We demonstrate that quality and efficiency often can, and must, go hand in hand. Also, performance is enhanced by aligning long-, medium-, and short-term decision making and by realizing coordination and collaboration between the various care chain actors. Taking an integral approach is the key to achieving quality-driven efficiency.

3 - Capacitated Network Design – Multi-Commodity Flow Formulations, Cutting Planes, and Demand Uncertainty

Christian Raack, Optimization, Zuse Institute Berlin, Takustr. 7, D-14195, Berlin, Germany, raack@zib.de

This thesis is about methods in mathematical optimization to dimension networks at minimal cost. The considered planning problems arise in the strategic design of telecommunication or public transport networks and in logistics. One of the essential aspects studied in this work is the use of cutting planes to enhance solution approaches based on multi-commodity flow formulations. Providing theoretical and computational evidence for the efficacy of mixed integer rounding (MIR) inequalities based on network cuts, we extend existing theory and algorithmic work in different directions.

Tuesday, 14:30-16:00

■ TD-03

Tuesday, 14:30-16:00
O1-3

DC programming, DCA and applications

Stream: Nonconvex Programming: Local and Global Approaches
Invited session

Chair: *Tao Pham Dinh*, INSA Rouen, 76131, Rouen, France, pham@insa-rouen.fr

1 - Cell Segmentation and Counting by a DCA based approach
Bich Thuy NGUYEN Thi, Computer Science, University of Lorraine, Île du Saulcy, 57045, Metz, France, thi-bich-thuy.nguyen9@etu.univ-lorraine.fr, *Minh Tam Le*, *Hoai An Le Thi*

Cytological analysis, specially the cell counting, is an important element in the diagnosis of many diseases. Cell segmentation, the major phase of cell counting procedure, was basically performed by intensity thresholding, feature detection, morphological filtering, region accumulation and deformable model fitting. We present an automatic method for cell counting in which the segmentation is based on Feature Weighted Fuzzy Clustering via a Difference of Convex functions Algorithm (called DCA). This new application of our method can give excellent results despite the very high cell density.

2 - DC Programming and DCA for Nonnegative Matrix Factorization (NMF)
Vo Xuan Thanh, LITA - Université de Lorraine, 57045, Metz, France, xuan-thanh.vo5@etu.univ-lorraine.fr, *Hoai An Le Thi*, *Tao Pham Dinh*

Techniques of matrix factorization or decomposition always play a central role in numerical analysis and statistics with many applications in real-world problems. Recently, the NMF dimension-reduction technique, popularized by Lee and Seung with their multiplicative update algorithm (an adapted gradient approach), has drawn much attention of researchers and practitioners. Since many of existing algorithms lack a firm theoretical foundation, and designing efficient scalable algorithms for NMF still is a challenging problem, we investigate DC programming and DCA for NMF.

3 - Optimizing a Generic Feature-Selection Measure by DC Programming and DCA based approaches and Application in Network Intrusion Detection
Le Anh Vu, Computer Science, University of Lorraine, Ile du Saulcy,, 57 045 , Metz, France, anhvu.le@umail.univ-metz.fr, *Hoai An Le Thi*, *Zidna Ahmed*, *Vo Xuan Thanh*

This paper aim to develop new efficient approaches based on DC programming and DCA for the generic feature selection. We consider two measures: the correlation feature-selection measure and the minimal-redundancy-maximal-relevance measure. The problem is formulated as a mixed 0-1 linear programming problem. By using an exact penalty technique we treat this problem as a DC program. Further, we combine the DCA with the classical Branch and Bound method for finding global solutions. Preliminary numerical results on Intrusion Detection Systems datasets show the efficiency of our approach.

4 - Local-global minimum property of nonlinear optimization problems
Pál Burai, Applied Mathemathics and Probability Theory, University of Debrecen, Faculty of Informatics, Pf.: 12., Technische Universität Berlin Institut für Mathematik Sekr. MA 4-1 Straße des 17.Juni 136 10623 Berlin, 4010, Debrecen, Hungary, burai.pal@inf.unideb.hu

In optimization theory sufficient conditions have a great importance. In the linear and convex cases, the theory is well-developed, because the first order necessary conditions usually become sufficient. The situation is completely different if the problem is highly nonlinear. In these cases sufficient conditions ensure only local optimality. This fact motivates the development of the following question: What kind of problems possess the so-called local-global minimum property? We will try to show some possible answers to this question. Applications in control theory are also presented.

■ TD-04

Tuesday, 14:30-16:00
O4-4

Nonlinear Optimization in Mathematical Biology

Stream: Mathematical Programming
Invited session

Chair: *Francesca Maggioni*, Department of Management, Economics and Quantitative Methods, University of Bergamo, Via dei Caniana n. 2, 24127, Bergamo, Italy, Italy, francesca.maggioni@unibg.it

1 - Sequence Alignments and Binary Steiner Trees
Susanne Pape, Mathematics, FAU Erlangen-Nürnberg, Cauerstraße 11, Erlangen, Germany, Germany, susanne.pape@math.uni-erlangen.de

Advances in molecular bioinformatics have led to increased information about biological sequences like protein or DNA sequences. Alignments of these sequences play an important role in inferring evolutionary history or predicting protein structure and function. Here we consider a special type of alignments called binary tree alignments. The problem of finding such alignments can be modeled as a binary Steiner tree problem. We study the computational complexity of this problem, introduce the binary Steiner tree polytope and its facets and present an approach for computing binary Steiner trees.

2 - Optimal kinematics of supercoiling
Francesca Maggioni, Department of Management, Economics and Quantitative Methods, University of Bergamo, Via dei Caniana n. 2, 24127, Bergamo, Italy, Italy, francesca.maggioni@unibg.it, *Florian Potra*, *Marida Bertocchi*

New kinematics of supercoiling of closed filaments as solutions of the elastic energy minimization are proposed. The analysis is based on the thin rod approximation of linear elastic theory. Time evolution functions are described by means of piecewise polynomial transformations based on cubic spline functions. In contrast with traditional interpolation, the parameters, which define the cubic splines representing the evolution functions, are the unknowns in a non-linear optimization problem. These results may find useful applications in DNA packing.

■ TD-05

Tuesday, 14:30-16:00
O4-1

Inventory Systems

Stream: Optimal Control
Invited session

Chair: *Andreas Novak*, Business Administration, Bruennerstrasse 72, A-1210, Vienna, Austria, andreas.novak@univie.ac.at

1 - Inventory Control with Piece-wise Linear Convex Variable Production Cost and Fixed Cost
Miao Song, The University of Hong Kong, Hong Kong, msong@hku.hk, *Ye Lu*

We study the optimal policy for a periodic-review inventory system in which production cost consists of a fixed cost and a variable cost defined by a piece-wise linear convex function. We fully characterize the

structure of the optimal policy for the single-period problem. For the multi-period problem, the optimal policy can be too complicated to be fully characterized and implementation of the optimal policy may not be practical. However, careful investigation shows the optimal policy has some interesting properties, which leads to a practical and well-performing heuristic policy.

2 - Optimal control problem for continuous inventory within the stochastic semi-Markov model with periodical consumption termination
Alexey Ivanov, Higher Mathematics, National Research University Higher School of Economics, Bolshoy Trehsvyatitelsky lane, bld. 3, 109028, Moscow, Russian Federation, A.I.Valerevich@gmail.com, *Peter Shourkoff*

The system of continuous inventory control is considered. As a model of the system functioning the controlled semi-Markov process having finite set of states is used. The main probabilistic characteristics of the model as well as the functionals characterizing the quality of the system control are obtained in the analytic form. The statement that the optimal strategy of controlling the system is a deterministic strategy is proved. Representation of the function the absolute extremum of which is determined as the optimal control strategy is obtained also.

3 - Inventory model with pricing and inventory-dependant demand
Andreas Novak, Business Administration, Bruennerstrasse 72, A-1210, Vienna, Austria, andreas.novak@univie.ac.at, *Richard Hartl*, *Peter M. Kort*

We consider a dynamic version of a static lotsizing model with two extensions. First demand depends explicitly on inventory and second, demand can be influenced by setting the price. In our model the level of inventory is the state variable of an intertemporal optimization problem whereas price is the control. Additionally to price the time between production as well as the amount of production have to be chosen optimally. The problem is solved by Pontryagin's maximum principle. The structure of optimal solutions is discussed and compared with results to classical benchmark models.

■ TD-06

Tuesday, 14:30-16:00
O4-2

Nonsmooth Optimization in Machine Learning

Stream: Nonsmooth Optimization
Invited session

Chair: *Manlio Gaudioso*, Università della Calabria, 87036, Rende, Italy, gaudioso@deis.unical.it

1 - A mathematical programming approach for classification problems
Burak Ordin, Mathematics, Ege University, Ege University Science Faculty, Department of Mathematics, 232, izmir, bornova, Turkey, burak.ordin@ege.edu.tr, *Nur Uylas*

Binary classification problem is an essential issue in data mining. In this work, we propose a classification algorithm to separate two discrete A and B point sets in the n-dimensional space. The algorithm is based on the concepts of polyhedral conic functions and hard clustering methods. We present results of numerical experiments on real-world data sets.

2 - SVM Polyhedral Separability
Annabella Astorino, ICAR, CNR, C/0 DEIS - UNICAL, CUBO 41 C, 87036, RENDE, Italy, astorino@icar.cnr.it, *Antonio Fuduli*

We extend the polyhedral separability concept to the Support Vector Machine technique in the supervised and semisupervised learning. Our approach is aimed at separating two finite and disjoint sets of points by means of a polyhedron, obtained by minimizing a nonconvex nondifferentiable error function. Such a function, in the semisupervised case, exploits information coming from both labeled and unlabeled samples. Numerical results are presented on small and large scale datasets drawn from literature.

3 - Nonsmooth nonconvex optimization approach to clusterwise linear regression problems
Adil Bagirov, School of Science, Information Technology & Engineering, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au, *Julien Ugon*

Clusterwise regression consists of finding a number of regression functions each approximating a subset of the data. In this talk, we present nonsmooth nonconvex optimization approach to clusterwise linear regression. An incremental algorithm based on this approach is designed. A special procedure is introduced to generate a good starting point for solving global optimization problems at each iteration of the incremental algorithm. Results of numerical experiments are presented using several data sets for regression.

4 - The proximal trajectory algorithm in svm model selection
Antonio Fuduli, Dipartimento di Matematica e Informatica, Universita' della Calabria, Via P. Bucci, CUBO 31B, 87036, Rende, Italy, antonio.fuduli@unical.it, *Annabella Astorino*

We exploit the proximal trajectory from nonsmooth optimization to select the weighting parameter C of the error function characterizing the Support Vector Machine (SVM) technique. In particular we construct the entire regularization path by solving a finite number of structured linear programs. Differently from other approaches, we work directly on the primal form of SVM. Numerical results are presented on binary datasets drawn from literature.

■ TD-07

Tuesday, 14:30-16:00
O4-3

Copositive and Conic Optimization: Nonnegativity and Approximation

Stream: Copositive and Polynomial Optimization
Invited session

Chair: *Luis Zuluaga*, Faculty of Business Administration, University of New Brunswick, Canada, lzuluagag@gmail.com

1 - Copositive Optimization Based Bounds for Standard Quadratic Optimization
Gizem Sağol, Industrial Engineering, Koç University, Turkey, gizemsagol@gmail.com, *E. Alper Yildirim*

The standard quadratic optimization problem (StQP) admits an exact copositive programming reformulation and we replace the difficult conic constraint in the reformulation by a sequence of polyhedral cones, which provide inner and outer approximations that are exact in the limit. We study the upper and lower bounds arising from the use of inner and outer approximations for StQP. We give characterizations of instances for which the bounds are exact at a finite level of the inner and outer approximations and the instances for which the bounds converge to the optimal value only in the limit.

2 - Non-negative polynomials on unbounded domains
Luis Zuluaga, Faculty of Business Administration, University of New Brunswick, Canada, lzuluagag@gmail.com

Certificates of non-negativity are fundamental in optimization. A "certificate" is generally understood as an expression that makes the non-negativity of the function in question evident. We present a new certificate of non-negativity for polynomials over the intersection of a closed set S and the zero set of a given polynomial h(x). The certificate is written in terms of the set of non-negative polynomials over S and the ideal generated by h(x). Our certificate of non-negativity yields a copositive programming reformulation for a very general class of polynomial optimization problems.

3 - Bernstein Polynomials for Range Approximation of Multivariate Polynomials and Application in Global Optimization

Martin Stöcker, Fakultät Mathematik, Professur Wirtschaftsmathematik, Technische Universität Chemnitz, Reichenhainer Str. 41, Zimmer 727, 09107, Chemnitz, Germany, martin.stoecker@mathematik.tu-chemnitz.de

Optimization algorithms which definitely find all global solutions of an optimization problem with a given accuracy can be developed with the help of bounds on the range of the considered function. We concentrate on polynomials in an arbitrary number of variables and introduce two approaches which generate lower and upper bounds. The first method is based on the estimation of the contribution of the polynomial's summands, while the second one uses an expansion into Bernstein polynomials to obtain the desired bounds. The development process of vehicle transmissions will serve as an example.

■ TD-08

Tuesday, 14:30-16:00
O3-2

Keynote - A. Goel

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Ana Meca*, Operations Research Center, Universidad Miguel Hernández, Avda. Universidad s/n, Edificio Torretamarit, 03202, Elche, Alicante, Spain, ana.meca@umh.es

1 - Some Algorithmic Aspects of Social Commerce

Ashish Goel, Management Science and Engineering, Stanford University, Terman 311, 94305-4026, Stanford, CA, United States, ashishg@stanford.edu

A signi

cant fraction of socio-economic activity is now conducted on the Internet, using paradigms that did not exists before the Internet. Some examples are personalized advertising and product recommendations; online reputation systems to rate buyers, sellers, and service providers; question/answer forums and discussion boards; and novel pricing mechanisms. In this talk, we will focus on three examples from social networks, illustrating the use of algorithmic tools in particular, and Operations Research techniques in general.

1. Personalized advertising and recommendations: We will describe our experience designing twitter's revenue model and the initial version of its ad targeting algorithms. We will also point out the synergies between personalized advertising and personalized recommendations, and describe algorithmic techniques for real-time personalized recommendations.

2. Reputation Systems and Virtual Currencies: Reputation systems are crucial for social commerce, given the large number of sellers and buyers, the ease of acquiring fake identities, and the large number of

first-time transactions. We will describe a model of networked trust that is an alternative to centralized reputation/virtual currency systems on the Internet. Informally, every node in the network acts as a bank and prints its own currency, which is then used to purchase services within the network. Transactions between untrusting agents proceed through exchange of IOUs along a chain of trust. Such "trust networks" are robust to infiltration. We will show that in many interesting cases, the liquidity of these trust networks is comparable to a system where currency is issued by a single centralized bank.

3. Polarization in Social Networks: While social networks and the Internet have made it much easier to communicate, there is considerable anecdotal and research evidence that we are getting more polarized as a society. We will present an analysis of the dynamics of opinion polarization in a social network, and discuss its implications for the design of recommendation algorithms, as well as social systems that enable large scale collective decision making.

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■ TD-09

Tuesday, 14:30-16:00
O3-3

Sponsor - SAS

Stream: Sponsors
Sponsor session

Chair: *Renata Mansini*, Department of Information Engineering, University of Brescia, 25123 , Brescia, Italy, rmansini@ing.unibs.it

1 - Solving Business Problems with SAS Analytics and OPTMODEL

Manoj Chari, SAS Institute srl, 20143, Milano, Italy, Manoj.Chari@sas.com

SAS provides diverse analytic capabilities including data integration, statistical analysis, data/text mining, and forecasting, all integrated with OPTMODEL's optimization modeling and solution capabilities. OPTMODEL delivers unified access to a wide range of optimization models (LP, MILP, QP, NLP) and supports both standard and customized optimization algorithms. We'll demonstrate OPTMODEL's power and versatility in building and solving optimization models, especially noting the significant improvements resulting from recently added optimization features. We'll also emphasize its integration with SAS data, analytic, and reporting capabilities, with a few example case studies drawn from our successful work with customers across a broad range of industries.

■ TD-10

Tuesday, 14:30-16:00
G5-1

Steiner and tree network design problems

Stream: Telecommunications and Network Optimization
Invited session

Chair: *Ivana Ljubic*, Department of Statistics and Operations Research, University of Vienna, Bruennerstr. 72, 1210, Vienna, Austria, ivana.ljubic@univie.ac.at

1 - A constant factor approximation algorithm for connected facility location with buy-at-bulk edge costs

Andreas Bley, TU Berlin, Straße des 17. Juni 136, 10623, Berlin, Germany, bley@math.tu-berlin.de, *Mohsen Rezapour*

We present an approximation algorithm for the connected facility location problem with buy-at-bulk edge costs. Given are a metric graph containing clients and potential facilities, a core cable type of infinite capacity, and several access cable types with decreasing cost/capacity ratio. We shall open some facilities, connect them by a Steiner tree of core cables, and build a forest network using access cables such that the edge capacities suffice to route all client demands to open facilities. The total cost for opening facilities and installing core and access cables shall be minimal.

2 - Steiner multi-ring network design problem with revenues
Ana Bautzer, ISCAL / CIO, Av. Miguel Bombarda, 20, 1069-035, Lisboa, Portugal, aapedro@iscal.ipl.pt, *Luís Gouveia*, *Ana Paias*, *José Pires*

We address the Steiner multi-ring network design problem with revenues which arises in the design of metropolitan optical networks. The SmRNDP consists of designing m capacitated node-disjoint rings that start and end at a central depot and pass through all the costumers with high priority of service and some of the costumers with low priority of service, minimizing the difference between the total connection cost and the total profit. We compare three integer linear programming formulations concerning the quality of the corresponding lower bounds and we propose some valid inequalities.

3 - The bi-objective prize-collecting Steiner tree problem
Markus Sinnl, University of Vienna, Austria, markus.sinnl@univie.ac.at, *Markus Leitner*, *Ivana Ljubic*

We consider the bi-objective prize-collecting Steiner tree problem, whose goal is to find a subtree considering the conflicting objectives of minimizing the edge costs and maximizing the collected node revenues. We present a computational study of five iterative mixed integer programming frameworks that identify one efficient solution for every point on the Pareto front. Moreover, we investigate how to exploit the information gained during these iterative procedures. Standard benchmark instances from the literature are used to assess the efficacy of the proposed methods.

4 - The Maximum Node-Weight Connected Subgraph Problem
Ivana Ljubic, Department of Statistics and Operations Research, University of Vienna, Bruennerstr. 72, 1210, Vienna, Austria, ivana.ljubic@univie.ac.at, *Eduardo Álvarez-Miranda*, *Petra Mutzel*

The Maximum Weight Connected Subgraph Problem searches for a connected subgraph with maximum total weight in a node-weighted (di)graph. We introduce a new MIP model built on node variables only, which uses connectivity constraints based on node-separators. We study the facets of the connected subgraph polytope and theoretically and computationally compare the new model with MIP models recently proposed in the literature. Two sets of benchmark instances were considered: a) regulatory networks from system biology, and b) network design inputs.

■ TD-11

Tuesday, 14:30-16:00
G5-3

Location Problems in Transportation

Stream: Location Analysis
Invited session

Chair: *Monica Gentili*, University of Salerno, P.te Don Melillo, Fisciano, 84084, Salerno, Italy, mgentili@unisa.it

1 - Service network design for less-than-truckload carriers
Martin Savelsbergh, University of Newcastle, Australia, martin.savelsbergh@newcastle.edu.au, *Alan Erera*, *Kate Lindsey*

A terminal in a less-than-truckload linehaul network operates as a breakbulk (BB) or as an end-of-line (EOL). At an EOL freight is picked up and sent to a BB and received from a BB and delivered. At a BB freight from EOLs is transferred and consolidated to increase trailer utilization. The operating role of terminals in the network impacts the operating cost and the level of service. We develop an IP-based solution approach to determine the operating roles of terminals and present an extensive computational study using data from a super-regional LTL carrier in the US.

2 - Location of battery swap stations for electric vehicles
Pitu Mirchandani, System and Industrial Engineering, University of Arizona, Tucson, Arizona, United States, pitu@sie.arizona.edu

We discuss the infrastructure design for electric vehicles. In particular, we discuss detouring to stations due to the limited range of the vehicles, and subsequently the location of swap stations. Some theoretical results for tree networks will be given.

3 - A shelter location model for flood emergencies
Melissa Gama, Universidade de Coimbra, 3004-531, Coimbra, Portugal, melissa@student.dec.uc.pt, *Maria Paola Scaparra*, *Bruno Santos*

A time-dependent maximal covering location model is proposed to determine the location of shelters in emergency situations, such as floods. The covering radius of the shelters is time dependent, reflecting the changes in road conditions due to the flood dynamics. It is assumed that shelters have limited capacities and that the demand nodes can be fully, partially, or not at all covered. The objective of the model is to locate a predefined number of shelters so that the covered demand is maximized over the entire time horizon. The applicability of the model is illustrated using a case study.

4 - On the Location of High-Speed Rail Stations
Antonio Antunes, Dept. of Civil Engineering, University of Coimbra, Polo 2, 3030-788, Coimbra, Portugal, antunes@dec.uc.pt, *Hugo Repolho*

The success of HSR investments heavily depends on rail ridership, which in turn depends on the location of stations. The mixed-integer programming model dealt with in this presentation determines the optimum location of stations along a HSR line to be built over an existing transportation network, according to the objective of maximizing travel cost savings and taking into account the sensitivity of rail ridership to stops at intermediate stations as well as competition from other modes. The practical usefulness of the model is illustrated for the Lisbon-Oporto planned HSR line.

■ TD-12

Tuesday, 14:30-16:00
G5-4

Applications of Vehicle Routing and Optimization in Public Transport

Stream: Transportation and Logistics
Invited session

Chair: *Daniele Vigo*, DEIS, University of Bologna, Via Venezia 52, 47023, Cesena, Italy, daniele.vigo@unibo.it

1 - Territory-Based Vehicle Routing in the Presence of Time Window Constraints
Daniele Vigo, DEIS, University of Bologna, Via Venezia 52, 47023, Cesena, Italy, daniele.vigo@unibo.it, *Michael Schneider*, *Andreas Stenger*, *Fabian Schwahn*

Territory-based routing approaches (TBRAs) are commonly used to achieve high service consistency, e.g., in the small package shipping industry, but their drawback is a decline in routing flexibility. We develop a two-phase TBRA and use it both to investigate the design requirements of a TBRA for successfully handling time windows and to study the influence of time window constraints on the performance of such an approach. We report the results of an extensive analysis of the impact of time windows and their characteristics on the efficiency and consistency of the obtained solutions.

2 - Instances and Algorithms for Real World Waste Collection Problems (P-MCARP-IF)
Volker Engels, Fraunhofer IML, Germany, volker.engels@iml.fhg.de, *Uwe Clausen*

We focus on curbside collection of municipal solid waste in containers with different capacities and different collection frequencies by the servicing teams. To elaborate a collection schedule for service teams a tour planning for collection districts is required. We define decision rules for fairness and acceptance, define a Periodic Mixed Capacitated Arc Routing Problem with Intermediate Facilities (P-MCARP-IF), present one and two stage algorithms on real world and artificial instances (including one way and service side) with comparison of acceptable and efficient solutions.

3 - Design and Control of a Public-Transport Service Contract
Enrico Malaguti, DEI, University of Bologna, Viale Risorgimento, 2, 40136, Bologna, Italy, enrico.malaguti@unibo.it, *Andrea Lodi*, *Nicolas Stier-Moses*, *Tommaso Bonino*

We consider the problem of an Agency who contracts a public transport service to a private Operator. We address the informative asymmetry between the two players from a game theoretical perspective, and propose an optimized control strategy based on the solution of a price collecting routing model. We show that an improved control results in an incentive, for the Operator, to provide reliable information about its own performance. We present a case study for the city of Bologna, Italy, which was addressed within the European project EPTA.

4 - A new algorithm for dynamic shortest hyperpaths on multimodal networks applied to journey planning
Guido Gentile, Dipartimento di Ingegneria Civile Edile e Ambientale, University of Rome "La Sapienza', Università degli Studi di Roma, Via Eudossiana, 18, 00184, Roma, Italy, guido.gentile@uniroma1.it, *Lorenzo Meschini*, *Simone Decristofaro*

We present the application of a unified framework for the computation of dynamic shortest paths and hyperpaths on transit networks, where passengers optimize their route choice based on the available information about service performances and reliability. The algorithm, implemented in the journey planner HyperPath (www.sistemaits.com), is a convenient specification of the above general model, which allows to address the case of mixed transit services with both schedule-based and frequency-based lines. An application to the case of Rome integrates realtime data from floating cars and bus AVL.

■ TD-13

Tuesday, 14:30-16:00
G5-5

Transport planning

Stream: Traffic
Invited session

Chair: *Vasileios Zeimpekis*, Financial & Management Engineering, University of the Aegean, Kountouriotou 41, Chios, 82100, Chios Island, Greece, vzeimp@fme.aegean.gr

1 - Estimating the value of information in the choice between different public transport services
Marialisa Nigro, Engineering, Roma Tre University, Via Vito Volterra 62, 00146, Rome, Italy, mnigro@uniroma3.it, *Stefano Carrese*, *Livio Muzzetto*

The study quantifies the value of information (VOI) in the choice between different public transport services. The VOI is of interest of both public transport operators, in order to make their strategies, and transport planners and engineers, in order to correctly depict their models. Different methods are adopted: behavioral models using random utility theory, Multi-Criteria analysis using Analytic Hierarchy Process. The models have been calibrated and validated using RP data from users choosing between different transit services connecting Fiumicino Airport to the center of Rome.

2 - Design of transportation lines with competition.
Gabriel Gutiérrez-Jarpa, School of Industrial Engineering, Pontificia Universidad Católica de Valparaíso, 2362807, Valparaíso, Chile, Chile, gabriel.gutierrez@ucv.cl, *Gilbert Laporte*, *Vladimir Marianov*

We design a transportation system (a set of lines) in the presence of competition. The goals are minimizing construction costs and maximizing origin-destination demand capture from competitors. The demand is known for each origin destination pair in the region. Applications are found also in distribution systems. We formulate a non-linear, integer programming model and solve it using heuristics. We provide preliminary computational experience.

3 - A Decision Support System for smart yachts
Giorgio Iacobellis, DEI, Politecnico di Bari, 70123, Bari, Italy, iacobellis@deemail.poliba.it, *Maria Pia Fanti*, *Walter Ukovich*, *Gabriella Stecco*, *Stefano Mininel*, *Angelo Poliseno*

This research aims at developing a Decision Support System (DSS) able to simplify the access to all information about the state of the yacht by a unique user friendly interface. The DSS will support the ship owner on decisions such as: the choice of the best place to refueling or the closest maintenance center. The suggestions proposed by the DSS will take into account all information available concerning, e.g., distance of the centers, weather condition, the available amount of fuel. The research is developed within the project "DOMARE" financed by the Friuli Venezia Giulia region.

4 - Assessment and benchmarking of freight transport operations: The case of Pan-European Corridors IV, V and VII
Vasileios Zeimpekis, Financial & Management Engineering, University of the Aegean, Kountouriotou 41, Chios, 82100, Chios Island, Greece, vzeimp@fme.aegean.gr, *Christina Arampantzi*, *Leonardo Caggiani*, *Primoz Kranjec*, *Ioannis Minis*, *Michele Ottomanelli*

Sustainable freight transport via co-modality is gaining more importance lately in the S.E. Europe region. However, there are not adequate studies that analyze the status of the SEE transport corridors as well as assess and benchmark their performance. This paper assesses infrastructure, operational, environmental, market and ICT status of the three important Pan-European transport corridors namely IV, V and VII. Subsequently these corridors are benchmarked with 4 "corridors of excellence" from North and South Europe in terms of service efficiency as well as environmental sustainability.

■ TD-14

Tuesday, 14:30-16:00
G5-6

Metaheuristics and Matheuristics Applications

Stream: Matheuristics
Invited session

Chair: *Vittorio Maniezzo*, dept. Computer Science, University of Bologna, via sacchi 3, 47521, Cesena, – Please Select (only U.S. / Can / Aus), Italy, vittorio.maniezzo@unibo.it
Chair: *Stefan Voss*, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de

1 - Simultaneous multi-objective beam angle and fluence map optimisation in intensity modulated radiation therapy
Guillermo Cabrera G., University of Auckland; Pontificia Universidad Catolica de Valparaiso, Chile, gcab623@aucklanduni.ac.nz, *Matthias Ehrgott*, *Andrew J Mason*

In intensity modulated radiation therapy beam angle and fluence map optimization problems are usually solved sequentially. Once the number and directions of the radiation beams are determined, intensities for those angles are calculated. In this work we address both problems simultaneously from a multi-objective point of view by using a hybrid strategy combining heuristics and exact methods. While heuristics allow us to search for a good set of angles without getting trapped in local optima, exact methods allow us to generate a good set of non-dominated points for each beam angle configuration.

2 - An evolutionary multi-objective simulation optimization and decision making approach for buffer allocation problem
Simge Yelkenci Kose, Directorate General for Industry, Ministry of Science, Industry and Technology, Cankaya, 06510, Ankara, Turkey, simge.yelkenci@deu.edu.tr, *Ozcan Kilincci*

In this study, an evolutionary multi-objective simulation optimization approach is proposed to solve the buffer allocation problem for unreliable production lines so as to maximize average throughput rate and minimize total buffer size. The approach is based on a multi-objective genetic algorithm using the Pareto dominance relationship. Pareto optimal set is derived by non-dominated sorting genetic algorithm II. The performance measures are evaluated by simulation. Also decision making before search and search before decision making strategies are analyzed.

3 - The multiple travelling salesperson problem with hotel selection
Marco Castro, Faculteit Toegepaste Economische Wetenschappen, Universiteit Antwerpen, Prinsstraat 13, 2000, Antwerpen, Belgium, marco.castro@ua.ac.be, *Kenneth Sörensen*, *Peter Goos*, *Pieter Vansteenwegen*

In this talk, the multiple travelling salesperson problem with hotel selection is presented. This is a generalisation of the travelling salesperson problem with hotel selection which considers costs per stay at the intermediate facilities (hotels), as well as multiple salespeople based in a central hotel. The objective is to minimise the total travel costs. A number of benchmark instances are designed in order to test this problem. A mathematical formulation is presented as well as an effective two-phase parallel solution strategy for this problem.

4 - Feature Selection as Set Covering solved with Probabilistic Cellular Automata
Benedetto Scoppola, università di Roma Tor Vergata, 00100, roma, Italy, scoppola@mat.uniroma2.it, *Giovanni Felici*, *Sokol Ndreca*, *Aldo Procacci*, *Emanuel Weitschek*

Computationally challenging mathematical programming problems often arise in the analysis of large bodies of biomedical data. Here we consider a particular formulation of a Feature Selection (FS) problem for classification formulated in terms of a Set Covering problem. We present a randomized algorithm based on Probabilistic Cellular Automata (PCA) theory in which a Poissonian number of features are selected and accepted with a suitable probability. We compare the proposed approach with standard Monte-Carlo Markov Chain algorithm and state of the art integer programming solvers.

■ TD-15

Tuesday, 14:30-16:00
G5-2

Particle swarm and artificial bee algorithms

Stream: Metaheuristics (contributed)
Contributed session

Chair: *Jorge A. Ruiz-Vanoye*, CTI, Universidad Autónoma del Carmen, Calle 56, No. 4, Col. Benito Juarez, 24180, Cd. del Carmen, Campeche, Mexico, jorge@ruizvanoye.com

1 - Constrained binary Particle Swarm Optimization approach to the solution of job rotation scheduling problem
Muhammad Al-Salamah, Industrial Engineering, Majmaah University, Majmaah, Saudi Arabia, alsalamahm@gmail.com

This paper presents a new solution heuristic to the job rotation scheduling problem where the objective is to minimize the workload assigned to each worker. In this paper, a particle swarm optimization algorithm has been used to construct the schedules. However, it has recently not been applied to job rotation scheduling problem based on the review of the available literature.

2 - An Artificial Bee Colony Algorithm for Solution of the Knapsack Problem
Mike Byrne, Business School, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, mike.byrne@nottingham.ac.uk, *Arpad Baksai*

This paper presents a computational study applying an Artificial Bee Colony (ABC) algorithm to solve the Knapsack Problem (KP). The algorithm is based on the DisABC algorithm of Kashan et al (2012) and is adapted for the KP. The results were impressive: the algorithm was able to equal or outperform the greedy algorithm for all 54 cases tested. Several directions for further development and testing of the algorithm are proposed. Reference: Kashan, Nahavandi & Kashan (2012), DisABC: A New Artificial Bee Colony. Algorithm for Binary Optimization, Applied Soft Computing 12, 342-352.

3 - A random-key based artificial bee colony algorithm for p-center problem
Erdal Emel, Industrial Engineering Department, Uludag University, Faculty of Engineering and Architecture, Gorukle Campus, 16059, Bursa, Turkey, erdal@uludag.edu.tr, *Alkin Yurtkuran*

The objective of p-center problem is to locate p centers on a network in such a way to minimize the maximum of the distances from each node to its nearest center. The artificial bee colony (ABC) algorithm is swarm based meta-heuristic algorithm which simulates the foraging behavior of honey bee colonies. This study proposes an ABC algorithm with random-key based coding schemes to solve p-center problem effectively. Proposed algorithm is compared to state-of-art techniques using different benchmark problems and computational results reveal that the proposed technique is very efficient.

4 - Science of Life Intelligent Algorithms
Jorge A. Ruiz-Vanoye, CTI, Universidad Autónoma del Carmen, Calle 56, No. 4, Col. Benito Juarez, 24180, Cd. del Carmen, Campeche, Mexico, jorge@ruizvanoye.com, *Ocotlan Diaz-Parra*, *María de los Ángeles Buenabad-Arias*

The science of life intelligent is a discipline that deals with grouping of animals or artificial systems by social behavior. We show a survey and a classification of meta-heuristics algorithms based science of life intelligent. The classification of algorithms contains the algorithms with swarm intelligence, school intelligent, flock intelligent and herds intelligent. And it mentions the difference between the different types of intelligent.

■ TD-16

Tuesday, 14:30-16:00
G5-7

Rich Routing Problems

Stream: Routing Problems
Invited session

Chair: *Gunes Erdogan*, School of Management, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, Hampshire, United Kingdom, G.Erdogan@soton.ac.uk

1 - Large neighborhoods for prize-collecting vehicle routing and other related problems
Thibaut Vidal, CIRRELT – Universidade Federal Fluminense – Universidade Federal do Rio de Janeiro, Brazil, Rua Passo da Patria 156, Bl E - 3o andar, Sao Domingos, 24210-240, NITEROI, RJ, Brazil, thibaut.vidal@cirrelt.ca, *Nelson Maculan*, *Luiz Satoru Ochi*, *Puca Huachi Penna*

We introduce a new compound neighborhood of exponential size for prize-collecting vehicle routing problems. The search for an improving move in this neighborhood is assimilated to a resource-constrained shortest path problem with a single resource. Similar dynamic programming-based techniques are used to produce large neighborhoods for related problems such as arc routing, generalized and clustered VRPs. These neighborhoods are embedded within an iterated local search and a hybrid genetic search. Computational experiments demonstrate their notable contribution to the search performance.

2 - Capacitated Vehicle Routing in Finished Vehicle Distribution
Thomas Wensing, INFORM GmbH, Pascalstr. 23, 52076, Aachen, NRW, Germany, wensingt@web.de

We examine the problem of shipping consumer cars from one compound to various dealer locations within a daily planning framework. The truck fleet is heterogeneous, where each trip must match with a feasible load pattern of the selected trailer. For some pairs of cars it may be forbidden to be put on the same trip. The objective is to minimize a weighted sum of mileage, stops and tardiness. The problem is solved with a solution-pool-based heuristic that combines extensive local search with recombination principles. We examine runtimes and solution quality on basis of real-world data sets.

3 - Metaheuristics for the Clustered VRP
Maria Battarra, School of Mathematics, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, United Kingdom, m.battarra@soton.ac.uk, *Gunes Erdogan*, *Anand Subramanian*, *Thibaut Vidal*

The Clustered VRP is a variant of the Vehicle Routing Problem in which customers are partitioned into clusters. Vehicles have to visit all customers in a cluster before any other customer or before returning to the depot. Clusters are widely used in practice and allow practitioners to obtain compact solutions; moreover they remarkably simplify the resolution of large scale CVRPs. We propose alternative metaheuristic algorithms, exploiting the special structure of clusters. The metaheuristics' performances are compared and computational results presented.

4 - Heuristics for the team orienteering problem with time windows and flexible fleet
Gunes Erdogan, School of Management, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, Hampshire, United Kingdom, G.Erdogan@soton.ac.uk, *Fraser McLeod*, *Tom Cherrett*, *Tolga Bektas*

This paper compares the performance of two alternative solution methods — one employing tabu search, the other large scale neighbourhood search — on a real-life collection problem involving a heterogeneous and flexible fleet servicing charity donation banks and high street shops that operate with time windows. The objective is to maximise profit, where profit is calculated as the estimated value of the goods (e.g., clothes, books) collected minus the associated transport costs. The algorithms led to a profit gain of 5% and estimated CO2 savings of around 1 tonne per week.

■ TD-17

Tuesday, 14:30-16:00
G5-8

Transportation Planning 4

Stream: Transportation Planning
Invited session

Chair: *Vassilios Vrisagotis*, Department of Logistics Management, Technological Educational Institute of Chalkis, 32200, Thiva, Greece, brisxri@otenet.gr

1 - A linear regression model to evaluate the impact of revenues and costs for a 3-stage distribution channel
Vassilios Vrisagotis, Department of Logistics Management, Technological Educational Institute of Chalkis, 32200, Thiva, Greece, brisxri@otenet.gr, *Maria Panta*, *George Kaimakamis*

For a profitable distribution channel is crucial to model profit's components revenues and distribution costs. We model revenues earned by a retailer as a function of price and the distribution cost as a function of unit holding cost and shortage unit cost. We combine them in a linear profit function. Based on the last function and using the linear regression method the impact of revenues and distribution cost on profit is assessed and many conclusions for distribution optimization are derived.

2 - A New Heuristic Framework for The Canadian Traveler's Problem
Vural Aksakalli, Industrial Engineering, Istanbul Sehir University, Kusbakisi Cad. No:27, Altunizade, 34662, Istanbul, Turkey, aksakalli@sehir.edu.tr, *Ibrahim Ari*

Canadian Traveler's Problem is a challenging stochastic optimization problem wherein an agent needs to traverse as quickly as possible between two given vertices in a graph with stochastic edges such that traversability status of each edge is uncertain. We present a new heuristic framework for the problem that uses penalty functions to guide the agent's navigation in real-time within what we call a "navigate-disambiguate-repeat" paradigm. We also provide computational experiments on a variant of the problem with dependent edge probabilities.

3 - Minimizing Total Scaled Cost in a Fleet Size and Mix Vehicle Routing Problem with Time Windows
Debora Ronconi, Production Engineering, University of Sao Paulo, Av. Prof. Almeida Prado,128, 05508070, Sao Paulo, Sao Paulo, Brazil, dronconi@usp.br, *João Manguino*

The theme of vehicle routing has been widely studied due its practical relevance and, throughout the literature, more real characteristics have been added. Aligned with this trend, this work addresses the fleet size and mix vehicle routing problem with time windows and scaled costs when there is outsourcing of the fleet. A MILP model is proposed and evaluated under a real scenario. Furthermore, sequential insertion heuristics are presented in order to deal with larger problems. A computational comparative study was conducted and the results indicate that the proposed methods are efficient.

4 - An exact resolution for the PTSP
Mohamed Walid, math, ENSI, 12 rue de kairouan, tunis, tunisia, Tunisia, mwkhaznaji@yahoo.fr, *Monia Bellalouna*

The probabilistic travelling salesman problem (PTSP) is an extension of the well-known travelling salesman problem (TSP). The main difference is the stochastic presence of the cities. PTSP is a generic NP-Complete problem. Till now, researches are rather directed towards Heuristics for having acceptable solutions. In this paper, we propose an exact resolution for the PTSP, Our solution is based on the addition of some probability elements in Little's algorithm.

■ TD-18

Tuesday, 14:30-16:00
G5-9

Transportation and Logistics

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de
Chair: *Inci Batmaz*, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr
Chair: *Dmytro Fishman*, Mathematics and Computer Science, University of Tartu, Estonia, dmytrofishman@gmail.com

1 - Simulation-based assessment of the robustness of IP-based truck schedules for cross-docking operations

Anne-Laure Ladier, G-SCOP, 46 avenue Félix Viallet, 38031, Grenoble cedex, France, anne-laure.ladier@grenoble-inp.fr, *Allen Greenwood*, *Gülgün Alpan*, *Halston Hales*

A previously developed IP-based model for scheduling truck arrivals, truck departures, and pallet handling in a cross-docking platform is assessed using discrete-event simulation. Experimentation with a simulation model of basic cross-docking operations subjects the schedules to a more realistic environment (e.g., stochastic truck arrival times, pallets transfer times, truck content) than can be formulated in the IP model. Analysis of the simulation experiments, in terms of the schedules' performance and robustness under pragmatic conditions, provides insights to help refine the IP model.

2 - Performance evaluation of worker timetables in cross-docking facilities using simulation

Allen Greenwood, Industrial & Systems Engineering, Mississippi State University, PO Box 9542, 260 McCain Engr. Bldg., 39762, Mississippi State, MS, United States, greenwood@ise.msstate.edu, *Halston Hales*, *Gülgün Alpan*, *Anne-Laure Ladier*

A previously developed general approach for generating worker timetables is applied to cross-docking facilities to evaluate its performance under varying operating conditions. The timetables, generated from MILP models, are tested under stochastic conditions - random process times, varying working availabilities, and early/late truck arrivals - using discrete-event simulation. Experimentation and analysis using the simulation models identify which MILP model assumptions need to be relaxed or which constraints need to be reformulated in order to provide more robust and useful worker schedules.

3 - The impact of Urban Logistics Services on emerging market megacities — a traffic flow model

Matthias Winkenbach, Kuehne Foundation Endowed Chair in Logistics Management, WHU - Otto Beisheim School of Management, Burgplatz 2, 56179, Vallendar, Germany, matthias.winkenbach@whu.edu, *Edgar E. Blanco*, *Stefan Spinler*

We present a queuing theory based macroscopic traffic flow model representing private and commercial vehicular traffic in emerging market megacities. Road infrastructure is modeled as a large-scale M/G/C/C state-dependent queuing network with Markov modulated service processes to account for traffic flow interruptions, e.g., due to un-/loading of commercial vehicles. Based on this model we analyze the potential impact of implementing an Urban Logistics coordination and consolidation platform for thitherto highly fragmented retail store supply on congestion, emissions and fuel consumption.

4 - The impacts of urban electric mobility on road pollutant emissions: a case study in the city of Rome

Simone La Spada, Department of Civil Engineering, Roma Tre University, 00146, Rome, Italy, Italy, slaspada@uniroma3.it, *Stefano Carrese*

Road pollutant emissions in urban context have reached unsustainable values exceeding law-limits. Through the emission regulation procedure, vehicle industry provides to the market less pollutant vehicles; but it is not still enough. Electric and hybrid vehicles seem to be the best and suitable solution to combine and integrate the increase of public transport users. Through a first case study in the city of Rome (Italy), the paper wants to assess the emissions reduction and the role of ITS and traffic management solution in the incoming changes in fleet compositions.

■ TD-19

Tuesday, 14:30-16:00
G5-10

Transport Problems

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Fatemeh Sarayloo*, Computer Science and Operation Research, University Of Montreal, 130, Rue De la Barre, j4k 1a4, Longueuil, Quebec, Canada, saraylof@iro.umontreal.ca

1 - Solving the Capacitated Two-Stage Transportation Problem

Sonia ., Decision Sciences, Indian Institute of Management, Lucknow, Prabandh Nagar, Off-Sitapur Road, 226013, Lucknow, Uttar Pradesh, India, sonia@iiml.ac.in, *Faiz Hamid*

In this paper, a capacitated two-stage transportation problem is introduced where the objective is to minimize the sum of the first and second stage shipment times. Certain practical imperative situations lead the shipment phenomenon to the two stages, one stage followed by the other. The total capacity of each route is specified because of budget/political/capacity considerations. A polynomial time algorithm is proposed to solve the above problem to optimality.

2 - Optimal order picking strategies in mobile rack systems for a special case

Bettina Groestlinger, University of Graz, Austria, bettina.groestlinger@uni-graz.at, *Marc Reimann*

We try to find order picking strategies for warehouses with movable racks. We consider a situation where a warehouse is stocked for the first time or completely emptied. Consequently, each rack has to be visited exactly once. Furthermore, the model is set as an unit-load problem where only single-sided picking is possible. The aim is to minimize the cycle time, which is represented by a combination of travel time of the vehicle and waiting time. Waiting time occurs if the vehicle should enter a non-opened aisle. Given these assumptions, we present optimal picking sequences for the problem.

3 - Solving a Large Scale Crew Pairing Problem

Okan Ozener, Industrial Engineering, Ozyegin University, Kusbakisi Cad No:2, Altunizade Uskudar, 34662, Istanbul, Turkey, orsan.ozener@ozyegin.edu.tr, *Gunes Erdogan*, *Mohamed Haouari*, *Melda Ormeci Matoglu*

Crew pairing problem is considered to be one of the most challenging problems in airline planning. In the literature, standard and complex solution methodologies for North American and European airlines exist. These problems differ from ours, which has its specific properties, e.g., fixed crew salaries, single crew base, properties of flight schedule, objective function. Based on a representative data of a European Airline's flight schedule we address the monthly crew pairing problem. This makes it a very large and difficult problem to solve. We develop heuristic based solution methods.

4 - Finding Robust Schedules Using Worst-case Performance Measure and a Scenario-Based Approach in Presence of Uncertainty

Fatemeh Sarayloo, Computer Science and Operation Research, University Of Montreal, 130, Rue De la Barre, j4k 1a4, Longueuil, Quebec, Canada, saraylof@iro.umontreal.ca

Using a robust schedule as an a priori scheduling, is one of the well-known approaches to hedge against uncertainty. A stochastic jobshop problem with random processing time is addressed, while a scenario-based approach is used to take stochasticity of processing times into the account. The objective function of addressed problem is modeled as a minimax formulation to develop a constraint programming (CP) algorithm for finding more robust schedules. We have implemented the scenario-based approach and worse-case performance measure in ILOG CPLEX 12.5.

■ TD-20

Tuesday, 14:30-16:00
G5-11

Robustness and Recoverability in Rapid Transit System Design

Stream: Optimization in Public Transport
Invited session

Chair: *Ángel Marín*, Matemática Aplicada y Estadística, Universidad Politécnica de Madrid, E.T.S.Ingenieros Aeronáuticos, Plaza Cardenal Cisneros, 3, 28040, Madrid, Madrid, Spain, angel.marin@upm.es

1 - Enhanced Benders Decomposition applied to a model of network topology design and frequency setting for rapid transit systems
Francisco Lopez, EIO, UPC, Jordi Girona 34, Campus Nord Ed. C5, Barcelona, 08034, Barcelona, Catalonia, Spain, francisco.lopez.ramos@upc.edu, *Esteve Codina*, *Ángel Marín*, *Roberto Cominetti*

Rapid transit systems are extended gradually and the problem of adding new lines to those already in operation is more usual than 'ex-novo' design. This problem is formulated and solved using the Benders Decomposition with enhancements for accelerating the convergence. The model determines the layout of the new lines considering a set of points that can work either as stations or just as through-points. The FS assigns vehicles and frequencies to the lines while meeting link and vehicle capacity constraints as well as the size of vehicle's fleet and planning horizon requirements.

2 - A path-based congested transit assignment algorithm, a simplified dynamic model and its application to the Bus-Bridging problem
Esteve Codina, Statistics and Operational Research, UPC, Edifici C5, Desp 216 Campus Nord, 08034, Barcelona, Spain, esteve.codina@upc.edu, *Gemma Ibañez*, *Lídia Montero*

A path-based algorithm for solving a variational inequality formulation of the congested strategy-based transit assignment problem is presented in this paper. On the other hand, a simplified dynamic transit assignment model is also formulated as a variational inequality problem which can be solved using the previous algorithm. The possibilities for using this model in the frequency setting problem are analysed and discussed. Scenarios for public transport systems are considered where disruptions of metro and rapid transit are alleviated by bus-bridging.

3 - A Dynamic Estimation of passenger OD Matrices based on Space-State models
Lidia Montero, EIO, UPC, C/Jordi Girona, 31, Campus Nord, Edifici C5 Despatx 217, 08034, Barcelona, Catalonia, Spain, lidia.montero@upc.edu, *Esteve Codina*

Dynamic OD passenger matrices must be taken into account when designing robust public transport systems. The adjustment of these matrices is examined using passenger counts provided by a space-state model formulation in a demand-variable peak-period. The Kalman filter approach also incorporates ICT data, based on the detection of the electronic signature of on-board devices, thus providing a rich source of data that can be used in space-state models to simplify its formulation. It reduces the dimension of the state vector and allows a linear mapping between state variables and measurements.

4 - Robust Infrastructure design in rapid transit rail system
Ángel Marín, Matemática Aplicada y Estadística, Universidad Politécnica de Madrid, E.T.S.Ingenieros Aeronáuticos, Plaza Cardenal Cisneros, 3, 28040, Madrid, Madrid, Spain, angel.marin@upm.es, *Luis Cadarso*, *Esteve Codina*

Robust rail network design is expensive to be operated in regular daily basis. A low utilization of the infrastructure occurs if the network is designed considering the possible disruptions. We propose an approach to recoverable robustness rail network design as an alternative to robust design in order to ameliorate the effects of disruptions and minimize the cost of recovery while lowering network design costs. The computational experiments demonstrate that the developed model reduces the robustness costs using a new formulation of the design model and Benders Decomposition.

■ TD-21

Tuesday, 14:30-16:00
G6-1

Real Scheduling Problems

Stream: Scheduling
Invited session

Chair: *Erwin Pesch*, FB 5, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, erwin.pesch@uni-siegen.de

1 - Scheduling use cases and related challenges
Sofiane Oussedik, IBM, France, soussedik@fr.ibm.com

This presentation will give you an insight into some of the latest clients scheduling use cases using IBM ILOG Optimization. The use cases developments have been driven by the need to accomplish key business objectives and rapidly deploy the right flexible solutions. The presentation will include details on the business problem solved and the challenges faced, as well as the fulfilled need for a seamless integration with existing systems and processes.

2 - Medium-term production planning of novel modular multi-product continuous plants
Christian Schoppmeyer, Department of Biochemical and Chemical engineering, Technische Universität Dortmund, Emil-Figge strasse 70, 44227, Dortmund, NRW, Germany, christian.schoppmeyer@bci.tu-dortmund.de, *Henry Vermue*, *Sebastian Engell*

A mathematical formulation for medium-term scheduling of novel modular multi-product continuous plants including physical reconfiguration of the plant for different products is presented. The formulation is based on a traveling salesperson problem (TSP)-based mixed-integer linear programming (MILP) model for campaign planning using a hybrid discrete/continuous time representation. Additional sequence-dependent changeovers are introduced to represent the physical reconfiguration of the plant. The proposed model is tested on an industrial case study of an acrylates polymerization process.

3 - A genetic algorithm for a chain-reentrant shops with an exact time lag
Karim Amrouche, Economics and Management sciences, University of Algiers 3, 2 street Ahmed Waked,, Dely Brahim, Algiers, Algeria, amrouche-karim@hotmail.com, *Mourad Boudhar*

This paper considers a chain-reentrant flow shop with two machines and exact time lag L, in which each task may be processed in this order M1, M2, M1 and there is an identical time lag between the completion time of the first operation and the start time of the second operation on the first machine called also primary machine. The objective is to minimize the total completion time. The general problem is NP-Hard, we propose some heuristics and a metaheuristic to solve it with numerical experiments.

4 - Exact method for the flight track/level scheduling problem
Sabrina Azam, Mechanical and Industrial Engineering, Qatar University, College of Engineering, P.O. Box 2713, Doha, Qatar, Qatar, sa092163@qu.edu.qa, *Mohamed Kharbeche*, *Aisha Al-nabet*, *Sara Althalathini*, *Ameer Al-Salem*

The aim of the study is to find the optimal flight schedules and track/level assignments satisfying the safety constraints, which ensure the minimum separation time between departures of any two flights on the same track and level. To this end, we propose a nonlinear formulation that will be linearized and solved using AMPL. To assess the performance of the proposed model, computational experiments are conducted on randomly generated instances.

■ TD-22

Tuesday, 14:30-16:00
G6-2

Scheduling and timetabling

Stream: Scheduling II
Invited session

Chair: *Federico Della Croce*, Automatica e Informatica, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italy, federico.dellacroce@polito.it

1 - Scheduling ground personnel for aircraft maintenance operations
Giuseppe Lancia, Math and C.S., University of Udine, via delle scienze 206, 33100, Udine, Italy, giulan@gmail.com, *Paolo Serafini*

Between its arrival and departure, each aircraft may undergo some maintenance operations. These operations are not known in advance, and require different skills. The airport personnel works following a cyclic table, whose rows specify each day turns. The workers must be assigned starting rows in the table, so that the airport can satisfactorily meet the incoming requests for the next six months. We describe a heuristic based on statistical evaluation of the requests, network-flow optimization and local-search techniques. The procedure is currently being implemented in a large Italian airport.

2 - An absolute approximation algorithm for a scheduling problem with cumulative payoffs
Yasmina Seddik, Laboratoire d'Informatique de Paris 6, France, yasmina.seddik@lip6.fr, *Christophe Gonzales*, *Safia Kedad-Sidhoum*

Starting from a real world digitization workflow issue, we identified a scheduling problem with a new criterion involving common delivery dates for the jobs and cumulative payoffs. We consider the maximization of this criterion for a single machine problem with release dates where jobs are to be scheduled nonpreemptively. A complexity analysis is addressed for this class of problems as well as a polynomial time algorithm with an absolute perfomance guarantee.

3 - Two Agents Single Machine Scheduling under a Coordination Mechanism
Andrea Pacifici, Dip. di Informatica, Sistemi e Produzione, Università di Roma Tor Vergata, Via del Politecnico, 1, 133, Roma, Italy, andrea.pacifici@uniroma2.it, *Alessandro Agnetis*, *Gaia Nicosia*, *Ulrich Pferschy*

We address a deterministic scheduling problem in which two agents own a set of tasks each and compete for the usage of a common processing resource. The agents submit their tasks in successive steps to an external coordination subject, who sequences them on the machine according to a given (and known) priority rule. We consider the problem from different perspectives and provide algorithms suggesting an agent how to sequence its own tasks to optimize its objective. Moreover, we characterize Pareto-optima and analyse the performance of standard algorithms in the two-agent scenario.

4 - Reoptimization of machine scheduling problems
Federico Della Croce, Automatica e Informatica, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italy, federico.dellacroce@polito.it, *Nicolas Boria*

We consider the reoptimization version of several machine scheduling problems. The reoptimization setting is as follows: given an instance of the problem for which an optimal solution is provided and given some local perturbations on such instance, the aim is to search for a near-optimal solution for the modified instance requiring very little computation. We consider two kinds of modifications: job-insertions and job-deletions. For these problems, we show how simple reoptimization procedures can ensure constant approximation ratios for several classes of scheduling problems.

■ TD-23

Tuesday, 14:30-16:00
G6-3

Prediction and Forecasting

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Hans-Jörg von Mettenheim*, Leibniz Universität Hannover, Institut für Wirtschaftsinformatik, Königsworther Platz 1, 30167, Hannover, Germany, mettenheim@iwi.uni-hannover.de
Chair: *Stefan Lessmann*, Institute of Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, lessmann@econ.uni-hamburg.de

1 - A Comparison of Generalized Additive Neural Networks and Radial Basis Function Networks for Spam Detection
Tiny Du Toit, School of Computer, Statistical and Mathematical Sciences, North-West University, North-West University, 11 Hoffman Street, 2531, Potchefstroom, North-West, South Africa, Tiny.DuToit@nwu.ac.za, *Nawaf Hamadneh*

Spam has developed from an irritating characteristic of electronic mail to a time-consuming and costly resource problem. In this research the performance of the relatively unknown Generalized Additive Neural Network (GANN) applied to spam detection is compared to that of a Radial Basis Function Neural Network. The GANN has previously shown promise as a feasible spam filtering technique. The Radial Basis Function Neural Network is best known classification applications and has not been applied extensively to spam detection. Results obtained will be discussed.

2 - The analysis of the effect of proteinuria follow-up on kidney disease detection with neural networks
Almıla Özcan, Electric-Electronic Engineering, Graduate School of Natural and Applied Science, Kırıkkale Üniversitesi Mühendislik Fakültesi, Bilgisayar Mühendisliği Bölümü, 71450, Yahşihan, KIRIKKALE, Turkey, almilao@gmail.com, *Tuğrul Özcan*

The proteinuria follow-up is important in kidney diseases. In this study the kidney diseases were examined with classification considered proteinuria of 194 people by using Modular Neural Network, Jordan-Elman Neural Network and Radial Basis Function. Then classifying performance of these neural networks were compared and discussed.

3 - Car Resale Price Prediction with Ensemble Selection and Asymmetric Cost Functions
Stefan Lessmann, Institute of Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, lessmann@econ.uni-hamburg.de

Resale price prediction is important to inform decision making in the used car business. We develop a prediction model that integrates the principles of ensemble selection and asymmetric cost of error functions. This allows us to create prediction models that account for the economic consequences of forecast errors, and avoid the more costly errors type in particular. Empirical experiments on real-world data suggest that the new approach produces more accurate forecasts, is better aligned with application requirements, and offers better decision support.

■ TD-24

Tuesday, 14:30-16:00
G6-4

New frontiers in teaching Project Management

Stream: Project Management and Scheduling
Invited session

Chair: *Avraham Shtub*, Industrial Engineering & Management, Technion - Israel Institute of Technology, 32000, Haifa, Israel, shtub@ie.technion.ac.il

1 - Teaching Project Scheduling under resource constraints — integrating cost benefit and risk in a dynamic stochastic environment
Avraham Shtub, Industrial Engineering & Management, Technion - Israel Institute of Technology, 32000, Haifa, Israel, shtub@ie.technion.ac.il

This paper presents a teaching environment designed to support traditional project scheduling teaching methods. A simulator and a scenario builder are used to practice the solution of a large variety of project scheduling problems. The system is flexible in both the definition of the objective function (cost schedule and technical requirements are

combined) and the constraints (cost schedule and resource constraints). Students trained in this environment can see how sophisticated Operations Research models can be used to solve real problems in a dynamic stochastic environment.

2 - Lessons learned from teaching design to cost and benefit to cost strategies by SBT (Simulation Based Training)
Izack Cohen, IE&M, Technion, Israel, izik68@tx.technion.ac.il, *Shlomi Benshabat*, *Avraham Shtub*

This research offers a Simulation-Based Training approach that integrates project management and engineering education. An experiment that evaluated the simulator indicates that the proposed approach is efficient. The simulator was used as a research platform to evaluate trainees' performance when managing a project using two common strategies: Design to cost and Benefit to Cost. This research contributes to the literature on management strategies and compares between them through a controlled experiment. The results allow developing guidelines for teaching and training student.

3 - Time/Cost/Uncertainty trade-offs in a business game: practical experiences
Mathieu Wauters, Faculty of Economics and Business Administration, Ghent University, 9000, Ghent, Belgium, mathieu.wauters@ugent.be, *Mario Vanhoucke*

The Project Scheduling Game (PSG) is an IT-supported tool used for educational purposes in business schools and universities. Based on data collected at 2 universities and 3 management schools, we identified prominent solution strategies which were evaluated using different performance criteria. Computational experiments revealed under which conditions a solution strategy performs best. The outcome of this study culminated in the incorporation of a Game Scan, which provides direct and multidimensional feedback during teaching and company training sessions.

4 - Design, Development, Deployment, and Delivery Considerations for Successful Simulation-based Project Management Education in Corporate Environments
Richard Yarn, IBM, 7950 IDLEWILD LN, 33777, SEMINOLE, FL, United States, rickyarn@gmail.com

Successful simulation-based project management education requires considerations for how learning activities will be designed, developed, deployed, and delivered in order to satisfy corporate learning program objectives. This paper examines each of these four instructional components with the intent of providing a framework for organizational decision makers who develop and evaluate simulation-based education, tools, and offerings for knowledge workers, specifically project and program managers working in corporate environments.

■ TD-25

Tuesday, 14:30-16:00
G9-1

Decision Support Systems 1

Stream: Artificial Intelligence, Fuzzy systems (contributed)
Contributed session

Chair: *Amelia Bilbao-Terol*, University of Oviedo, Oviedo, Spain, ameliab@uniovi.es

1 - Goal Programming for solving Socially Responsible Investment with Mental Accounts
Verónica Cañal, Applied Economics, University of Oviedo, Avda. del Cristo s/n, 33006, Oviedo, Spain, Spain, vcanal@uniovi.es, *Amelia Bilbao-Terol*, *Mar Arenas-Parra*

This work presents an approach based on GP for aiding a socially responsible investor that wants management her investments by an Mental Account (MA) structure of portfolios. Also, she wishes to hold a certain amount of her budget on assets verifying standard on responsibility social/ESG features. The proposal runs in two stages, the optimal MA-subportfolio is fund regardless her SR profile. In the second stage a GP model is proposed for reconciling the financial targets on each MA with the target associated to the SR of the aggregated portfolio. Our approach has been applied to real case.

2 - The Effect of Defuzzification Methods on Fuzzy Economic Order Quantity and Numerical Examples
Muhammet Deveci, Industrial Engineering, Yildiz Technical University, Besiktas, Istanbul, Turkey, muhammetdeveci@gmail.com, *Nihan çetin Demirel*

The usage of fuzzy set theory in inventory control systems becomes popular due to the uncertainty about supply, demand, and costs as well as indefinite and fuzzy knowledge. This study analyzes the effect of Graded Mean Integration Representation (GMIR) and median rule methods on the optimal fuzzy Economic Order Quantity (EOQ), total cost, and maximum inventory level. The aim of this study is the determination of the optimal fuzzy order quantity that maximizes total profit. Parameters are used in triangular fuzzy numbers and GMIR and median rule methods are used for total cost function.

3 - Development of a Decision Support System for International Commercial Terms - Incoterms® 2010 in foreign trade operations using Fuzzy Logic
Laura Marina Valencia Niño, Engenharia de Produção, Universidade Federal do Rio de Janeiro, 22745005, Rio de Janeiro, Rio de Janeiro, Brazil, lauravalencia84@gmail.com, *Carlos Cosenza*, *Francisco Doria*

The main objective of this project is to use Fuzzy Logic in International Trade and able to give the user a tool-interface to support decision based on Fuzzy Inference Systems of Mamdanis type, suggesting the term international negotiation Incoterms more convenient to apply in foreign trade operations. It will be used for programming the computational tool MatLab and Fuzzy Toolbox.The program will be able to classify user type, mode of transport and type of cargo. As the risks and obligations acquired by the program user to be able to answer more coherent thin the suggestion the term to use.

4 - ANFIS with Inference of R2 Incremental for Forecasting Load Peak Data in Indonesia
Brodjol Sutijo Suprih Ulama, Statistics Department, Institut Teknologi Sepuluh Nopember, Department of Statistics, Kampus ITS Keputih Sukolilo, 60111, Surabaya, East Java, Indonesia, brodjol_su@statistika.its.ac.id, *Indah Puspitasari*, *Suhartono Suhartono*

We propose a new procedure for determining the best Adaptive Neuro Fuzzy Inference System (ANFIS) model for time series forecasting. The proposed procedure was developed based on statistical inference of R2 incremental. Three components in ANFIS were evaluated by using inference of R2 incremental for selecting the best model, i.e. the inputs, number of membership functions and the rules. First, a simulation study was used to validate the effectiveness and efficiency of the proposed procedure. Finally, the procedure was applied to find the best ANFIS model for load peak electricity data.

■ TD-26

Tuesday, 14:30-16:00
G9-7

Integral Simplex Using Decomposition

Stream: Combinatorial Optimization I
Invited session

Chair: *Francois Soumis*, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca

1 - Integral Simplex with cuts in the Sub-Problem
Samuel Rosat, GERAD research center, Canada, samuel.rosat@gerad.ca, *Issmail Elhallaoui*, *Francois Soumis*

We present a new algorithm for the set-partitionning problem (SPP). It is a purely integral simplex, based on a decomposition of SPP. Given a solution, the method solves a sub-problem (CP) to find an integer decreasing direction. We make a theoretical study and show the method

always reaches optimality. To find the optimal direction, some cuts of SPP are transferred to CP. We make a complete description of the cuts that can be transferred and show that such cuts always exist. Computational results will be shown for real aircrew and bus-drivers scheduling problems with up to 500,000 variables.

2 - Lagrangian relaxation of additional constraints in the integer simplex
Matthieu Delorme, Mathématiques appliquées et Génie industriel, Ecole Polytechnique de Montréal, Apt 16, 3870 rue Saint Hubert, H2L 1B3, Montreal, Quebec, Canada, matthieu.delorme@polytechnique.edu, *Francois Soumis*

Companies are faced with large problems containing many set partitioning (SP) constraints. Building on the work of Balas and Padberg and the ideas from the improved primal simplex of Elhallaoui and al, Zaghrouti and al have developed a simplex-type algorithm enabling to solve SP problem via a sequence of basic integer solutions. We adapt this algorithm to solve problems where besides the SP constraints there are others constraints which do not have any particular structure. We use Lagrangian relaxation techniques to treat those constraints and present our results along with those of CPLEX.

3 - Parallel integral simplex using decomposition algorithm
Issmail Elhallaoui, Math., Polytechnique, cp. 6079 succ. centre-ville, H3C 3A7, Montreal, Qué., Canada, issmail.elhallaoui@gerad.ca, *Zaghrouti Abdelouahab*

This work aims at solving to optimality huge set partitioning problems by a parallel version of the integral simplex using decomposition algorithm (ISUD). We decompose the complementary problem of ISUD into sub-problems by a fast, self-adjusted and non-problem-dependent procedure in order to solve them in parallel. The solutions of the sub-problems are orthogonal descent directions that improve the current solution. Finding these directions iteratively and in parallel considerably reduces the solving process time. Numerical results on instances with up to 500 000 variables will be presented.

4 - A contraction-expansion algorithm for the capacitated minimum cost flow problem
Marco Lübbecke, Operations Research, RWTH Aachen University, Kackertstraße 7, 52072, Aachen, Germany, marco.luebbecke@rwth-aachen.de, *Jean-Bertrand Gauthier*, *Jacques Desrosiers*

Let network G contain n nodes and m arcs. We show that a slight modification of the Improved Primal Simplex method used for solving degenerate linear programs (Raymond et al. 2010, Elhallaoui et al. 2011) results in a strongly polynomial algorithm for solving the capacitated minimum cost network flow problem. The new algorithm is similar to the well known minimum mean cycle-canceling algorithm (Goldberg and Tarjan 1989, Radzik and Goldberg 1994) that performs O(nm2) iterations. We also analyze the behavior of the Improved Primal Simplex for the assignment and shortest path problems.

■ TD-27

Tuesday, 14:30-16:00
G9-8

Combinatorial problems of facility location

Stream: Combinatorial Optimization II
Invited session

Chair: *Mikhail Y. Kovalyov*, United Institute of Informatics Problems, National Academy of Sciences of Belarus, Surganova 6, 220012, Minsk, Belarus, kovalyov_my@yahoo.co.uk

1 - Impact of the distance values distribution to uncapacitated facility location problem
Marta Janackova, Applied mathematics, Zilinska univerzita v Ziline, Univerzitna 8215/1, 01026, Zilina, Slovakia, Marta.Janackova@fstroj.uniza.sk, *Alzbeta Szendreyova*

The contribution deals with dependence of the computational time of exact method for uncapacitated facility location problem on characteristics of underlying transportation network. The research is motivated by previous experience in experimental work with approximate method for the p-median problem. During these experiments it was found that distribution of distance values may considerable influence the effectiveness of the solving process. We want to verify the similar hypothesis for the specific algorithm developed for the uncapacitated facility location problem.

2 - Distribution of Facilities relative to Customers.
Vladimir Medvid, Faculty of Humanities, University of Zilina, Univerzitna 1, 01026, Zilina, Slovakia, vladimir.medvid@fhv.uniza.sk

This paper deals about the p-median problem of locating p facilities relative to a set of customers such that the sum of the shortest demand distance between customers and facilities minimized. This problem is a graph theory problem that was originally designed for, and has been extensively applied to, facility location. We propose a new approach for solving this problem and we bring computational experiments on a set of benchmark instances.

3 - How does the use of different road networks effect the optimal location of facilities in rural areas?
Pascal Rebreyend, Computer engineering, Högskolan Dalarna, Högskolan Dalarna, 79188, Falun, Sweden, prb@du.se, *Johan Håkansson*

The aim in this study is to analyse how the optimal location solutions vary, using the p-median model, when different road networks are used on a large-scale problem with 15 000 demands points. Road network complexity varies from 1500 to 1.5 billion nodes. We compare the solutions which are computed by a simulated annealing algorithm with adaptive tuning of the temperature. The investigation is conducted by the means of a case study in a rural region with an asymmetrically distributed population, Dalecarlia. Results shows that a more accurate road networks leads to better solutions.

4 - Tighting Lagrangian bounds and greedy heuristics for the generalized assignment problem
Jania Saucedo, Logistics and Supply Chain, FIME-UANL, Av. Universidad s/n, Ciudad Universitaria, 66451, San Nicolás de los Garza, Nuevo León, Mexico, jania.saucedo@gmail.com, *Igor Litvinchev*, *Miguel Mata*, *Socorro Rangel*

The generalized assignment problem (GAP) consists in minimize the cost of assigning a set of n tasks to m agents, where each task must be assigned to a single agent, while each agent can perform various tasks, as long as your capacities permit. We built a heuristic solution methodology based on Lagrangian relaxation and a greedy heuristics to get Lagrangian feasible solutions. Numerical results for problem instances with number of agents close to number of tasks are provided.

■ TD-28

Tuesday, 14:30-16:00
G9-2

Emerging Applications of Stochastic Programming

Stream: Stochastic Programming
Invited session

Chair: *Patrizia Beraldi*, Department of Electronics, Informatics and Systems, University of Calabria, Via P. Bucci - CUBO 41/C, 87036, Rende (CS), ITALY, Italy, beraldi@deis.unical.it

1 - A risk averse multi-stage stochastic mixed integer optimization model for power generation expansion planning in the long term
Paolo Pisciella, Department of Information Technology and Mathematical Methods, Unversity of Bergamo, Italy, paolo.pisciella@unibg.it, *Maria Teresa Vespucci*, *Marida Bertocchi*, *Stefano Zigrino*

We propose a multi-stage stochastic model for long term planning of capacity expansion for a single power producer. The scope of the article is to show how different levels of risk aversion influence the mix of production technologies that the producer decides to develop. Different CVaR definitions are considered for the multi-stage approach in order to account for risk aversion. Tests for two and three stages results comparison and time-stage consistency are carried out to analyze the properties of the modeling framework.

2 - Optimal long-term management of a P&C insurance portfolio with endogenous risk control
Giorgio Consigli, Mathematics, Statistics and Computer Sciences, University of Bergamo, Via dei Caniana 2, 24127, Bergamo, Italy, giorgio.consigli@unibg.it, *Vittorio Moriggia*, *Massimo Di Tria*

We clarify in this paper the complex interaction between investment and insurance operational constraints, which motivates a multi-objective strategy based on a short-term profit target and longer term risk-adjusted return goals. From a mathematical viewpoint the problem finds a natural formulation as a dynamic stochastic program (DSP). We summarize the key elements of a real-world asset-liability management development, integrating an optimal asset allocation policy over a 10 year planning horizon with the inclusion of liability constraints generated by an ongoing P&C business.

3 - Decision support for large institutional investors: a case study
Vittorio Moriggia, Mathematics, Statistics, Computer Science and Applications, University of Bergamo, via dei Caniana, 2, 24127, Bergamo, BG, Italy, vittorio.moriggia@unibg.it, *Giorgio Consigli*

We present the elements of a real world development conveying the complexity of an enterprise-wide optimal allocation problem modelled as a multistage stochastic optimization program. The key elements of a generic decision support system based on Matlab-Gams-Microsoft interfaces will be presented with collected computational evidence.

4 - A Stochastic programming approach for the strategic valve locations problem in a water distribution system
Maria Elena Bruni, unical, via Pietro bucci, 87030, cosenza, italy, Italy, mebruni@deis.unical.it, *Patrizia Beraldi*, *Domenico Conforti*

Water distribution networks (WDN) are important systems providing citizens with an essential public service. Despite many water distribution network problems have been investigated in the literature, major uncertainties have been neglected. We present a stochastic programming approach for the strategic valve locations problem in WDN, which is a crucial strategic problem in water network design. In order to efficiently solve the problem, both exact and heuristic solution approaches will be illustrated. Numerical results on case studies taken from the literature will be also presented.

■ TD-29

Tuesday, 14:30-16:00
G9-3

Sustainable stochastic inventory models

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Peter Kischka*, Statistics, University Jena, Carl-Zeiss-Str. 3, 07743, Jena, Germany, P.Kischka@wiwi.uni-jena.de

1 - The Single Period Inventory Model Under Dual Sourcing and Product Carbon Footprint Constraint
Werner Jammernegg, Department of Information Systems and Operations, Vienna University of Economics and Business, Nordbergstrasse 15, A-1090, Wien, Austria, werner.jammernegg@wu-wien.ac.at, *Emel Arikan*

We consider a single period inventory model with an upper bound for the product carbon footprint. Besides the classical newsvendor model with a single order possibility we study a dual sourcing problem under different scenarios for the second supply option after random demand is realized. For the first supply option we consider an offshore supplier, and for the second supply option we model two cases: an onshore supplier and the offshore supplier with a faster transport mode. We characterize the optimal ordering policy and discuss the tradeoff between economic and environmental performance.

2 - A two-stage newsvendor model with demand forecast updating and transport emissions
Katja Rettke, Department of Business Statistics, Friedrich Schiller University of Jena, Carl-Zeiß-Straße 3, 07743, Jena, Germany, katja.rettke@uni-jena.de

One reason for integrating environmental issues in operations management are various regulations related to carbon emissions caused by economic activities. In this study a newsvendor model is developed that incorporates transport carbon emissions. A company faces stochastic demand when ordering a product from two suppliers but can still improve its forecast by using a market signal observed after placing the first order. Moreover, the company has to comply with an emission trading scheme. The optimal order quantities are determined and analyzed with respect to several model parameters.

3 - Decentralized vs. centralized distribution of a newsvendor product with carbon footprint constraint
Peter Kischka, Statistics, University Jena, Carl-Zeiss-Str. 3, 07743, Jena, Germany, P.Kischka@wiwi.uni-jena.de, *Werner Jammernegg*

In the newsvendor framework the distribution of a product to two markets from regional warehouses is contrasted with the centralized distribution. At first glance the distribution system with pooled demand leads to higher expected profit but it may have also higher product carbon footprint because of shorter transportation distances in local distribution. We compare the decentralized and the centralized system by considering different logistics cost and also the related carbon emissions.

4 - Dynamic Pricing and Inventory Decisions for Perishable Products
Onur Kaya, INDR, Koc University, Koc University, Eng 206, Sariyer, 34450, Istanbul, Turkey, okaya@ku.edu.tr, *Sajjad Rahimi Ghahroodi*

We consider dynamic pricing and inventory decisions for perishable products in a stochastic setting assuming that the demand rate is affected by not only the prices of the products but also with the freshness of the products. We use dynamic programming to determine the optimal price and inventory decisions assuming that the products are sold on a last-come-first-sold basis due to the freshness considerations. We prove certain characteristics of the optimal solution and also analyze the effect of different parameters on the optimal solution through numerical experiments.

■ TD-30

Tuesday, 14:30-16:00
G9-10

Recent Contributions to Discrete Optimization, Geometry & Graphs

Stream: Discrete Optimization, Geometry & Graphs (contributed)
Contributed session

Chair: *Shuichi Shinmura*, Facultu of Economics, Seikei University, Kichijoji Kitamachi 3-3-1,, 180-8633, Musashinoshi, Tokyo, Japan, shinmura@econ.seikei.ac.jp

1 - Polygon deformation approach - a new linear integer formulation for the tsp model
Elias Munapo, Graduate School of Business and Leadership, University of KwaZulu-Natal, GSB & L, UKZN Westville., 27, Durban, South Africa, munapoe@ukzn.ac.za

The paper presents a approach for formulating the TSP linear integer model. The approach assumes an optimal tour as a polygon that has been deformed. The outmost cities or nodes of the traveling salesman problem (TSP) are joined together to form a polygon. The polygon is then deformed by joining an interior node to any of the two outmost nodes. The process is repeated until all nodes inside the polygon are connected. Sub-tour elimination constraints that are usually used in the available four classes of formulations are not necessary.

2 - Proof of the first part of the conjecture of aouchiche and hansen about the randic index
Ljiljana Pavlovic, Department of Mathematics, Faculty of Natural Sciences and Mathematics, Radoja Domanovica 12, 34000, Kragujevac, Serbia, pavlovic@kg.ac.rs, *Tomica Divnic*

Let G(k,n) be the set of connected simple n-vertex graphs with minimum vertex degree k. The Randic index of a graph G is defined as sum of d(u)d(v) raised to the power of -1/2, where d(u) is the degree of vertex u and the summation extends over all edges uv of G. We prove, for k less to n/2, the conjecture about the graphs for which this index attains its minimum value. We show that the extremal graphs have only two degrees, k and n-1. At the end we generalize our results to graphs with prescribed maximum degree q.

3 - Evaluation of linear discriminant functions by mathematical programming
Shuichi Shinmura, Facultu of Economics, Seikei University, Kichijoji Kitamachi 3-3-1,, 180-8633, Musashinoshi, Tokyo, Japan, shinmura@econ.seikei.ac.jp

Six discriminant functions such as Revised IP-OLDF based on MNM (Minimum Number of Misclassifications) criterion and soft margin SVM are compared with Fisher's linear discriminant function and logistic regression by 100 fold cross-validation. It is concluded that the mean of error rates of MP methods are less than those of statistical methods. And statistical methods can't recognize Swiss bank note data are linear separable for the training and evaluation data, nevertheless MP methods can recognize it.

■ TD-31

Tuesday, 14:30-16:00
G9-11

Retail Inventory Management I

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Rob Broekmeulen*, OPAC, TU Eindhoven, P.O. Box 516, Pav. E10, 5600 MB, Eindhoven, -, Netherlands, r.a.c.m.broekmeulen@tue.nl

1 - The impact of endogenous lead times on continuous review (s,S) policies
Ann Noblesse, KU Leuven, Naamsestraat 69, 3000, Leuven, Belgium, ann.noblesse@kuleuven.be, *Robert Boute*, *Marc Lambrecht*, *Benny Van Houdt*

We consider a two echelon supply chain where the retailer's inventory is controlled by a continuous review (s,S) policy. The retailer's orders are produced by a supplier with finite capacity and replenished when the order is completed. In this setting, orders and lead times are linked endogenously, as opposed to assuming lead times are exogenous. Using matrix analytic methods, we are able to compute the distribution of demand during lead time and the distribution of inventory levels. We numerically show the impact of taking the endogenous lead time into account.

2 - The joint replenishment problem with distance dependent joint order costs
Christian Larsen, Economics, CORAL, Aarhus School of Business, Aarhus University, Fuglesangs Alle 4, DK-8210, Aarhus V, Denmark, chl@asb.dk

A set of retailers is served from a central warehouse and the total transport cost, for serving a subset of the retailers together in one common shipment, is mainly proportional to the total distance travelled. The case where all the retailers are located along a major traffic artery, that is, a one-dimensional line structure, is analyzed. Different solution strategies, like clustering retailers together in delivery zones or using power of two rules for determining shipment intervals to individual retailers, is explored and compared, with and without capacity limitations on the shipments.

3 - The Routed Inventory Pooling Problem with Three Non-Identical Retailers
Harmen Bouma, Operations, University of Groningen, Nettelbosje 2, 9747 AE , Groningen, Netherlands, h.w.bouma@rug.nl, *Ruud Teunter*

Inspired by a real-life case, we consider a single period inventory problem with 3 non-identical retailers in which items can be pooled at a predetermined point in time. Pooling can only be done via a fixed (shortest) route. We derive cost expressions which are optimized over order-up-to levels and the time of pooling. Compared to complete pooling, routed pooling appears to obtain most of the pooling benefits. We investigate how stock is distributed among retailers at the beginning of the period and look into the influence of a retailer's size and position in the route on expected costs.

4 - Optimal Inventory Management with Supply Backordering
Marko Jaksic, Faculty of Economics, University of Ljubljana, Kardeljeva ploscad 17, 1000, Ljubljana, Slovenia, marko.jaksic@ef.uni-lj.si

We study the inventory control problem of a retailer working under stochastic demand and stochastic limited supply. The unfulfilled part of the retailer's order is backordered at the supplier and that the retailer has a right to cancel the replenishment of the backordered supply, if desired. We show the optimality of the order-up-to type policy and derive the threshold inventory position over which it is optimal to cancel the replenishment of the backordered supply. We carry out a numerical analysis to quantify the benefits of supply backordering and the value of the cancelation option.

■ TD-32

Tuesday, 14:30-16:00
G8-1

Models for Supply Chain Operations

Stream: Supply Chain Optimization
Invited session

Chair: *Joseph Geunes*, Industrial and Systems Engineering, University of Florida, 303 Weil Hall, 32611-2083 , Gainesville, FL, United States, geunes@ise.ufl.edu

1 - Constructing risk-reward tradeoff curves for the selective newsvendor problem
Edwin Romeijn, Department of Industrial and Operations Engineering, University of Michigan, 48109-2117, Ann Arbor, Michigan, United States, romeijn@umich.edu, *Arleigh Waring*

We study a generalization of the selective newsvendor problem that accounts for risk aversion. This problem introduces demand shaping into the traditional newsvendor problem through market selection decisions. Prior to the selling season, the firm determines how much to procure and in which markets to operate. We assume that the decision maker is risk-averse and considers both expected profit and (Conditional) Value-at-Risk. We show that in some cases the Pareto frontier can be constructed efficiently, and we develop an effective algorithm for approximating the frontier in general.

2 - Production Planning with Price-Dependent Demand and Supply Capacity

Joseph Geunes, Industrial and Systems Engineering, University of Florida, 303 Weil Hall, 32611-2083 , Gainesville, FL, United States, geunes@ise.ufl.edu, *Gokce Palak*, *Melis Teksan*

We consider a producer who procures an input for production by offering a price to suppliers. The input supply depends on a price offered by the producer and constrains production output. The producer also sets a price for production output, which determines the number of demands it must meet. In addition, the producer must create a production plan that maximizes profit. We model two variants of the problem: an infinite horizon model with stationary costs, demand rate, and input supply rate, and a finite-horizon, discrete-time version with non-stationary costs, demands, and supply levels.

3 - Mathematical Programming-Based Sales and Operations Planning for Television Manufacturing

Semra Agrali, Industrial Engineering, Bahcesehir University, Ciragan Cad. No: 4, 34353, Istanbul, Turkey, semra.agrali@bahcesehir.edu.tr, *Z. Caner Taşkın*, *Ali Tamer Unal*

We investigate sales and operations planning (S&OP) problem in a major television manufacturer. The company's product portfolio is very wide due to a large number of configuration options, and changes rapidly due to technological advances. Demand volatility is high in this industry and materials procurement requires long lead times. Hence, long term S&OP process is critical for efficient management of company resources and its supply chain as well as customer satisfaction. We devise a mathematical model for S&OP problem and describe a decision support system that has been in use since 2011.

4 - Optimizing Inland Waterway Infrastructure Maintenance for Supply Chain Operations

Chase Rainwater, Industrial Engineering, University of Arkansas, 72701, Fayetteville, AR, United States, cer@uark.edu, *Ridvan Gedik*, *Heather Nachtmann*, *Edward Pohl*

To ensure that the arm of the U.S. supply chain dependent on the flow of goods via inland waterway is viable, the U.S. Army Corps of Engineers (USACE) dredges hundreds of navigation projects. This effort requires allocating dredge resources to projects under necessary system constraints including but not limited to: (i) environmental window restrictions on when dredging can take place, (ii) equipment resource availability, and (iii) varying equipment productivity. We discuss modeling aspects of this scheduling problem using constraint programming (CP).

2 - Rolling horizon approaches for short-medium term production planning

Luis Guimarães, Industrial Engineering and Management, Faculty of Engineering of Porto University, FEUP, Portugal, luis.santos.guimaraes@gmail.com, *Diego Klabjan*, *Bernardo Almada-Lobo*

When planning their production several industries have to size and schedule lots on a set of parallel machines to satisfy forecasted demand. We exploit the practice of rolling basis planning to develop efficient approaches to the problem. The horizon is decomposed in two parts: the first periods explicitly detail the production sequences, while in the remaining periods a rough plan is generated to give an estimation of future costs and capacity. Alternative models are proposed to both the detailed and approximate horizons and their computational efficiency vs. solution efficacy is assessed.

3 - Quality-based multi-level capacitated lot-sizing in closed-loop supply chains

Florian Sahling, Department of Production Management, Leibniz University Hannover, Koenigsworther Platz 1, 30167, Hannover, Germany, sahling@prod.uni-hannover.de, *Kristina Burmeister*

We present a new model formulation for a multi-level capacitated lot-sizing problem in closed-loop supply chains (MLCLSP-RM). Components and final products can be either remanufactured or newly produced. However, remanufacturing times and costs depend on the quality level of the recoverables. A setup for (re)manufacturing causes setup costs and times. The objective of the MLCLSP-RM is to determine a feasible production plan at minimal costs. For the solution of the MLCLSP-RM, we adapted known MP-based solution approaches. Our numerical results show a high solution quality of these heuristics.

4 - A multi-objective integrated lot sizing and vehicle routing model for fast deteriorating products

Pamela Nolz, Institute for Production Management, Vienna University of Economics and Business, Nordbergstrasse 15, 1090, Vienna, Austria, pamela.nolz@wu.ac.at, *Tom Vogel*, *Christian Almeder*

We formulate a multi-objective production-distribution model for products loosing quality within several hours after production regarding two criteria: (i) a combination of production costs and travel costs, (ii) a measure of product freshness. The production process of perishable products is captured by a general lot sizing problem (GLSP), which we combine with aspects of an inventory routing problem (IRP). We investigate and compare different solution approaches: production first - distribution second, iteration between production and distribution, integration of production and distribution.

■ TD-33

Tuesday, 14:30-16:00
G8-3

Lot-Sizing and Related Topics 1

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Christian Almeder*, Chair for Supply Chain Management, European University Viadrina, Große Scharrnstr. 59, 15230, Frankfurt (Oder), Germany, Almeder@europa-uni.de

1 - Dynamic capacitated lot-sizing problem with multiple processing steps and common setup operators

Karina Copil, Supply Chain Management and Production, University of Cologne, Albertus-Magnus-Platz, 50923, Colgone, Germany, copil@wiso.uni-koeln.de

We present a model for a dynamic capacitated lot-sizing problem with multiple machines, sequence dependent setups and setup carry-over. The production process consists of multiple consecutive processing steps which can be performed independently on several process levels of a machine. If a previous level becomes available, production of a new product can start. For each processing step, a setup is necessary. Setups are carried out by common setup operators. All operations have to be synchronized in order to avoid overlapping since an operator can perform only one setup at a time.

■ TD-34

Tuesday, 14:30-16:00
G8-4

Supply chains: Pricing and interaction

Stream: Supply Chain Planning
Invited session

Chair: *Wolfgang Burgholzer*, Department of Information Systems and Operations, WU Vienna University of Economics and Business, Austria, wolfgang.burgholzer@wu.ac.at

1 - Costly Price-changes in Joint Pricing and Production Planning

Elham Mardaneh, Mathematics and Statistics, Curtin University, Perth, WA, Australia, elham.mardaneh@curtin.edu.au

We propose an adaptation of the Cross Entropy method to solve a joint production planning and pricing problem with costly price changes and shared production capacity. Both cases of uncertain and deterministic price-dependent demand are considered. We seek a policy that is both economical and operational from the production perspective. The above problem is mathematically formulated as a mixed integer nonlinear program which is algorithmically very challenging to solve. The proposed method shows promise in solving optimization problems regardless of continuity or other assumptions.

2 - Determining optimal discount policies for a supplier in B2B relationships
Viktoryia Buhayenko, Economics Informatics and Social science, Molde University College, Britvegen 2, 6410, Molde, Norway, cpl@mail.ru, *Dirk Van Eikenhorst*
This research studies which discounts a supplier needs to offer to give incentive to his customers to change their order patterns in a way that minimizes the supplier's total cost. This approach is very different from the yield management and is more accurate in many B2B market situations. We believe this is the first time that the problem of when and how much discount to offer is addressed. A solution is given by separating the problem when orders should be placed and how much discount should be offered to achieve this. Optimality conditions for the solution are also given.

3 - Pricing and Capacity Allocation with Competing Manufacturers and Buyers
Zehra Bilginturk Yalcin, Koc University, Acarlar Sitesi, E50 Blok Daire 5 Sarıyer, 34450, Istanbul, Turkey, zbilginturk@yahoo.com, *Selcuk Karabati*
We consider the capacity allocation and pricing problem of competing manufacturers, and buyers each of whom demand a bundle of products, in the presence of private information among parties. The objective of the manufacturers is to maximize their own revenue generated by selling the products minus the production and inventory holding costs. The objective of each buyer is to maximize the difference between the time-dependent utility of their bundle and the price of that bundle. We develop an iterative auction mechanism to solve the problem and present a computational analysis with benchmarks.

4 - Supply Chain Emulation Tool: The impact of operations on supply chain performance
Wolfgang Burgholzer, Department of Information Systems and Operations, WU Vienna University of Economics and Business, Austria, wolfgang.burgholzer@wu.ac.at
The coordination and understanding of supply chains as well as its interrelations is very important. In this regard, various supply chain analysis tools as well as management rules on a strategic level are known. The impact of different management decisions at the operational level on the whole supply chain performance, however, is mostly disregarded. Thus, the proposed tool enables the emulation of a whole supply chain while focusing on in-house processes and their impacts on the entire supply chain. It allows to recreate "real-world' scenarios and to understand important interrelations.

■ TD-35

Tuesday, 14:30-16:00
G8-2

Analysis of Warehouse and Manufacturing Systems

Stream: Manufacturing and Warehousing
Invited session

Chair: *Jelmer van der Gaast*, Erasmus University Rotterdam, Netherlands, jgaast@rsm.nl

1 - Small is Beautiful: A Framework for Evaluating and Optimizing Compact Storage Systems
Nima Zaerpour, Department of Management of Technology and Innovation, RSM Erasmus University, Rotterdam School of Management (RSM), Erasmus University Rotterdam Department of Management of Technology and Innovation, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, nzaerpour@rsm.nl
Warehouses are important nodes in supply chains. They decouple supply from demand. Warehouses are particularly needed in densely populated areas while in many of these areas space has become short. In order to address this issue, enterprises are moving toward new storage systems, namely, compact storage systems. In this study, we propose a framework to help warehouse managers in their decision making process. This framework includes response time analysis of different system configurations, investment and operational cost comparisons, and energy consumption and CO2 emission calculations.

2 - Performance analysis of sequential zone picking systems
Jelmer van der Gaast, Erasmus University Rotterdam, Netherlands, jgaast@rsm.nl
We develop an analytical model for analyzing sequential zone picking systems which belongs to the most popular internal transport and order picking systems in practice. The system is analyzed by a queueing network and features a dynamic block-and-recirculate protocol and priority merging. An iterative algorithm is used to evaluate the performance statistics of the order picking system. The accuracy of the algorithm is compared with this results of a discrete event simulation.

3 - A queueing network model for a manufacturing system
Luigi Rarità, Department of Information Engineering, Electric Engineering and Applied Mathematics, University of Salerno, Via Ponte Don Melillo, 84084, Fisciano (SA), Italy, lrarita@unisa.it, *Matteo Gaeta*
A manufacturing system, modeled by an exponential queueing network, is considered. Unfinished parts and control signals arrive at working stations, the nodes, according to Poisson streams. When the service (of exponential type) in a node ends, goods move to other nodes either as parts to process or as impulses, or leave the network. Control impulses, activated during a random exponentially distributed time, move a good from the node they arrive to another node, or destroy another unfinished part. Stationary probabilities and mean numbers of unfinished parts in nodes are numerically computed.

4 - Order Acceptance with Load Dependent Lead Time: A Lagrangian Relaxation-Based Approach
Nadjib Brahimi, Industrial Engineering and Management, University of Sharjah, POBox 27272, Sharjah, United Arab Emirates, POBox 27272, Sharjah, Sharjah, United Arab Emirates, nbrahimi@sharjah.ac.ae, *Tarik Aouam*
This research considers the integration of order acceptance and production planning with load-dependent lead times. The problem consists of deciding which customer orders to accept/reject in order to maximize profit. If an order is accepted, it generates revenue, incurs production and inventory or backordering costs, and affects the production lead time. If the order is rejected, a lost sale cost occurs. The problem is formulated as a MIP and solved using an efficient Lagrangian relaxation heuristic with excellent results with very small gaps between the obtained lower and upper bounds.

■ TD-36

Tuesday, 14:30-16:00
G7-1

Cutting and Packing 2

Stream: Cutting and Packing
Invited session

Chair: *A. Miguel Gomes*, INESC TEC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias s/n, 4200-465, Porto, Portugal, agomes@fe.up.pt

1 - A heuristic approach to the Container Loading Problem with multi-drop constraints
David Álvarez, São Paulo State University, Brazil, david.unesp@gmail.com, *Francisco Parreño*, *Ramon Alvarez-Valdes*
In this paper, we present a randomized constructive algorithm for the Container-Loading problem with multi-drop constraints. The problem consists in maximizing the total value of the container loading, satisfying a set of constraints found in practical situations, such as box rotations, load-bearing strength, weight limits, full support and multi-drop. The solution procedure includes a local search phase and has the structure of a GRASP algorithm. A computational study on benchmarks and real-world instances from the literature is presented and discussed.

2 - A physical packing sequence algorithm for the container loading problem whith static mechanical equilibrium conditions
António Ramos, INESC TEC, Faculty of Engineering, University of Porto, Portugal, deg09006@fe.up.pt, *José Fernando Oliveira*, *Manuel Lopes*

The container loading problem is a combinatorial optimization problem that addresses the optimization of spatial arrangement of cargo inside containers, maximizing containers space utilization. The actual sequence by which each box is placed inside the container in a specific location is usually ignored, mainly because the restrictive full or almost full base support condition defined to guarantee static cargo stability, guarantees a feasible sequence. This article presents a physical packing sequence algorithm with a less restrictive stability condition based on static mechanical equilibrium.

3 - Selecting the best shipper sizes for sending products to customers
Francisco Parreño, MAthematics, Universidad de Castilla-La Mancha, 02002, Albacete, Spain, Francisco.Parreno@uclm.es, *Maria Teresa Alonso Martínez*, *Ramon Alvarez-Valdes*, *Jose Tamarit*

A distribution company in Spain has to send products, packed into shipper boxes, from the store to the retail shops. The problem is to decide the sizes of the shipper boxes to be kept at the store so as to minimize the cost of packing all the forecasted demands along the planning horizon. In this work we describe two integer linear programming formulations for the problem. We have also used a metaheuristic algorithm in order to improve the packing of products in the shipper boxes. A computational study conducted on real instances provided by the company is presented and discussed.

4 - Discovering an algorithm for the strip packing problem using a computational game
Gustavo Gatica, Escuela de Informática, Facultad de Ingeniería, Universidad Andres Bello, República 237, Santiago, Chile, gustgatica@gmail.com, *Carlos Contreras Bolton*, *Pablo Reyes*, *John Willmer Escobar*, *John Atkinson*

Are human heuristics good enough to solve games? In this paper, a new approach is proposed to investigate humans ability to discover resolution heuristics in a combinatorial optimization problem using a computational game. It extracts knowledge used by players to address the strip packing problem. The analysis is based on pattern-recognition and decision-tree algorithms resulting in an algorithm performing similarly to Bottom Left Decreasing Height. Experiments show the promise of the algorithm to solve all instances provided from the state-of-the-art approaches.

■ TD-37

Tuesday, 14:30-16:00
G7-4

Multicriteria Decision Making and Its Applications V

Stream: Multicriteria Decision Making
Invited session

Chair: *Margaret Wiecek*, Department of Mathematical Sciences, Clemson University, Martin Hall O-208, 29634, Clemson, SC, United States, wmalgor@clemson.edu
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - A Hybrid Dynamic VIKOR-GRA Approach for Financial Performance Evaluation of Turkish Manufacturing Industry
Muhammet Gul, Industrial Engineering, Yildiz Technical University, Turkey, mgul@yildiz.edu.tr, *Erkan Celik*, *Ali Fuat Guneri*, *Alev Taskin Gumus*

Dynamic multi criteria decision making (DMCDM) has an important position in modern decision science together with classic MCDM approaches. In DMCDM the decision data is generally obtained from different time periods. This paper presents a hybrid DMCDM approach where three years of multi-period decision data is calculated from financial performance determination ratios of Turkish manufacturing companies that are traded at Istanbul Stock Exchange (ISE). By combining concepts of VIKOR and grey relational analysis (GRA), a new DMCDM method is proposed to deal with the evaluation of the companies.

2 - Multi-objective decision making approach for the identification of the air carrier organizational structures
Olja Cokorilo, Air Transport Department, Faculty of Transport and Traffic Engineering, University of Belgrade, Vojvode Stepe 305, 11000, Belgrade, Serbia, oljav@sf.bg.ac.rs

The paper describes multi objective decision making approach for determining optimal air carrier organizational structure model based on TOPSIS method. A comparison of the observed parameters is based on: economical parameters, system flexibility and ability to adapt the market requirements, motivation and training of employees and number of hierarchical levels. The conducted research includes a sample of functional, divisional and matrix organizational structure. The results obtained would help in determining the proper business solution for traditional carriers based on their existing fleet.

3 - A Multi Criteria Decision Making Approach in Selecting Renewable Energy Alternatives Using The Fuzzy VIKOR Method for The Case of Marmara Region
Kadriye Büşra Yılmazer, Department of Industrial Engineering, Yildiz Technical University, Barbaros Bulvarı, Yıldız, 34349, Istanbul, Turkey, busrayilmazer@gmail.com, *Umut Rifat Tuzkaya*

Energy strategies for countries are vitally important in todays' competitive environment. Energy policies of the countries must focus on using most efficient energy alternatives. So, in this study, a multi-criteria decision making method named the Fuzzy-VIKOR is used to evaluate renewable energy alternatives. This method is applied to the case of Marmara Region. It is aimed to make the best strategical and tactical decisions on selecting appropriate renewable energy alternative for the Marmara Region in Turkey in order to set up a new power plant that provides high energy and less emissions.

4 - Project cost estimation for R&D research of Government in Korea
Dong-Guen Kim, KISTEP, Korea, Republic Of, ise97@kaist.ac.kr, *YongSoo Kim*

In Korea, the preliminary feasibility study(PFS) carried for the newly proposed large-scaled government programs and PFS about research and development (R&D) programs also became compulsory since 2008. In case of a PFS on R&D programs, there are three major criteria about technology, policy and economic effects and the analysis on economic effect is composed of estimation of cost and benefit. In this study, the estimation on R&D project cost are researched. The distributions of R&D project costs are investigated and the methodology for estimation on parameters of project cost is developed.

■ TD-39

Tuesday, 14:30-16:00
G7-3

Dominant AHP

Stream: Analytic Hierarchy Processes, Analytic Network Processes
Invited session

Chair: *Eizo Kinoshita*, Urban Science Department, Meijo University, 4-3-3 Nijigaoka, 509-0261, Kani, Gifu, Japan, kinoshit@urban.meijo-u.ac.jp

1 - Super Pairwise Comparison Matrix in MDAHP with the Logarithmic Least-Squares Method
Takao Ohya, School of Science and Engineering, Kokushikan University, 4-28-1 Setagaya, 154-8515, Setagaya-ku, Tokyo, Japan, takaohya@kokushikan.ac.jp, *Eizo Kinoshita*

We have proposed a super pairwise comparison matrix (SPCM). This presentation shows, using the error models, that an evaluation value resulting from the application of the logarithmic least-squares method (LLSM) to a SPCM does not necessarily coincide with that of the evaluation value resulting from the application of the geometric mean multiple dominant AHP (GMMDAHP) to the evaluation value obtained from each pairwise comparison matrix by using the geometric mean method in the multiple dominant AHP (MDAHP).

2 - Practical use of dominantAHP in the data analysis of management activity
Shunei Norikumo, General Management Department, Osaka University of Commerce, 4-1-10, Mikuriyasakae-machi, 577-8505, Higashiosaka, Osaka, Japan, shunei.norikumo@gmail.com, *Eizo Kinoshita*

This study attempts to contribute actively as a tool for decision support management activities Analytic Hierarchy Process. In recent years, such as ERP(Enterprise Resource Planning) systems that are used by companies, data management is performed by using the DBMS(DataBase Management System), data analysis is performed using the DM(Data Mart) and DWH(Data Warehouse). Propose the use of AHP in order to carry out a reasonable business decision, Introduces the problem of AHP in order to take advantage of the BI(Business Intelligence) of the corporate database.

3 - Multi-Resolution Analysis (MRA): Integrated Solutions for Today's Analytical Challenges
John Tindle, Tindle Analytics LLC, 18175 Archers Drive, 80132, Monument, Colorado, United States, TindleAnalytics@gmail.com

Multi-Resolution Analysis (MRA) provides an array of analytical capabilities for decision support to government and industry processes, including capability requirements generation, planning and programming, and research and development. It provides this support through operations research techniques and tools in five areas. This presentation will discuss development of the MRA process and provide examples of its practical use on completed and ongoing projects.

4 - Evaluation Principles between AHP/ANP and Dominant AHP/CCM
Eizo Kinoshita, Urban Science Department, Meijo University, 4-3-3 Nijigaoka, 509-0261, Kani, Gifu, Japan, kinoshit@urban.meijo-u.ac.jp

In this research, we provide evaluation principles of decision making processes: Analytic Hierarchy Process (AHP), Analytic Network Process (ANP) which is an extension of AHP for typical network structure, Dominant AHP, and its Concurrent Convergence Method (CCM). We also list differences and similarities among them in discussions.

■ TD-40

Tuesday, 14:30-16:00
Y12-1

DEA Theory IV

Stream: DEA and Performance Measurement
Invited session

Chair: *Ozren Despic*, Aston Business School, Aston University, Aston Triangle, B4 7ET, Birmingham, West Midlands, United Kingdom, o.despic@aston.ac.uk

1 - Local governments, expenditure needs and level of services: a parametric approximation of nonparametric robust frontier approach
Francesco Vidoli, SOSE SPA, Italy, fvidoli@gmail.com, *Cinzia Daraio*, *Elisa Fusco*

In the literature expenditure needs and cost efficiency of local governments have been analysed separately. Departing from previous approaches, we propose a robust (to outliers) method for the estimation of the expenditure needs at local level that simultaneously takes into account the optimal level of services. It is based on a parametric approximation, using a Fourier Flexible Form, of non parametric frontiers which use the duality theory without requiring information on input prices. We illustrate the approach on a detailed database of 6,712 Italian municipalities for the year 2009.

2 - Frontier Performance Measurement Techniques for the Quality of Public Services, Endogeneity and Non-Convexity
David Mayston, Economics and Related Studies, University of York, University of York, Y010 5DD, York, United Kingdom, dm3@york.ac.uk

The paper explores the issues, and possible solutions, posed for performance measurement techniques, including Data Envelopment Analysis (DEA), by the endogeneity of the resource inputs of public service producers which arises when the quality of their output feeds back upon their ability to attract able staff and additional income, and by the non-convexity of the feasible sets facing the public service producers which arises when their output quality is judged by reference to discrete quality grades whose thresholds are subject to stochastic variations.

3 - Measuring the Impact of Evaluation Directions on the Performance of Units — A DEA-based Management Control Approach
Mohsen Afsharian, Institute of Management Control and Business Accounting, Braunschweig University of Technology, Fallersleber-Tor-Wall 23 38100 Braunschweig, Germany, 38100 , Braunschweig, Germany, m.afsharian@tu-braunschweig.de, *Heinz Ahn*

This paper presents a DEA-based approach which measures the contribution of the evaluation direction to the performance of units in an evaluation system. Directional distance functions are used as a managerial control element to determine in what strategic direction the units will be evaluated. The authors construct a new Luenberger productivity index and provide a new decomposition of this index to measure the degree to which the imposed evaluation directions affect the performance of the units over time. The suggested index will be illustrated by means of a real-world example from banking.

4 - Geometric Data Envelopment Analysis: An application to the Human Development Index
Ozren Despic, Aston Business School, Aston University, Aston Triangle, B4 7ET, Birmingham, West Midlands, United Kingdom, o.despic@aston.ac.uk, *Placido Moreno*

Most Data Envelopment Analysis (DEA) models used in practice rely on weighted arithmetic means of inputs and outputs in order to measure efficiency. The use of multiplicative DEA models, which are based on weighted geometric means, has been very limited. Here we present a comprehensive mathematical formulation of Geometric DEA (GDEA) and its relation to classical DEA, making a proper foundation for further research and applications of GDEA models. Beneficial properties of GDEA over classical models are highlighted and illustrated through the problem of calculating Human Development Index.

■ TD-41

Tuesday, 14:30-16:00
Y12-5

DEA Aplications XIII

Stream: DEA and Performance Measurement II
Invited session

Chair: *Mariana Almeida*, Production engennig, Escola de Engenharia de Sao carlos, Avenida Trabalhador Sãocarlense, 400 - Centro, 13566-590, Sao Carlos, Sao Paulo, Brazil, almeidamariana@yahoo.com

1 - An Effective Demand Management Model for the Airline Industry
Ling-Feng Hsieh, Department of Transportation Science and Logistics Management, Chung Hua University, 707, Sec.2, WuFu Rd., Hsinchu, Taiwan, lfhsieh@chu.edu.tw, *Li-Shih Yang*

The demand management and performance evaluation are keys for improving the efficiency and effectiveness of the airline industry. An overall performance evaluation model is proposed, it is with respect to the non-preservation characteristic of airline products. DEA is applied for evaluating the production efficiency, marketing effectiveness, and executive effectiveness first. Secondly Grey Forecasting is used to predict the number of passengers, then feedback to adjust the resources allocation, and enhance the competitiveness of the airline industry.

2 - Cross efficiency evaluation under the principle of rank priority of DMUs
Majid Zohrehbandian, Mathematics, Karaj Branch, Islamic Azad University, karaj, Iran, Islamic Republic Of, zohrebandian@yahoo.com

Cross efficiency evaluation has been suggested as an alternative method of efficiency evaluation in DEA, where secondary goals have been introduced in it, due to the presence of alternative optima. This paper proposes an MILP and a GP model as secondary goals to choose suitable weights in cross efficiency evaluation. These models consider to optimize the rank priority of DMUs under evaluation. As an advantage, the obtained weights are more appropriate from the standpoint of the DEA evaluation framework and can reflect the relative strength of the efficient DMU under consideration.

3 - Performance Measurement of Turkish Manufacturing SMEs using DEA
Muhammet Enis Bulak, Industrial Engineering, Fatih University, Turkey, mebulak@fatih.edu.tr, *Ali Turkyilmaz*

This study purposes to measure and evaluate the performance efficiency of manufacturing SMEs in Turkey. For this target, 746 manufacturing companies from 11 different sectors are evaluated. The firms are classified to sectors regarding their NACE codes which are provided by KOSGEB, Turkish Small and Medium Enterprises Development Organization. Data Envelopment Analysis is applied for a set of input and output performance measures which are crucial for the manufacturing companies. The industry based efficiency analysis provide management with information regarding the relatively best practices.

4 - Application of Data Envelopment Analysis (DEA) for demand forecasting in a small Brazilian agribusiness company
Mariana Almeida, Production engennig, Escola de Engenharia de Sao carlos, Avenida Trabalhador Sãocarlense, 400 - Centro, 13566-590, Sao Carlos, Sao Paulo, Brazil, almeidamariana@yahoo.com, *Fernanda Rocha*, *Marianna Campos*, *Claudia Francisco*

Demand forecasting identifies the use of resources in the production system. In response to this demand, the research objective to compose an efficient production mix, aiming to maximize the financial performance of a small company in agribusiness sector. The Data Envelopment Analysis and statistical techniques were used to verify the inefficiency in production planning. The CCR and BCC models were applied in the production data of three months to determine the most efficient mix. From this analysis, it was possible to propose some diagnostics to increase the level and operational efficiency.

■ TD-42

Tuesday, 14:30-16:00
Y12-3

Decision Processes in Practice

Stream: Decision Processes
Invited session

Chair: *Alec Morton*, Management/ Operational Research, London School of Economics, Houghton St, London, wc2a2ae, London, England, United Kingdom, a.morton@lse.ac.uk

1 - Catching more criminals
Sue Merchant, Blue Link Consulting, 4,Shepherds Way, WD3 7NJ, Rickmansworth, Hertfordshire, United Kingdom, suemerchant@hotmail.com

The Crimestoppers charity takes anonymous calls from the public who have information about crimes or criminals and sends actionable information on to police forces. The workload of Crimestoppers' call centre has increased greatly recently and in early 2012 a way of improving performance for no increase in cost was sought. Working with the client, two OR analysts used PRISM software, developed by Lanner for police call centres, to compare a range of possible staff rosters and improve upon these. The talk describes the problems faced in carrying out the work and the outcome achieved.

2 - Using Decision Theory to Select the National Audit Office's Portfolio of Work
Tom McBride, National Audit Office, SW1W 9SP, London, United Kingdom, Tom.McBride@nao.gsi.gov.uk

The National Audit Office produces 60 reports on value for money to the UK parliament annually. As our work examines a wide range of Government activity, from defence procurement to international aid, choosing a study portfolio which addresses the right issues, meets the needs of our stakeholders and enhances our reputation is a key strategic decision. We have applied techniques from decision theory to design a set of criteria which address the range of elements which make up a 'good' study, and select a study portfolio designed to meet the expectations of internal and external users.

3 - Methods for Systematic Gap Closure
Ian Seed, Cogentus, RG1 1ET, Reading, United Kingdom, iseed@cogentus.co.uk

Good decisions are predicated on accurately describing the problem that needs to be solved. Once the problem has been defined the range of options that offer a solution can be developed before selecting the one that best meets the objective. Much work has been done in selection methodologies, but less has been done in defining problems and idea/options generation. This paper describes a number of techniques for framing and for options generation that have been proven to work in industry. It includes creativity tools for random thinking and Triz for systematic thinking.

4 - Systems Mapping - Causal Loop Diagrams for concept development and communication
Ian Mitchell, OR Society, 3 Beyer Road, Amesbury, SP4 7XG, Salisbury, Wiltshire, United Kingdom, IanMitch1@gmail.com

This submission describes recent practical project experiences using Causal Loop Diagrams as qualitative descriptive analytics. Having established the context of the Causal Loop Diagram the submission addresses the practical aspects of engaging non-analysts. An effective worked example appears before a discussion of actual outputs from a range of policy areas and how these aided concept development and communication. The submission describes the constraints and opportunities generated by Causal Loop Diagrams.

■ TD-43

Tuesday, 14:30-16:00
Y12-2

Applications in Decision Making & Decision Analysis

Stream: Decision Support Systems
Invited session

Chair: *Pascale Zaraté*, Institut de Recherche en Informatique de Toulouse, Toulouse University, 118 route de NarBonne, 31062, Toulouse, France, zarate@irit.fr
Chair: *Fatima Dargam*, SimTech Simulation Technology, Ries Strasse 120, 8010, Graz, Austria, F.Dargam@SimTechnology.com

1 - A Decision Support System For Exchange Rates Selection Problem and An Application In Turkey
Aykan Akincilar, Department of Industrial Engineering, Gazi University, Faculty of Engineering, Department of Industrial Engineering, Faculty of Engineering, Gazi University, Maltepe, 06570, Ankara, Turkey, aykanakincilar@gazi.edu.tr, *Erol Sahin*, *Ertan Guner*

Forecasts of exchange rates may be insufficient themselves for exchange rates selection problem by the reason of that numerious factors affect the market and financial players. The purpose of this study is to develop a decision support system, which comprises both forecast values and the other possible factors affecting exchange rates. Time series analysis approach and MCDM approach are integrated to achieve this purpose. The proposed model is applied to Turkish market, indicating that intangible and qualitative criteria are as effective as forecast values in exchange rates selection problem

2 - How Supply Competency Affects FDI Decisions: Some Insights
Prabir Bagchi, Decision Sciences, George Washington University, 20052, Washington, DC, United States, bagchi@gwu.edu, *Miguel Lejeune*, *Arshad Alam*

Foreign investment decisions by multinational enterprises are usually arrived by considering not just the firm-specific factors, but location-specific factors are also of paramount importance. Using three supply factors specific to a country - supply environment and infrastructure, absorptive capacity, we construct a rating system representing the potential of a nation to attract foreign direct investment (FDI). We use the combinatorics- and Boolean-based logical analysis of data (LAD) method to capture the individual and combined impact of the supply factors on the FDI inflow.

3 - A decision-making support tool for project manager selection
Baruch Keren, Industrial Engineering and Management, SCE - Shamoon College of Engineering, Bialik Sts. 56, P.O.B. 950, 84100, Beer Sheva, Israel, baruchke@sce.ac.il, *Zohar Laslo*, *Yossi Hadad*

This research proposes a decision-making support tool for selecting a project manager. The selection is based on the relative past performance of potential managers. Past projects are ranked in accordance with a ranking method. Project managers are ordered according to past project rank. The difference in quality between the past performance of the candidates is statistically examined using the Mann-Whitney U test. This enables the establishment of a subgroup of one or more preferred candidates. The final candidate may be selected from this subgroup according to personal qualifications.

4 - Application of Multicriteria Models in Project Portfolio Selection
Adiel Teixeira de Almeida, Management Engineering, Federal University of Pernambuco - UFPE, Cx. Postal 7462, 50630-970, Recife, PE, Brazil, almeidaatd@gmail.com, *Rudolf Vetschera*

Selection of Project portfolio based on multicriteria decision making (MCDM) methods is analyzed. Two aggregating methods are considered: outranking method PROMETHEE and an additive method. The former represents a non-compensatory rationality, while the latter correspond to a compensatory one. Problems related to scales used for intra-criteria evaluation are considered, which is linked to inter-criteria elicitation in the case of additive methods. Although the findings are applied in general, the context of Research and Development (R&D) project portfolio selection is considered.

■ TD-44

Tuesday, 14:30-16:00
Y12-4

Dynamical Systems

Stream: Dynamical Systems and Game Theory
Invited session

Chair: *João Almeida*, Mathematics, LIAAD - INESC TEC and Instituto Politécnico de Bragança, Escola Superior de Tecnologia e Gestão, Campus de Santa Apolónia, Ap. 1134, 5301-857, Bragança, Portugal, jpa@ipb.pt
Chair: *José Martins*, Polytechnic Institute of Leiria, Portugal, jmmartins@ipleiria.pt

1 - Deviation from collusion with and without dumping
José Martins, Polytechnic Institute of Leiria, Portugal, jmmartins@ipleiria.pt, *Alberto Pinto*, *Nilanjan Banik*

In this work, we consider a firm that has the monopoly of a certain market in its own country and competes with an outside firm, in the outside country, for a market where it is traded the same product. Assuming that both firms are cooperating in the outside market, we study two possible strategies of deviation that can be adopted by the foreign firm: one committing dumping and another without committing dumping. We compare the profits in both strategies and characterize the parameters for which each strategy should be adopted.

2 - Anosov diffeomorphisms and a-tilings
João Almeida, Mathematics, LIAAD - INESC TEC and Instituto Politécnico de Bragança, Escola Superior de Tecnologia e Gestão, Campus de Santa Apolónia, Ap. 1134, 5301-857, Bragança, Portugal, jpa@ipb.pt, *Alberto Pinto*

We introduce the notion of a-tiling. The a-tilings record the infinitesimal geometric structure determined by the dynamics along the unstable leaf that is invariant under the action of the Anosov diffeomorphism given by G(x,y)=(ax+y,y), where a is a positive integer that is fixed. The properties of the a-tilings are defined through the a-Fibonacci decomposition of natural numbers. This decomposition encodes the combinatorics determined by a Markov partition of G along the unstable leaf. We exhibit a natural correspondence between a-tilings, Anosov diffeomorphisms and solenoid functions.

3 - Using value co-creation concept to improve tourism service delivery performance.
Mona Soufivand, University of Palermo, Italy, m.soufivand@gmail.com, *Marco Alessi*, *Carmine Bianchi*, *Enzo Bivona*, *Lanfranco Marasso*

In service sector, it is very crucial to continuously watch services out, and note that changing them may alter receivers' perception. In this paper, we elaborate on the role of "value co-creation" and "system thinking" in improving performance of service delivery in service supply chain sector. To do so, we study a specific case from tourist industry of Sicily, Italy. Using system dynamics approach, we analyze the impacts of tourists' engagement in setting investment policies. We show that this remarkably helps service providers to improve their policy making processes.

■ TD-45

Tuesday, 14:30-16:00
Y10-3

New Mathematical Models in Energy Markets II

Stream: Mathematical Models in Macro- and Microeconomics
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Miray Hanım Yıldırım*, Institute of Applied Mathematics, Middle East Technical University; Department of Industrial Engineering, Çankaya University; European Commission, Joint Research Centre, Institute for Energy and Transport, Institute of Applied Mathematics Middle East Technical University, 06531, Ankara, Turkey, e160106@metu.edu.tr
Chair: *Sudhakara Reddy*, Energy and Envt., Indira Gandhi Institute of Development Research, Film City Road, Goregaon (E), 400065, Mumbai, Maharashtra, India, sreddy@igidr.ac.in
Chair: *Dorien DeTombe*, Methodology of Societal Complexity, Chair Euro Working Group, P.O.Box 3286, 1001 AB, Amsterdam, Netherlands, detombe@nosmo.nl

1 - Congestion Management in Electricity networks: evidence from EU electricity markets
Silvia L. Vitiello, European Commission - Joint Research Centre, Institute for Energy and Transport, westerduinweg 3, room 204/bldg 309, 1755 LE, Petten, Netherlands, silvia.vitiello@ec.europa.eu

The aim of this study is to evaluate the degree of congestion in EU cross border interconnections in the short term, under the assumptions that a) the Single Energy Market is completed in 2014 as expected by the European Commission, b) building additional transmission capacity is not possible. Two different scenarios are then compared: one with a central European Power Exchange, that allocates on the basis of a uniform price, and another one with 7 different regional power exchanges that encompass the electricity market of several EU Countries (Electricity Regional Initiatives).

2 - Optimum Energy Portfolio using Genetic Algorithm with Random Walk Selection
Secil Ercan, Industrial Engineering, Istanbul Technical University, Turkey, ercansec@itu.edu.tr, *Gulgun Kayakutlu*

Hybrid metaheuristic algorithms are applied to have bigger success in optimization. For Genetic Algorithm (GA) there are several selection algorithms that are based on only the fitness values. Random walk selection is the algorithm that is based on not only the fitness value but also the distance. Optimum energy portfolio is a popular subject for the application of GA. In this study, GA with random walk selection is applied to obtain the optimum energy portfolio. The model will enlighten the new algorithms in energy optimization applications that will improve the selection phase.

3 - Optimization of Turkey's Natural Gas Policy using Fuzzy Mathematical Programming
Serhat Tüzün, Industrial Engineering, Yildiz Technical University, Besiktas, 34349, Istanbul, Turkey, serhat.tuzun@gmail.com, *Tufan Demirel*

The aim of the present study is to calculate the necessary amount of natural gas to be used as an energy source in Turkey and determine the optimal policy. Natural gas is one of Turkey's main sources for electricity generation and heating and it is fully imported from foreign countries. Therefore, consumption forecasts should be accurate for future purchase agreements. The model developed uses past data and growth estimates to calculate the amount of consumption in the next ten years with the aid of fuzzy approach. Afterwards, the optimal policy is determined and the results are discussed.

■ TD-46

Tuesday, 14:30-16:00
Y10-1

Search Games

Stream: Game Theory and Combinatorial Optimization
Invited session

Chair: *Shmuel Gal*, Statistics, University of Haifa, Haifa , Israel, 31905, Haifa, Israel, sgal@univ.haifa.ac.il

1 - Ambush strategies in search games
Robbert Fokkink, Applied Mathematics, TU Delft, PO Box 5031, 2600GA, Delft, Netherlands, r.j.fokkink@tudelft.nl

The Princess and Monster game was defined by Isaacs and solved by Gal, http://en.wikipedia.org/wiki/Princess_and_monster_game. In the original version of the game, P and M are points and the radius of detection is small. The game remains open for a large radius of detection. Think of playing blind man's buff in many rooms that are connected by narrow corridors. Should the blind man search a room or wait in a corridor, in ambush? One can model this dilemma by point processes, which provides a new view on the P-M game. This is joint work with Steve Alpern, Shmuel Gal and Marco Timmer.

2 - Searching among heterogenous locations
Shmuel Gal, Statistics, University of Haifa, Haifa , Israel, 31905, Haifa, Israel, sgal@univ.haifa.ac.il, *Jerome Casas*

A predator (searcher) looks for a prey (hider) in a search space consisting of n locations. The hider chooses a location and the searcher visits k different locations, where k is a parameter of the game ('giving-up time' for the continuous version). If the predator visits a location i at which the prey hides, then capture occurs with probability p_i. We show that if k is smaller than a threshold, then it is optimal to hide with probability proportional to 1/p_i for each location i. If k exceeds the threshold, then the optimal hiding strategy is to stay at the location with the smallest p_i.

3 - Optimal search for a small (or well hidden) object
Thomas Lidbetter, Mathematics Department, London School of Economics, Houghton Street, London, WC2A 2AE, London, United Kingdom, T.R.Lidbetter@lse.ac.uk, *Steve Alpern*

A Searcher seeks an immobile Hider located on a given network Q: the Searcher can move on Q at speed 1, but to detect the Hider he must move at a slower speed. This models the search for a small or well hidden object (e.g. contact lens, improvized explosive device). We consider this as a game against a Hider who aims to maximize the search time, and give solutions for trees Q in both the cases when the Searcher has a fixed and arbitrary starting point. We also consider a variation of the game where the Searcher detects the Hider with positive probability when passing him at the fast speed.

4 - Motion planning under security aspects
Elmar Langetepe, Institute of Computer Science I, University of Bonn, Friedrich-Ebert-Allee 144, 53113, Bonn, Germany, elmar.langetepe@informatik.uni-bonn.de

The problem of computing a shortest path that visits a set of geometrical objects in the Euclidean plane or the vertices of a network in some (probably predefined) order is a natural task in many applications. An interesting variant of this problem deals with security aspects. A geometrical object is "safe" as long as the path runs inside the object. A "safe" path in a network requires that an edge has to be passed by more than one agent simultaneously. We consider motion planning problems that covers such security constraints for weighted networks or in the Euclidean plane.

■ TD-47

Tuesday, 14:30-16:00
Y10-2

Promotions and Advertising in Revenue and Price Optimization

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Natalia Viktorovna*, SAS Institute Inc., 27513, Cary, United States, Natalia.Viktorovna@sas.com

1 - Study on Discount Vouchers as Marketing and Revenue Management Strategies
Jian Chen, Management Science and Engineering, Tsinghua University, School of Economics and Management, 100084, Beijing, China, jchen@tsinghua.edu.cn

In the discount voucher market, customers usually face two types of valuation uncertainties, i.e., preference uncertainty and consumption state uncertainty. Given these two types of uncertainties, optimal voucher price is derived. And given the merchant's forward-looking behavior, we propose a capacity allocation rule between the discount voucher channel and spot selling channel. Moreover, we find that the customer no-show behavior may not be a good thing for large or start-up merchants. Finally, we find that the customer dilution behavior may not be a bad thing for merchants.

2 - A Simulation Platform for Evaluating Revenue Impact of Display Advertising Pricing Algorithm
Jian Yang, Yahoo! Labs, 701 First Avenue, 94089, Sunnyvale, CA, United States, jianyang@yahoo-inc.com
Pricing is critical to online display advertising since it typically has a direct impact on the demand from advertisers and thus revenue for the publisher. We develop a simulation platform to evaluate the revenue impact before any changes to the pricing algorithm are launched in production system. The simulation platform is built on top of the code base of the real campaign booking system and fed with queries based on real historical bookings. It allows us to easily observe how the pricing algorithm behaves with different configuration settings and under different market conditions.

3 - Coop advertising in a supply chain with competition
Salma Karray, Faculty of business & IT, UOIT, 2000 Simcoe Street North, L1H7K4, Oshawa, Ontario, Canada, salma.karray@uoit.ca, *Saman Hassanzadeh.Amin*
We develop and solve a game-theoretic model to assess the effectiveness of cooperative advertising in coordinating the supply chain. While previous research focused mainly on bilateral channels, we consider competing retailers. Equilibrium strategies from decentralized and coordinated channels are compared. Results show the importance of accounting for competition in the channel to set pricing and cooperative advertising strategies.

4 - Multicriteria Optimization Model for Promotions Selection and Allocation
Natalia Viktorovna, SAS Institute Inc., 27513, Cary, United States, Natalia.Viktorovna@sas.com
Marketing efforts are commonly used to drive customer demand. This research focuses on modeling the selection and allocation of promotions, specifically those in retail industry (coupons, circulars, etc.) with a novel multicriteria approach, maximizing revenue and minimizing inventory simultaneously. Known algorithms as NSGA-II are then used to solve the mathematical formulation and Pareto solutions are explored further.

■ TD-48

Tuesday, 14:30-16:00
Y11-1

New Optimization Supported Methods of Data Mining with Applications to Finance

Stream: Financial Mathematics and OR
Invited session

Chair: *Ayse Özmen*, Scientific Computing, Institute of Applied Mathematics, Middle East Technical University, Kazimkarabekir Mah. 2048. Sok No:5/5, Etimesgut, 06790, Ankara, Turkey, ayseozmen19@gmail.com
Chair: *Azar Karimov*, Financial Mathematics, Institute of Applied Mathematics, Middle East Technical University, Eskishehir road, 06530, Ankara, Turkey, azer.kerimov@gmail.com

1 - Evaluating the Performance of Robust Multivariate Adaptive Regression Splines (RMARS) by Simulation and an Application in Finance under Polyhedral Uncertainty
Ayse Özmen, Scientific Computing, Institute of Applied Mathematics, Middle East Technical University, Kazimkarabekir Mah. 2048. Sok No:5/5, Etimesgut, 06790, Ankara, Turkey, ayseozmen19@gmail.com, *Gerhard-Wilhelm Weber*
MARS is a form of non-parametric regression analysis and, in recent years, applied in various areas of science, technology and finance. There, it is assumed that the input data are known exactly and equal to some nominal values to obtain a model but, in real life, both output and input data include noise. So, we involve the existence of uncertainty into MARS and robustify it through robust optimization proposed to deal with data and, hence, parametric uncertainty. We present new Robust MARS (RMARS) method in theory and show its well performance with a numerical example and simulation study.

2 - A Heuristic Approach for Solving the Prospect Theory Portfolio Optimization Problem with a Cardinality Constraint
Nina Grishina, Mathematical sciences, Brunel University, Kingston Lane, UB8 3PH, Uxbridge, Middlesex, United Kingdom, ninell5@rambler.ru, *Cormac Lucas*, *Paresh Date*, *Andrey Homchenko*
According to Prospect Theory risk is evaluated in terms of gains and losses taking into account that individuals perceive the losses and gains utility function subjectively. In our research we consider a metaheuristic approach using genetic algorithm for finding the efficient frontier for the Prospect Theory portfolio optimisation problem with cardinality constraint. This is a combinatorial optimisation problem and we will present results of model compared with classical portfolio optimisation problems such as MV, Mean-CVaR, SSD. All results will have in and out-of-sample simulations.

3 - Efficiency evaluation of mergers and acquisitions cases
Paulo Rotela Junior, IEPG - Instituto de Engenharia de Produção e Gestão, UNIFEI - Universidade Federal de Itajubá, Av. BPS, 1303, 37500-903, Itajubá, Minas Gerais, Brazil, paulo.rotela@gmail.com, *Edson Pamplona*, *Aneirson Silva*
When performing merger and acquisition (M&A), companies expect to improve its performance and achieve any type of synergy. This study evaluates the efficiency of M&A in Brazil. We used models with multiple objectives from Goal Programming and Data Envelopment Analysis (GPDEA), employing accounting indicators as input / output variables, and thus evaluated the emergence of synergy gains. It was noticed that few of the cases investigated proved to be effective. Through that application, it was possible to gain a better understanding of efficiency generation in creating synergies through M&A.

■ TD-49

Tuesday, 14:30-16:00
Y11-2

Stochastic financial modelling

Stream: Actuarial Sciences and Stochastic Calculus
Invited session

Chair: *Galina Timofeeva*, Mathematical Dept., Ural State University of Railway Transport, Kolmogorov str., 66, 620034, Yekaterinburg, Russian Federation, Gtimofeeva@mail.ru

1 - Variations on the Brownian Motion: fit for purpose approach to modelling returns distributions
Muhammad Bilal Shakeel, Business Studies, London South Bank University, 103, Borough Road, London, United Kingdom, shakeem2@lsbu.ac.uk, *Gurjeet Dhesi*
Variations of geometric Brownian motion by adding extra weighted information factors are simulated and the results compared with historic data of market indices for different countries in specific time periods. The best possible modified models are determined by the closest match to the underlying returns distribution of the historic data sets. These modified variations of random walk models with the new factors and the weights are then given interpretation. Further to this, an indication how these modified Brownian motion models change the option pricing equation is intended.

2 - The Valuation of the Interest's Derivatives under LIBOR Market Models with Jump Risks
Shih-Kuei Lin, National Chengchi University, 886, Taipei, Taiwan, square@nccu.edu.tw, *Shin-Yun Wang*
As an important economic index, interest rates are assumed to be constant in the Black and Scholes model (1973); however, they actually fluctuate due to economic factors. Using a constant interest rate to evaluate derivatives in a stochastic model will produce biased results. This research derives the LIBOR market model with jump risks, assuming that interest rates follow a continuous time path and tend to jump in response to sudden economic shocks. We then use the LIBOR model with jump risk to price a Range Accrual Interest Rate Swap (RAIRS).

3 - Estimation of risk and profitability for credit portfolio based on Markov model with incomplete information
Galina Timofeeva, Mathematical Dept., Ural State University of Railway Transport, Kolmogorov str., 66, 620034, Yekaterinburg, Russian Federation, Gtimofeeva@mail.ru

In Markov chain model a loan portfolio is divided into several groups with different quality. We use two possible approaches to define transition probability in the model with discrete time: as a relation of the number of individuals and as a relation of shares of the principal amounts. Methods for estimation the portfolio structure dynamics in case of incompletely known migration matrix are suggested. The distribution of the payment flows generated by the portfolio is analyzed. Obtained results apply to evaluate necessary reserves and to forecast profitability of the portfolio.

■ TD-50

Tuesday, 14:30-16:00
Y11-3

Topics in Production and Inventory Management

Stream: Advanced Inventory Control and Pricing Strategies
Invited session

Chair: *Yongjian Li*, Nankai University, China, liyongjian@nankai.edu.cn

1 - Optimal selling policies of a dissovable product
Xiaolin Xu, Nanjing University, China, xlxu.se@gmail.com

In this paper, we consider a dissovable product which can be decomposed into multiple parts sold through different channels. A particular part retailer has incentive to purchase that part at a wholesale price set by the dissovable product supplier who sells the left parts through spot market with an uncertain demand. We first invetigate the optimal selling strategies of the supplier under the decentralized setting. Then, we design new contractual arrangemetns between the supplier and part retailer which allows the decentralized system perform as well as the centralized one.

2 - On Core Sorting and Demand Revelation in a Stochastic Remanufacturing System
Yongjian Li, Nankai University, China, liyongjian@nankai.edu.cn, *Xiang Li*, *Xiao-qiang Cai*

This paper considers a firm that acquires cores of random quality conditions, and remanufactures them to satisfy a stochastic demand. Before the remanufacturing process, a core sorting (CS) and/or a demand revelation (DR) operation may be adopted to resolve the uncertainties in core condition and/or demand. We derive the optimal decisions on the acquisition and remanufacturing quantities, in two scenarios with respect to the cores of low quality. We conduct a numerical study, to show the effect of CS/DR.

3 - An Inventory Model with Price Fluctuations
Caner Canyakmaz, Industrial Engineering and Operations Management, Koc University, Koc University Main Campus, Engineering Building, Office No: 218, Sarıyer, Istanbul, Turkey, 34450, Istanbul, Turkey, ccanyakmaz@ku.edu.tr

We consider a single-item, single-period inventory model where unit demands for the product arrive according to a renewal process and at each arrival items are sold at the market price which follows a general stochastic process. The entire unsold inventory is salvaged at a discounted price and a physical storage cost is incurred for every unit kept in inventory. Aim is to maximize the expected discounted profit by deciding how much to order at the beginning of the selling season. Conditions on the expected price process for the existence of unique optimal solutions are investigated.

4 - Analysis of compact storage systems using autonomous vehicles
Elena Tappia, Politecnico di Milano, Italy, elena.tappia@polimi.it

In today's competitive scenario, material-handling providers are progressively developing new solutions. A relevant example is represented by compact storage system using autonomous vehicles. This research presents new analytical models based on the queuing network approach for the performance analysis of such system. The aim is twofold: first, to investigate the design trade-offs and provide important design issues to warehouse design, and second, to understand the value of this solution in comparison with alternative automated solution.

■ TD-51

Tuesday, 14:30-16:00
Y11-4

Risk Analysis and Assessment 2

Stream: Decision Making Modeling and Risk Assessment in the Financial Sector
Invited session

Chair: *Utz-Uwe Haus*, IFOR, ETH Zürich, Rämistr 101, 8092, Zürich, Switzerland, uhaus@ethz.ch

1 - The ruin probabilities of a multidimensional perturbed risk model
Tatjana Slijepcevic-Manger, Faculty of Civil Engineering, University of Zagreb, Fra Andrije Kacica-Miosica 26, 10000, Zagreb, Croatia, tmanger@grad.hr

Multidimensional models with common arrival process describe situations where each claim event usually produces more than one type of claim. One common example is natural catastrophe insurance where an accident could cause claims for different types of bodily injuries and property damages. We consider a multidimensional insurance risk model perturbed by Brownian motion. An upper bound is derived for the ruin probability of this model.

2 - Bounding Stochastic Dependence, Complete Mixability of Matrices, and Multidimensional Bottleneck Assignment Problems
Utz-Uwe Haus, IFOR, ETH Zürich, Rämistr 101, 8092, Zürich, Switzerland, uhaus@ethz.ch

A matrix is completely mixable if the entries in its columns can be permuted to attain equal row sums. If it is not completely mixable, we want to determine the smallest maximal and largest minimal row sum attainable. These provide a approximation of of minimum variance problems for discrete distributions, a problem motivated by the question how to estimate VaR of an aggregate random variable with unknown dependence structure given marginals of the constituent random variables. We relate this problem to d-dimensiuonal bottleneck assignment problems and give various complexity results.

3 - Estimation of Project Volatility in Valuing Compound Real Options
Chan Park, Industrial & Systems Engineering, Auburn University, 3301P Shelby Center, 36849, Auburn, AL, United States, parkcha@auburn.edu, *Kyongsun Kim*

Volatility estimation in compound real options is quite challenging as the value of the option depends on the values of other nested options, and each phase requires a different volatility estimate. We propose a new technique combined with a Bayesian decision framework to estimate the volatility parameters as we receive additional information in each phase of compound options. The result indicates that our procedure offers a more rigorous estimation of model inputs for real options valuation.

■ TD-52

Tuesday, 14:30-16:00
B13-1

Modelling and forecasting in Power Markets

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Carolina García-Martos*, Laboratorio de Estadística, Escuela Técnica Superior de Ingenieros Industriales, Technical University of Madrid, c/ José Gutiérrez Abascal, 2, 28006, Madrid, Spain, garcia.martos@upm.es

1 - A hierarchical state-space model for short-term forecasting of residential electricity demand
Jonathan R. Hosking, Statistical Analysis and Forecasting, IBM T. J. Watson Research Center, 10598-0218, Yorktown Heights, NY, NY, United States, hosking@us.ibm.com, *Ramesh Natarajan*, *Soumyadip Ghosh*, *Shivaram Subramanian*, *Xiaoxuan Zhang*

We describe a model of the daily load curve for electricity that includes the effects of dynamic price incentives on the demand response. The model represents the observed values of the load curve by a set of periodic smoothing-spline basis functions and incorporates mean shifts, day-of-week and holiday adjustments, and temperature effects, as well as the dynamic price incentive effects. This modeling and forecasting methodology enables modeling of intraday load substitution in response to price changes, the use of fine-grained observational data, and fast updating of model forecasts.

2 - Interrelations of wind power and spot price dynamics
Simeon Hagspiel, Institute of Energy Economics at the University of Cologne, 50827, Cologne, Germany, simeon.hagspiel@ewi.uni-koeln.de, *Christina Elberg*

We develop a stochastic simulation model that incorporates the spatial dependencies of wind power and the interrelations with spot prices. We employ a structural supply and demand based model for the electricity spot price and copulas for the spatial dependencies of wind power. The model is applied to the case of wind power participating in the German spot market. Revenue distributions and the market value of different sites are analyzed, showing the importance of the wind turbine location and the corresponding dependence structure, especially if the wind power penetration further increases.

3 - Clearing Forward Markets Based on Forecasts of Stochastic Production
Juan Miguel Morales, Applied Mathematics and Computer Science, Technical University of Denmark, 2800, Kgs. Lyngby, Denmark, jmmgo@dtu.dk, *Marco Zugno*, *Salvador Pineda*, *Pierre Pinson*

We consider an electricity market that consists of a forward (typically day-ahead) and a balancing market and that operates with a large share of non-dispatchable and uncertain generation. Furthermore, we assume that a probabilistic model describing this stochastic generation at different nodes in the network is available to the market operator. We investigate then the impact of stochastic production on market efficiency depending on the type of forecast product—expected production, optimal quantile or the full probability distribution—that is employed to clear the day-ahead market.

4 - A multivariate model for electricity, fossil fuels and emission allowances prices and their volatilities
Carolina García-Martos, Laboratorio de Estadística, Escuela Técnica Superior de Ingenieros Industriales, Technical University of Madrid, c/ José Gutiérrez Abascal, 2, 28006, Madrid, Spain, garcia.martos@upm.es, *Julio Rodriguez*, *Maria Jesus Sanchez*

This paper is a starting point for risk management and portfolio optimization under uncertainty in the current context of energy markets. A first step consists of developing efficient forecasting tools. We focus on building a multivariate model for CO2, fossil fuels and electricity prices. An univariate model is also used as a benchmark. Besides, common features are extracted from the volatilities of all these series by means of a Conditionally Heteroskedastic Dynamic Factor Model, which allows to tackle the estimation problems that commonly arise when estimating multivariate GARCH models.

■ TD-53

Tuesday, 14:30-16:00
B13-2

Market Design and Renewable Energy

Stream: Stochastic Modeling in Energy Planning
Invited session

Chair: *Michael Coulon*, ORFE, Princeton University, 117 Sherrerd Hall, 08544, Princeton, New Jersey, United States, mcoulon@princeton.edu

1 - Transmission planning keeping reserves for wind power production
Enzo Sauma, Industrial and Systems Engineering Department, Pontificia Universidad Catolica de Chile, Vicuña Mackenna 4860, Macul, 00001, Santiago, Chile, esauma@ing.puc.cl, *Cristobal Muñoz*, *Javier Contreras*, *Jose Aguado*, *Sebastián De La Torre*

Wind power presents some special features, such as the variability and intermittent availability of the resource, which may affect the coordination of power markets. In this case, additional reserves are required for the secure market operation. Accordingly, variations in wind output can often be compensated for by adjusting the outputs of partially dispatched conventional generators. However, there is an opportunity cost associated. We propose a methodology for transmission planning that incorporates the costs and the uncertainty associated to the operation of wind power plants.

2 - On the problem of investment in SREC markets
Javad Khazaei, Operations Research and Financial Engineering, Princeton University, Sherrerd Hall, Charlton St.,, 08540, Princeton, New Jersey, United States, jkhazaei@princeton.edu, *Michael Coulon*, *Warren Powell*

SREC market prices have been proven to be extremely volatile in the past few years. This has caused higher risk and less investment in solar power generation. We propose an original SREC price model, and provide a dynamic programming solution algorithm. Our model includes a feedback mechanism for generation response to market prices. Finally, after calibrating our model to reproduce historical prices, we analyse and propose alternative market mechanisms capable of improving market performance.

3 - Cap-and-trade markets for emissions: price modeling and impact on power plant valuation and growth of renewables
Michael Coulon, ORFE, Princeton University, 117 Sherrerd Hall, 08544, Princeton, New Jersey, United States, mcoulon@princeton.edu

Putting a price on CO2 through cap-and-trade is an important policy tool among others that can help encourage the growth of renewables. However, the success of a carbon market is highly dependent on both market design and underlying fuel mix for electricity generation. We build a structural model for both power and carbon prices, capturing important feedback relationships between carbon price, merit order and emissions rate. We then investigate the implications of cap-and-trade markets on the long-term profitability of both fossil fuel plants and on the growing presence of renewables.

4 - Managing wind parks: the importance of high resolution weather forecasts and the impact of penalties on uncertain day-ahead production
Christian Jacobsson, Alpiq, Switzerland, christian.jacobsson@alpiq.com

We investigate the challenges of wind park operation via a case study of the Ramacca wind park in Sicily. Since 1:st of January 2013, delivering more/less power than offered day-ahead is being penalized. The

importance of good wind power forecasts is therefore crucial. This analysis shows the benefit of using high resolution weather models as well as mapping weather forecasts to individual turbine hub levels. It also discusses the need to optimize the bidding strategy conditioned on wind and price uncertainty, and possibilities to use flexible storage capacity.

■ TD-54

Tuesday, 14:30-16:00
B14-1

Mathematical Optimisation in Power Systems III

Stream: Energy, Environment and Climate
Invited session

Chair: *Nikita Zhivotovskiy*, Faculty of Control and Applied Mathematics, Moscow Institute of Physics and Technology, Russian Federation, nikita.zhivotovskiy@phystech.edu
Chair: *Maria Teresa Vespucci*, Dept. of Management, Economics and Quantitative Methods, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, maria-teresa.vespucci@unibg.it

1 - A hybrid approach for Fault Rush Repair Scheduling Problem in Distribution Grid

Wei Wu, Energy & Utility, IBM China Research Lab., 399 keyuan road, pudong district, 201203, shanghai, China, wuweish@cn.ibm.com, *Feng Jin*, *Wen Jun Yin*, *Xin Jie Lv*, *Zhi Bo Zhu*

Fault Rush Repair Problem in distribution grid has become very important in today's Power Company. In this paper, we firstly formulate the Fault Rush Repair Scheduling (FRRS) problem analyzing scheduling strategy of repair team. Based on the model for FRRS problem, we present a hybrid approach via Nested Partitions to solve it. The FRRS problem is consider as a partition tree. And heuristic strategy is incorporated into the sampling procedure, and uses the sample points to estimate the promising index of each region. Numerical examples are also presented to illustrate the hybrid approach.

2 - Optimizing consecutive nuclear reactor cycles

Roman Cada, Department of Mathematics, University of West Bohemia, Czech Republic, cadar@kma.zcu.cz

Nuclear fuel is depleted during a nuclear reactor cycle. Before starting a new cycle a portion of burned up fuel assemblies must be replaced by fresh ones. The task is then to find a suitable location of each fuel assembly in the zone.

Besides most important safety criterions, economy of energy production and cost of new fuel is worth to optimize.

We present methodology and mathematical methods related to this kind of optimization with respect to optimization of several consecutive fuel cycles. Results of a respective code tau-Athena will be presented.

3 - A branch-and-cut algorithm for the switch allocation problem

Fábio Usberti, DENSIS, Universidade Estadual de Campinas, Av. Albert Einstein, 400, 13083-852 , Campinas, SP, Brazil, fusberti@yahoo.com, *Celso Cavellucci*, *Christiano Lyra*, *José Federico Vizcaino*, *Laura Assis*

The switch allocation problem has the objective to determine the optimal amount and locations of sectionalizing switches in a primary distribution network. The role of sectionalizers is to enable the network reconfiguration in order to isolate faults. The solution has the potential to increase the overall system reliability and power efficiency. This talk discusses a flow-based mixed integer linear programming model to the switch allocation problem. Strong valid inequalities are embedded within a branch-and-cut framework. Case studies are discussed using real-life distribution networks.

4 - Structure of near optimal policies for calling energy contracts

Sriram Dasu, University of Southern California, Los Angeles, CA, United States, dasu@marshall.usc.edu, *Reza Ahmadi*, *Thomas Roemer*

One approach for controlling peak loads is to enroll customers in programs in which they get energy at a discounted price provided they lower their consumption during peak periods. These contracts have a number of constraints in terms of the number of calls per year and the duration of each call. Each day the supplier has to determine how many customers to call and the time over which these customers have to shed load. The problem is NP-hard. We identify a sub-set of problems that have a nice structure and for the others we identify near optimal policies.

■ TD-55

Tuesday, 14:30-16:00
B14-2

Decision Making and Decision Support Systems II

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Evangelos Grigoroudis*, Decision Support Systems Laboratory, Technical University of Crete, University Campus, Kounoupidiana, 73100, Chania, Greece, vangelis@ergasya.tuc.gr
Chair: *Mikhail Kuznetsov*, Moscow Institute of Physics and Technology, Russian Federation, mikhail.kuznecov@phystech.edu

1 - Integrated facility location and network design for bioenergy villages

Ingo Karschin, Chair of Production & Logistics, University Göttingen, Platz der Göttinger Sieben 3, 37073, Göttingen, Germany, ikarsch@gwdg.de

Bioenergy villages offer cutting-edge solutions to the question of how to supply a community with energy independent of external resources. The planning of bioenergy villages using biomass as main source of electricity and heat calls for the simultaneous consideration of facility location, capacity planning, and network design for the heating grid. A linear mathematical model is presented, that economically optimizes the local bioenergy production and distribution system and considers various parameters such as biomass availability, the number of heat customers, or heat loss in the system.

2 - Modeling additional preferences in the MUSA method: An improved robust approach

Evangelos Grigoroudis, Decision Support Systems Laboratory, Technical University of Crete, University Campus, Kounoupidiana, 73100, Chania, Greece, vangelis@ergasya.tuc.gr

The MUSA method is a collective preference disaggregation approach following the main principles of ordinal regression analysis. This study presents extensions of the method, which include additional DMs' preferences or desired properties of the inferred preference system. For example, additional preferences about the importance of the criteria are presented and additional constraints regarding special properties of the assessed model variables are discussed. The main aim of the study is to present an alternative approach that improves the robustness of the MUSA method.

3 - A Decision Support Tool for Multi-Objective Integer and Mixed-Integer Programming

Rui Borges Lopes, Dep. of Economics, Management and Industrial Engineering, CIO / University of Aveiro, Campus Universitário de Santiago, 3810-143, Aveiro, Portugal, rui.borges@ua.pt, *Carlos Ferreira*, *Beatriz Sousa Santos*

An interactive method following an open communication protocol for multi-objective integer and mixed-integer programming was recently

proposed. In each step of the human/computer dialogue, the decision maker is to provide the sub regions where to continue the search for non-dominated solutions. To test the applicability and easiness of the method, it was implemented in a decision support tool, able to interact with commercial solvers. The developed tool, and some examples, will be presented and discussed.

4 - Decision maker's preference model underlying TOPSIS method
Dmitry Podkopaev, Dept. of Mathematical Information Technology, University of Jyväskylä, P.O. Box 35 (Agora), FI-40014, University of Jyväskylä, Finland, dmitry.podkopaev@jyu.fi, *Ignacy Kaliszewski*, *Hsu-Shih Shih*, *Yuan-Sheng Lee*

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a practical MCDM method developed for (but not limited to) problems with explicitly given alternatives. Despite hundreds of reported applications in business and management, there are no studies of the preference model underlying TOPSIS. We characterize the order of alternatives imposed by TOPSIS in terms of Decision Maker's preferences in order to increase its transparency for customers and contribute to addressing the issue of MCDM method selection.

■ TD-56

Tuesday, 14:30-16:00
B15-3

Chemical Production Scheduling

Stream: OR Applications in Industry
Invited session

Chair: *Christos Maravelias*, Univeristy of Wisconsin - Madison, United States, maravelias@wisc.edu

1 - A framework for multi-parametric programming based pro-active scheduling
Efstratios Pistikopoulos, Chemical Engineering and Chemical Technology, Imperial College London, SW72AZ, London, United Kingdom, e.pistikopoulos@imperial.ac.uk, *Martina Wittmann-Hohlbein*

We address short-term batch process scheduling under uncertainty. A pro-active scheduling policy is obtained by solving the partially robust counterpart scheduling formulation. The counterpart model remains a multi-parametric problem, yet it is immunized against uncertainty in the entries of the constraint matrix and against parameters whose values are not available at the time of decision making. The parametric solution provides a valuable insight into the scheduling process and the anticipated schedule is readily obtained via function evaluation from the profiles stored in the look-up table.

2 - Integrated Production Planning and Product Pricing under Uncertainty in the Process Industry
Songsong Liu, Department of Chemical Engineering, University College London, WC1E 7JE, London, United Kingdom, s.liu@ucl.ac.uk, *Nilay Shah*, *Lazaros Papageorgiou*

This work addresses an integrated production planning and product pricing problem for a supply chain network in the process industry under demand uncertainty. Here, the production sequence-dependent changeovers are considered, as well as the price elasticity of demand at the markets. A mixed-integer programming-based optimization framework is developed, and model predictive control (MPC) approach is adopted to tackle the uncertain issues, as well as the inventory and price maintenance. The applicability of the proposed approach is illustrated by solving a supply chain example.

3 - Production Planning with Increasing Byproducts. MINLP Formulations and MILP Approximations.
Jeff Linderoth, University of Wisconsin-Madison, 1513 University Avenue, 3226 Mechanical Engineering Building, 53706-1572, Madison, Wisconsin, United States, linderoth@wisc.edu

We study a production planning problem where production creates both desirable products and undesirable byproducts, and where the fraction of production that is a byproduct increases as a function of the total cumulative product produced. A natural discrete-time formulation of this model is a mixed-integer nonlinear program with nonconvex nonlinear constraints. We introduce an alternative formulation that is both more accurate and easier to solve, and we describe piecewise-linear relaxations and approximations for this new formulation.

4 - Valid Inequalities Based on Demand Propagation for Chemical Production Scheduling MIP Models
Sara Velez, Univeristy of Wisconsin - Madison, 53706, Madison, United States, szenner@wisc.edu, *Christos Maravelias*

While several MIP models have been proposed for the scheduling of chemical manufacturing facilities, the development of solution methods has received limited attention. In this talk, we develop a constraint propagation algorithm for the calculation of lower bounds on the number and size of tasks necessary to satisfy demand. These bounds are used to express four types of valid inequalities which lead to computational enhancements of 3-4 orders of magnitude for a wide range of MIP scheduling models.

■ TD-57

Tuesday, 14:30-16:00
B15-4

Pricing

Stream: Operations/Marketing Interface
Invited session

Chair: *Tolga Aydinliyim*, Decision Sciences, University of Oregon Lundquist College of Business, 97403, Eugene, OR, United States, tolga@uoregon.edu
Chair: *Mehmet Altug*, Decision Sciences, George Washington University, 2201 G. Street, NW, Funger Hall 415P, 20052, Washington, DC, United States, maltug@gwu.edu

1 - Optimal Timing for a Newsvendor Problem with In-season Price Adjustment
Piotr Staliński, Department of Quantitative Methods in Management, WSB-NLU, ul. Zielona 27, 33-300, Nowy Sącz, Poland, piotr_stalinski@yahoo.com, *Chia-Shin Chung*

We investigate a single period inventory-pricing problem. The demand for the product is uncertain and multiplicative with constant price elasticity. We assume there exists a single opportunity to adjust the price during the season, as demand is observed. The key decision variables are the optimal timing and the optimal pricing of the in-season price-adjustment. The objective is to maximize the expected profits. We propose an efficient heuristic for finding the optimal timing of the price adjustment.

2 - Retail pricing and promotion design through customer segmentation
Pavankumar Murali, IBM Research, 1101 Kitchawan Road, 04-024, 10598, Yorktown Heights, NY, United States, pavanm@us.ibm.com, *Wei Sun*, *Anshul Sheopuri*

A new challenge retailers confront today is to incorporate new sources of data, such as clicks history, social media etc., to design effective marketing campaigns. We address this problem as a two step procedure. First, using the offline and online activity of a customer, we estimate her lifetime value along 3 dimensions — loyalty, revenue potential and network influence, and use this for enhanced targeting. Next, we predict the customer's response towards different campaigns by incorporating her lifetime value to determine targeted campaigns that maximize the firm's objective.

3 - Chasing Demand: Pricing and Learning in a Changing Environment
Bora Keskin, The University of Chicago Booth School of Business, United States, bora.keskin@chicagobooth.edu, *Assaf Zeevi*

Pricing of financial products in consumer lending involves a tradeoff between learning about customers' price sensitivity, and earning short-term revenues. A key issue in this context is the "perishability' of useful sales data, primarily due to changes in the demand environment. Motivated by such applications, we consider a dynamic pricing problem in which a seller faces an unknown demand model that can change over time. We design an asymptotically optimal pricing policy, and derive performance bounds to quantify the net effect of a changing demand environment on the seller's revenue.

■ TD-58

Tuesday, 14:30-16:00
B15-6

Real Implementation Optimization 1

Stream: OR and Real Implementations
Invited session

Chair: *Ben Lev*, Decision Sciences, Drexel University, LeBow College of Business, 101 N. 33rd st., 19104, Philadelphia, Pa, United States, blev@drexel.edu

1 - LocalSolver: toward a full mathematical programming solver based on local search
Frédéric Gardi, LocalSolver, 24 avenue Hoche, 75008, PARIS, France, fgardi@localsolver.com, *Thierry Benoist*, *Julien Darlay*, *Bertrand Estellon*, *Romain Megel*

Started in 2007 as a pure R&D project, LocalSolver has revealed the power of pure and direct local search for large-scale 0-1 nonlinear programming. A commercial version of LocalSolver was launched in 2012, while the product remains free at localsolver.com for academics. LocalSolver primarily relies on fast local moves tending to maintain the feasibility of the incumbent. Here we outline our current works to extend this technique for continuous or mixed-variable optimization. More generally, we present the roadmap of the LocalSolver project, toward an all-in-one math programming solver.

2 - Finding Good Feasible Solutions for Large MIP Model Instances Using MIP Solver Engines
Hermann Stolle, SWG, IBM Deutschland, Wilhelm-Fay-Str. 30-34, 65396, Frankfurt am Main, Hessia, Germany, commh22s@arcor.de

Many practicle optimization problems at commercial companies can often concisely formulated as mixed integer program (MIP). However the respective instances in whole often become too large to be solved in reasonable run times or to even fit into the machine memory. In this talk we illustrate this situation with MIP formulations derived from industry project situations and illustrate divide and conquer strategies applied in order to find good feasible solutions with subproblems formulated as mixed integer programs.

3 - In-depth features of the CPLEX Optimization Studio IDE
Frederic Delhoume, IBM, 9 Rue de Verdun, 94253, Gentilly, France, delhoume@fr.ibm.com

We will present many features that allow CPLEX Optimization Studio IDE users to accelerate their model development. Tips and tricks will be presented, related to editing models, viewing results, debugging and writing custom scripting code, profiling. This presentation will also introduce the Eclipse environment CPLEX Optimization Studio is based on.

4 - Creating your own optimization app store
Guido Diepen, AIMMS, Schipholweg 1, 2034 LS, Haarlem, Netherlands, Guido.Diepen@AIMMS.com

We all know how apps can make our lives easier and more enjoyable, but have you ever dreamed of having your own optimization app store? With our AIMMS PRO platform you can give every user in your organization quick and easy access to your optimization models.

I will show you how simple it is to build and deploy your own AIMMS optimization model in our AIMMS PRO platform (the app store) and how easy it is for users to access those optimization models - including using the GUI for various what-if analysis.

■ TD-59

Tuesday, 14:30-16:00
B15-5

Credit Scoring and Business Analytics for Finance

Stream: Business Analytics and Intelligent Optimization
Invited session

Chair: *Cristian Bravo*, Department of Industrial Engineering, University of Chile, Republica 701, Santiago, 8370439, Santiago, Chile, cbravo@dii.uchile.cl
Chair: *Vadim Strijov*, Russian Academy of Sciences, Computing Center, Vavilova 42-268, 119333, Moscow, Russia, Russian Federation, strijov@ccas.ru

1 - Estimation of Credit Card Exposure at Default using a Two Step Mixture Model
Jonathan Crook, University of Edinburgh Business School, University of Edinburgh, Credit Research Centre, 50 George Square, EH8 9AL, Edinburgh, Lothian, United Kingdom, jonathan.crook@ed.ac.uk, *Mindy Leow*

Using a large portfolio of defaulted loans we estimate EAD at the level of obligors by estimating the outstanding balance of an account, not only for the account at the time of default, but at any time over the entire loan period. We use a two-step mixture model. We find that we are able to get good predictions for outstanding balance which would allow us to make predictions for outstanding balance and hence EAD before default occurs, for delinquent accounts.

2 - Credit Scorecard Development: Model Generation and Multimodel Selection
Vadim Strijov, Russian Academy of Sciences, Computing Center, Vavilova 42-268, 119333, Moscow, Russia, Russian Federation, strijov@ccas.ru

The talk is devoted to the automatic model generation for application scoring. According to the bank requirements a scorecard consists of a combination of the logistic regression models. We will discuss the following problems: First, how many models we must generate? Second, which model from the generated model set should be used to compute the probability of default for a newcomer client? Third, what features must be selected for the models? These problems must be resolved to develop a precise, stable and simple scorecard.

3 - Controlling Dataset Shift in Credit Scoring using Model-Dependent Tests
Cristian Bravo, Department of Industrial Engineering, University of Chile, Republica 701, Santiago, 8370439, Santiago, Chile, cbravo@dii.uchile.cl, *Sebastian Maldonado*

Most real-world domains deal with the major changes that may occur after the development of a predictive model. This work shows a novel methodology to detect dataset shift in sets used for logistic regression based predictive modelling. The main difference compared to existing approaches is the use of the estimated coefficients to construct a statistical measure that identifies when predictors are shifting. We provide experimental results using credit scoring datasets, assessing the proposed method's effectiveness and gaining insight of the underlying process that generates the data.

■ TD-60

Tuesday, 14:30-16:00
B15-7

Data Mining in Early Warning Systems 4

Stream: Data Mining in Early Warning Systems
Invited session

Chair: *Inci Batmaz*, Department of Statistics, Middle East Technical University, 6531, Ankara, Turkey, ibatmaz@metu.edu.tr
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Semih Kuter*, Department of Forest Engineering, Cankiri Karatekin University, Cankiri Karatekin Universitesi, Orman Fakultesi, 18200, Cankiri, Turkey, semihkuter@yahoo.com

1 - Modelling the Extreme Precipitation Data: Case Study from Turkey
Büşra Aksoy, Statistics, METU, ANKARA, Turkey, e142582@metu.edu.tr, *Vilda Purutcuoglu*, *Inci Batmaz*, *Ceylan Yozgatligil*

The droughts and extreme precipitations are two major indications of climate changes. Here we analyze the extreme precipitation of the Turkish meteorological dataset of East Black Sea Region from 1950 to 2010 in junction with temperature with 7 categories. In the analysis we aim to model this set via time series regression and MARS methods and check the bestfitted model under certain model selection criteria.These outcomes can be helpful to construct a base for a comprehensive modeling of this type of data in Turkey and develop early warning system to prevent floods in the selected region.

2 - Cross-Selling Models for Private Banking — Which data are useful?
Ozden Gur Ali, Business Administration, Koc University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, oali@ku.edu.tr, *Haldun Aytug*, *Mehmet Hamdi Ozcelik*

Before suggesting an investment product to the customer, the banker has to consider the customer's willingness to add the product to her portfolio. Unlike consumer products where taste is the major driver, customer's willingness to invest in financial products depends on her evolving financial savvy and risk tolerance. Further, perceptions of financial products vary with the economic conditions. Working with a large private banking customer dataset, we compare sets of input variables in terms of key elements to implementation success: their predictive performance, simplicity and insights.

3 - Customers Walking Patterns and Influence on Their Shopping Behavior
Marina Kholod, College of Business Administration, Ritsumeikan University, Japan, marina@fc.ritsumei.ac.jp

In recent years the advancement of RFID (Radio Frequency Identification) technology allowed to track the movements of customers within the shopping environment.In this paper we use the concept of deviations from the shopping path, proposed by Hui et al. (2009) in order to classify basket sizes of the consumers with the purpose to examine the influence of their moving patterns on their shopping behavior. We also test several hypotheses and basing on the results, suggest managerial implications.

4 - The Use of a Memetic Algorithm at the Evacuation Plan Design
Lubomir Toman, Department of Transportation Networks, Faculty of Management Science and Informatics, University of Zilina, Univerzitna 8215/1, 01026, Zilina, Slovakia, Slovakia, lubomir.toman@fri.uniza.sk

This paper deals with the vehicle assignment problem which is solved at a design of an evacuation plan. This combinatorial problem is hard to solve but it has to be solved in a short computational time in order to the evacuation plan can be completed promptly. We propose to use a memetic algorithm to solve this problem. The proposed algorithm is an extension of a genetic algorithm by a local optimization which is done using a variable neighbourhood search method. Hereby, we study an impact of the proposed algorithm on a quality of the evacuation plan.

■ TD-62

Tuesday, 14:30-16:00
R18-1

MINLP emerging methods and applications II

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Sonia Cafieri*, Lab. MAIAA, Dept. de Mathematiques et Informatique, Ecole Nationale d'Aviation Civile, 7 Ave. Edouard Belin, 31055, Toulouse, France, sonia.cafieri@enac.fr

1 - Exact and Heuristic Approaches for Directional Sensor Control
Domenico Salvagnin, DEI, University of Padova, Italy, dominiqs@gmail.com, *Hans Mittelmann*

The Directional Sensor Control problem (DSCP) [1] consists in assigning a direction of view to each sensor with the goal of maximizing information gain on the location of a given set of target objects. In this paper we study and computationally evaluate exact and approximate approaches for the DSCP. In particular, we propose an exact mixed integer convex programming (MICP) formulation and several metaheuristic approaches.

[1] Ragi, Chong, Mittelmann, Directional Sensor Control for Maximizing Information Gain, Proceedings of Signal and Data Processing of Small Targets 2013

2 - MINLP in satellite communication
Frederic Messine, ENSEEIHT-IRIT, 2 rue Camichel, 31000, TOULOUSE, France, France, Frederic.Messine@n7.fr, *Christian Artigues*, *Laurent Houssin*

In satellite communication, Spatial DivisionMultiple Access is one of the most promising techniques. It relies on adaptive and dynamic beam-forming technology and well-designed algorithms for resource allocation among which frequency assignment is considered. This work studies static Frequency Assignment Problem in a satellite communication system involving a satellite and some users located in a area. The number of users that the system can serve while maintaining the signal to interference plus noise ratio has to be maximized. The problem is a MINLP that we solve using ILP and NLP methods.

3 - Optimal Design of Electrical Machines: Mathematical Programming Formulations
Sonia Cafieri, Lab. MAIAA, Dept. de Mathematiques et Informatique, Ecole Nationale d'Aviation Civile, 7 Ave. Edouard Belin, 31055, Toulouse, France, sonia.cafieri@enac.fr, *Frederic Messine*

The optimal design of electrical machines can be mathematically modeled as a MINLP problem. We investigate the impact of different mathematical formulations on the results obtained using a local and global optimization solvers (MatLab's fmincon function, COUENNE and IBBA). Our analysis is based on further different mathematically equivalent formulations for the same problem of the design of an electrical machine without slot. Our results underline the important impact that formulation differences may have on solver performance even on small examples of design.

■ TD-63

Tuesday, 14:30-16:00
R18-2

Cognitive Approach in Control Sciences II

Stream: Operational Research and Control Problems
Invited session

Chair: *Nina Abramova*, Lab of Cognitive Modelling and Situation Control, Institute of Control Sciences, 65 Profsoyuznaya Street, Moscow GSP-4, Russia, 117997 , Moscow, Russian Federation, abramova@ipu.ru

1 - A Cognitive Analysis Based Approach for Small Research Groups Management
Liliya Mukhamedrakhimova, Informatics and Robotics, Ufa State Aviation Technical University, 450000, Ufa, Bashkortostan, Russian Federation, Liliya.Muhamedrahimova@gmail.com, *Ilmira Gerasimova*, *Bary Ilyasov*

We consider the problem of small research groups (SRG) management. SRG is represented as a system of the triad of concepts: scientific supervisors, scientists, and the project manager. The SRG's goal consist in collective maintenance of a certain high rate of project implementation, which can be reached due to self-organization of systems active elements. We propose the approach based on the analysis of nonlinear cognitive-dynamic models. The paper provides examples of the study of SRG complex structures differing in self-organization algorithms and forms of relationships between concepts.

2 - The role of XOR and Equivalence operators in Non-Exact Concept Learning
Ilya Levin, School of Education, Tel Aviv University, Ramat Aviv, 69978, Tel Aviv, Israel, ilia1@post.tau.ac.il

A novel approach to understanding subjective concept complexity considers Concepts learning as a non-exact process is proposed. Our approach studies the humans' approximation mechanism of Non-exact learning, and trace back learned concepts to their Boolean properties — properties recognized from the algebraic and engineering study of Boolean Functions. Our findings indicate that Equivalence and XOR operators are of unique importance regarding Human concept learning. A key process in Non-exact modeling is finding XOR or Equivalence relations between variables, making them highly correlated.

3 - Applying OR tools to study team cognition
Sara McComb, Purdue University, United States, sara@purdue.edu, *Deanna Kennedy*

Converged mental model content is related to team performance based on data collected after teams complete a task. We examine the convergence process during teamwork via team communication, as it may better inform performance differences across teams. To that end, we (1) examine the mental model convergence process over time using survival analysis, (2) develop a computational model of team communication, (3) employ a genetic algorithm to identify the optimal convergence process, and (4) conduct simulated experiments to ascertain interventions that may enhance team performance.

4 - On models to analyze validity of expert estimation of influences weights in cognitive mapping
Tatyana Telitsyna, Laboratory of Cognitive modelling and management of development of situations, Institute of Control Sciences V. A. Trapeznikov Academy of Sciences, Russian Federation, tanyaudsu@yandex.ru

The problem of validity of expert estimates on prescribed universal scales is raised. The conceptual vagueness of expert knowledge on situations for their cognitive mapping is supposed to be the main factor of risk to validity. It is assumed that the most risky type of estimated variables in cognitive maps is the weight of influences. To analyze validity of estimation of weights the models of conceptual interpretation of prescribed universal scales is proposed. The effect of different types of conceptual vagueness on validity of estimation of weights is explained in terms of these models.

■ TD-64

Tuesday, 14:30-16:00
R18-3

Algorithms and Applications

Stream: Algorithm and Computational Design
Invited session

Chair: *Basak Akteke-Ozturk*, Department of Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, bozturk@metu.edu.tr
Chair: *Haldun Sural*, Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, sural@ie.metu.edu.tr

1 - A branch and bound algorithm for marker-assisted gene pyramiding
Herman De Beukelaer, Applied Mathematics and Computer Science, Ghent University, Krijgslaan 281 - S9, 9000, Gent, Belgium, Herman.DeBeukelaer@UGent.be, *Veerle Fack*

We present a flexible, heuristic branch and bound algorithm for the gene pyramiding problem, which consists of creating efficient crossing schedules that combine genes from several plants in one single new individual, through selection and crossing. Such crossing schedules can be modelled as directed acyclic graphs (DAGs) connecting parents with their children, where children are labeled with the number of seeds required to obtain this specific plant among the offspring. The goal is to construct such DAGs with minimum depth (number of generations) and minimal total number of required seeds.

2 - Solving aggregated formulations to optimality
Mette Gamst, DTU Management Engineering, Technical University of Denmark, Produktionstorvet 426, DK-2800, Kgs. Lyngby, Denmark, mega@dtu.dk, *Simon Spoorendonk*, *Stefan Ropke*

Aggregating formulations is a powerful approach for problems to take on tractable forms. Aggregation may lead to loss of information, i.e. the aggregated formulation may be an approximation of the original problem. In branch-and-bound context, aggregation can also complicate branching, e.g. when optimality cannot be guaranteed by branching on aggregated variables. We present a generic exact solution method to remedy the drawbacks of aggregation. It combines the original and aggregated formulations and applies Benders' decomposition. We apply the method to well-known optimization problems.

3 - A methodology to produce algorithms for combinatorial optimization problems.
Víctor Parada, Universidad de Santiago de Chile, 8320000, Santiago, Chile, victor.parada@usach.cl

This presentation describes a methodology for automatically producing algorithms that solve combinatorial optimization problems. The procedure consists of several stages which reflect the typical applications of genetic programming. Algorithms are produced by combining both well known heuristics for each problem and elemental components of a potential algorithm. Examples are presented for different cases.

4 - A hybridization of artificial bee colony and gravitational search algorithms for nonlinear global optimization
Mustafa Servet Kıran, Computer Engineering, Science, 42075, Konya, Turkey, mskiran@selcuk.edu.tr, *Mesut Gündüz*, *Hüseyin Haklı*, *Mehmet Akif Sahman*

The exploration and exploitation for heuristic methods are important in solving the continuous optimization problems.While artificial bee colony (ABC) algorithm has capable in exploration but poor in exploitation,gravitational search algorithm (GSA) has good exploitation ability but poor exploration ability.Therefore, a recombination-based hybridization of GSA and ABC (ABCGSA) is proposed in this study. ABCGSA is applied to solve numeric functions,and results of ABCGSA are compared with results of ABC and GSA.The experiments show that ABCGSA is an alternative solver for continuous optimization

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■ TD-65

Tuesday, 14:30-16:00
R18-5

Challenge EURO/ROADEF - Presentation 1

Stream: Challenge EURO/ROADEF
Invited session

Chair: *Eric Bourreau*, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr

1 - 2014 ROADEF/EURO Challenge start : Trains don't vanish !
Eric Bourreau, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr, *Christian Artigues*, *Safia Kedad-Sidhoum*, *Vincent Jost*, *François Ramond*

This challenge is an international contest aiming at solving an industrial optimization problem. Between duties, trains never vanish. Unfortunately, this aspect is often neglected in railway optimization approaches. In the past, rail networks had enough capacity to handle all trains without much trouble but this is not true anymore. This challenge propose by SNCF, the French railway company, consists in finding the best way to handle trains between their commercial duties, including temporary parking, shuntings on railway infrastructure facilities, using different storage facilities and tracks

■ TD-66

Tuesday, 14:30-16:00
R18-4

Optimization for Sustainable Development II

Stream: Optimization for Sustainable Development
Invited session

Chair: *Herman Mawengkang*, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, mawengkang@usu.ac.id
Chair: *Azizah Hanim Nasution*, Graduate School of Natural Resources and Environment Management, University of Sumatera Utara, Indonesia, nazizahhanim@yahoo.com

1 - Optimization of selecting control strategy in life system approach
Martina Restuati, Biology, University Negeri Medan/Grad. School of Biology USU, Fmipa usu, 20155, Medan, Indonesia, mrestuati@yahoo.com, *Melva Silitonga*, *Herman Mawengkang*

A life system concept can be regarded as a theoritical base for system's approach to population ecology. There are two different aspects of regulation in population should be considered, i.e., m- and v- stability. The quantitative characteristics of population dynamics' pattern which is depend on the structure of the life system is explored in this paper. Then we propose an optimization model for selecting the control strategy considering environmental uncertainty.

2 - A Sustainable Forest Management Optimization Model to Preserve Water Allocation for Hydroelectric Power Plant
Nurlely Aman, Grad. School of Env. Manag. Univ. Sumatera Utara, Fmipa usu, 20155, Medan, Indonesia, nurlelyaman@yahoo.com, *Herman Mawengkang*

Forest management is challenged today to better integrate ecological, economic, and social objectives. One of the main function of forests is as a media of water preservation for rivers to be used as a resource of a hydroelectric power plant. Other objectives of economic and silvicultural nature of forestry should be taken into account in developing the forest management planning. This paper proposes a goal programming approach to model the forest management planning in which several objectives have to be met. The model is applied to the forest in North Sumatra province of Indonesia

3 - An integrated optimization model for river water quality to estimate wastewater removal efficiencies
Syafari Syafari, Mathematics, University Negeri Medan, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, syafari79@yahoo.com

River water quality is affected by both point and diffuse sources of pollution. Point sources of pollution include domestic or industrial discharges via pipe connections to the river system, whereas diffuse sources of pollution include runoff from the agricultural land and mining sites. In this paper dynamic integrated modelling of basic water quality and organic contaminant fate and effect in rivers are explored. A basic river water quality model and organic contaminant submodel were developed and then linked in order to estimate the wastewater removal efficiencies for discharge site.

4 - An optimization model for logistic system and waste management in crude palm oil industry
Meslin Silalahi, Mathematics, University of Sisingamangaraja-Tapanuli/Grad School of Mathematics USU, FMIPA USU, 20155, Medan, North Sumatera Province, Indonesia, meslin_silalahi@yahoo.com

The crude palm oil industry IS an agro-industrial commodity which has a strategic value to be developed for Indonesian economy. However, there are a number of environmental problems at the factories, such as high water consumption, the generation of a large amount of wastewater with a high organic content, and the generation of a large quantity of solid wastes and air pollution. We include constraints involving random parameters of waste. In this paper we propose a multi-objective stochastic optimization model for tackling logistics and environmental risk production planning problem.

■ TD-67

Tuesday, 14:30-16:00
R19-1

EURO Journal on Transportation and Logistics

Stream: Journals
Sponsor session

Chair: *Michel Bierlaire*, ENAC INTER TRANSP-OR, École Polytechnique Fédérale de Lausanne (EPFL), GC B3 444 (Bâtiment GC), Station 18, CH-1015, Lausanne, Switzerland, michel.bierlaire@epfl.ch

■ TD-68

Tuesday, 14:30-16:00
R19-2

Modeling Sustainable Systems I

Stream: Sustainable Development Modeling with System Dynamics
Invited session

Chair: *Francois Guerrin*, UPR Recyclage & Risque, Inra & Cirad, Avenue Agropolis, TA B-78/01, 34398, Montpellier Cedex 5, France, francois.guerrin@cirad.fr

1 - Construction of a chilean energy matrix portraying interfuel substitution, a system dynamics approach
Carla Carolina Rúa Gómez, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia, ccrua@unal.edu.co, *Santiago Arango*

In this paper we model the evolution of Chile's energy matrix using a behavioral simulation model, the model was developed and calibrated considering a dynamic adjustment of interfuel substitution. Simulations reveal that the country needs to diversify its energy matrix given its heavy dependence on external supply, the rapid economic growth, the scarcity of natural resources. This energy matrix model supports the decision making processes, because it can reproduce the behavior of a particular country or region over the time and includes key factors such as equilibrium and instabilities.

2 - Simulation of a geological repository for high-level radioactive waste
Pierre Kunsch, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, pkunsch@vub.ac.be

Since the beginning of the electronuclear industry there was a growing concern for developing safe designs for disposing off high-level radioactive waste in geological layers. The planning of such project is still today a complex task because of limited or absent operational data. This article presents a simulation model developed with system dynamics and fuzzy logic as a project planning support system for such repositories. It takes into account uncertainties and risk factors on costs and schedule to establish global costs, planning and financing according to the polluter pays principle.

3 - A Holistic Model for Analyzing Sustainable Business Policies for Shared Partners in a Supply Chain
Jose Cruz, Operations and Information Management, University of Connecticut, School of Business, 2100 Hillside Road, 06269-1041, Storrs, CT, United States, jcruz@business.uconn.edu

In this paper we develop an end-to-end model of a closed loop supply chain, and analyze it from the economic viability perspective of all partners in the chain. In particular, we model the lifecycle of consumer electronics good and implement a system dynamics model to examine the interactions among different segments of the closed loop. Our results highlight the product and market policies that create positive revenue streams for all stakeholders in the chain for the closed loop to be economically and environmentally sustainable.

4 - Integrated Modelling of Agricultural Production Systems for Assessing Waste Recycling Scenarios
Francois Guerrin, UPR Recyclage & Risque, Inra & Cirad, Avenue Agropolis, TA B-78/01, 34398, Montpellier Cedex 5, France, francois.guerrin@cirad.fr

Recycling organic wastes of various kinds is a way to improve agriculture sustainability. Modelling agricultural systems for simulating scenarios and assessing their agronomical and environmental performances necessitates the integration of heterogeneous data and knowledge on both the biophysical processes involved and farming practices. We will describe our main methodological achievements relevant for modelling farming systems on whole-farm or territory scales; representing human activity situated in time and space; using the resulting simulation models for assessing recycling scenarios.

■ TD-69

Tuesday, 14:30-16:00
R19-3

OR Applications for Renewable Energy Development in Developing Countries II

Stream: OR for Development and Developing Countries
Invited session

Chair: *Youssef Masmoudi*, University of Sfax, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef.masmoudi@gmail.com

1 - Hybrid Battery System Design with VHDL
Soraya Tighidet, university of bejaia, Targa ouzemour, bejaia, Algeria, tighidet.soraya1953@gmail.com, *Zahira Benkhellat*

The paper deals with the design of a model for a multi battery sources using a system of autonomous hybrid power generation from photovoltaic panels, wind generators and electric generator, with multi-source VHDL (Hardware Description Language) which is designed to represent the behavior as well as the architecture of an electronic system. Battery management is based on two fundamental criteria: protection against deep discharge and optimal load. We adopted a regulation called "on-off" for battery management. We tested our system giving values that can represent almost all possible cases.

2 - Comparison Among Hourly Radiation Models For Using Concentrated Solar Power Technology (CSP) in the City of Barranquilla-Colombia
Alvin Henao Perez, Industrial Engineering, Universidad del Norte, Km 5 Via Antigua a Puerto Colombia, Carrera 28 No 65-33, Barranquilla, Colombia, henaoa@uninorte.edu.co, *Luceny Guzman*, *Ricardo Vasquez*

Solar energy is one of the most mature technologies to produce electricity from renewable energy. We analyze the solar radiation potential in Barranquilla-Colombia, 1059'16' N, 7447'20' W, for using Concentrated Solar Power technology (CSP). We use four hourly radiation models (Clear Sky, CPR, CPRG, DI) and five solar tracking modes. The results showed the high potential of solar radiation for CSP at the north coast of Colombia

3 - Towards the integration of SOLAP and MCDA: for the Spatial Decision Support.
Mohamed Hanine, Computer Science, Faculty of Sciences Semelalia, Cadi Ayyad University, Marrakesh, Morocco, m.hanine@uca.ma, *Omar Boutkhoum*, *Abdessadek Tiknioune*

In this paper, we propose an approach of decision making support that is based on linking the MCDA to the solap process, an essential component of the spatial decision support systems analysis.The testing of SOLAP process demonstrated that there exists a shortage in the consideration of the multicriteria aspect. Therefore, it is imperative to integrate multicriteria decision analysis for the expansion of the capabilities of SOLAP process in order that we could make the right decision. Our model is illustrated by a case study concerning a site for the location of renewable energy.

■ TD-70

Tuesday, 14:30-16:00
R19-4

Ethics and OR - EthOR Award Prize

Stream: OR and Ethics
Invited session

Chair: *Fred Wenstøp*, Strategy and Logistics, BI Norwegian School of Management, Nydalsveien 37, 0483, Oslo, Norway, fred.wenstop@bi.no
Chair: *Cristobal Miralles*, Depto. Organización de Empresas, Universidad Politecnica de Valencia, Cami de Vera s/n, 46022, Valencia, Spain, cmiralles@omp.upv.es

1 - A game theoretic framework to mitigate unethical behavior in construction projects
Yamini S, Department of Management Studies, Indian Institute of Technology, Madras, Research Scholar, Department of Management Studies, IIT Madras, 600036, Chennai, Tamil Nadu, India, yamini.bubbly@gmail.com, *Rahul R Marathe*

The economic impact of private information in the construction projects lead to unethical mechanisms such as conflict of interest or moral hazard, collusion and rent seeking (corruption). We design a contract between the owner and the contractor to mitigate the information asymmetry about quality of construction. Using game theoretic principles, we formulate mathematical models and analytically prove the conditions which prevent the unethical practices and motivate the agents to practice ethical behavior. In fact, we show that being ethical actually returns higher economic gain to the agents.

2 - Reaching consensus on water reforms: a case of Community Operational Research in Kapiti, New Zealand
Robyn Moore, Victoria Management School, Victoria University of Wellington, 16 Kotipu Place, Pukerua Bay, 5026, Porirua, Wellington, New Zealand, robyn@j.co.nz, *Vicky Mabin*

Living up to its "clean, green" image is a significant goal for New Zealand. A 2009 government task force suggested that a "business as usual" approach is undesirable and water reform should be a priority. This Community OR was undertaken to examine the challenges facing K'piti, a community with water scarcity and quality constraints for their sustainable development goals. Departing from the generally accepted procedure in qualitative studies, participants and their perspectives were identified, with approval sought and obtained from the University Human Ethics Committee.

3 - A Management Model for Closed-Loop Supply Chains of Reusable Articles
Ruth Carrasco-Gallego, Ingeniería de Organización, Administración de Empresas y Estadística, Escuela Técnica Superior de Ingenieros Industriales.Universidad Politécnica de Madrid., C/Jose Gutierrez Abascal, 2, 28006, Madrid, Spain, ruth.carrasco@upm.es, *Eva Ponce*

This finalist thesis of the EthOR Award addresses a contemporary problem with a strong ethical dimension, such as the lack of environmental sustainability of our current use-and-dispose model. Reuse practices reduce our consumption of natural resources, but, on the other hand, they entail more logistic complexity than their single-use counterparts. The thesis develops a management model for reusable articles, made up of qualitative and quantitative building blocks. The model structures the challenges that reuse practices involve and provides decision-making tools to address them.

■ TD-71

Tuesday, 14:30-16:00
R16-1

Health Care Management (Disease Policy Modelling II)

Stream: Health Care Management
Invited session

Chair: *Leonid Churilov*, Florey Institute of Neuroscience and Mental Health, Melbourne Brain Centre, 245 Burgundy St, 3084, Heidelberg, VIC, Australia, leonid.churilov@gmail.com

1 - A Two-Sided Mechanism to Coordinate Supply Chains with Uncertain Yield and Consumption Externalities
Kenan Arifoglu, Management Science and Innovation, University College London, United Kingdom, k.arifoglu@ucl.ac.uk

This paper studies coordination issues in a supply chain with consumption externalities and uncertain yield (e.g., influenza (flu) vaccine supply chain). We consider a supply chain consisting of a monopolist manufacturer with uncertain production process and rational (self-interested) consumers, and develop a two-sided coordinating mechanism which counteracts two main sources of inefficiency in the supply chain, namely, uncertain yield and rational consumer behavior. The two-sided mechanism includes tax/subsidy payments on the demand side and a transfer payment on the supply side.

2 - Cardiac Catheterization Lab Inpatient Forecast
Scott Levin, Emergency Medicine, Johns Hopkins University School of Medicine, 5801 Smith Ave, Ste 3220, 21209, Baltimore, MD, United States, slevin33@jhmi.edu, *Sauleh Siddiqui*, *Matt Toerper*, *Jeffrey Appelbaum*, *Eleni Flanagan*, *Edward Kasper*

Efficient hospital bed management in cardiac care areas is challenged by uncertainty in admissions from the catheterization lab. The objective was to forecast daily need for cardiac beds based on routine clinical data. Predictor information such as demographics, procedures, and clinical indicators mined from free-text notes are input to a multivariable logistic regression model predicting probability of admission. Aggregated probabilities produce forecasts 85% accurate within 1 bed over the 2-year evaluation. The model is embedded in a web-based application for real-time decision support.

3 - Model and simulation of assistance management for severe brain injured patients
Giorgio Romanin-Jacur, Management and Engineering, University of Padova, Stradella San Nicola, 3, 36100, Vicenza, Italy, romjac@dei.unipd.it, *Silvia Manea*, *Mauricio Alexandro Trujillo Morales*

We studied the care pathways for severe brain injured patients, to correctly dimensioning the dedicated resources so to improve the specific healthcare system. Patients have heterogeneous needs and characteristics throughout each phase (critical, acute and sub-acute, post acute, outcome) and are assisted by different hospital departments and residences. We built up a fairly general simulation model which evidences queues and resources utilization in correspondence of given demand and resources availability, both now and in the future, which was tested on the Veneto Region Healthcare System.

4 - Combining Critical Realism with Discrete Choice Experiments for clinical decision support: The case of patient mobilization after acute stroke thrombolysis treatment
Kristian Rotaru, Accounting and Finance, Monash University, Australia, 900 Dandenong Rd, 3145, Caulfield East, Victoria, Australia, Kristian.Rotaru@buseco.monash.edu.au, *Leonid Churilov*, *Thomas Linden*, *Julie Bernhardt*

Clinical decision-making is characterized by complex interplay of multiple factors that contribute to the causal mechanisms underlying the decision-making process. Better understanding of such mechanisms could enhance decision support and ultimately lead to improved clinical outcomes. In this study we demonstrate how the combination of Critical Realism philosophy of science and Discrete Choice Experiments can be used to facilitate understanding of generative mechanisms in acute stroke care decision-making using the case of patient mobilization after thrombolysis treatment.

■ TD-72

Tuesday, 14:30-16:00
R16-2

Data Analysis in Healthcare

Stream: OR in Health & Life Sciences (contributed)
Contributed session

Chair: *Fadime Uney-Yuksektepe*, Industrial Engineering, Istanbul Kultur University, E5 Karayolu Londra Asfalti Uzeri, Atakoy Kampusu, 34156, Istanbul, Turkey, f.yuksektepe@iku.edu.tr

1 - A mathematical programming model inferring pathway activity for accurate multi-class disease classification problems using gene expression profile
Lingjian Yang, chemical enigneering, UCL, Centre for process Systems Engineering (CPSE), Department of Chemical Engineering, University College London (UCL), Torrington Place, WC1F 7JE, London, United Kingdom, lingjian.yang.10@ucl.ac.uk, *Lazaros Papageorgiou*

This work proposes a novel framework for multi-class disease classification problems using gene expression profile. The proposed model builds for each biological pathway one composite feature (pathway activity) summarising the expression pattern of its member genes as a linear summation of gene expressions multiplying their weights (variables). A classifier is then trained on the pathway activity profile. Using published gene expression profiles, the proposed model is shown to offer higher prediction rates than existing classification methods for a number of classifiers, e.g., SVM and KNN.

2 - An Extended Cross-Entropy Method for Detection of Copy Number Variations in Biological Sequences.
Madawa Weerasinghe, Department of Statistics, Macquarie University, Building E4A, Balaclava Road, North Ryde, 2109, Sydney, NSW, Australia, madawa.weerasinghe@mq.edu.au, *Georgy Sofronov*

Detection of copy number variations(CNVs) in the human genome is an extremely important process, as it guides the exploration of potential genetic risk factors for complex diseases. We present an extended Cross-Entropy(CE) method, which is an evolutionary computational method to detect CNVs in both array comparative genome hybridization(aCGH) and next generation sequencing(NGS) data. Moreover, we implement a parallel execution of the methodology, which improves the processing time significantly. Results suggest that our method is effective in detecting break-points in genome wide data.

3 - Combinatorial optimization for short-epitope immunoassays

Hannes Planatscher, Biochemistry, NMI, Germany, hannes.planatscher@nmi.de, *Oliver Poetz*, *Dieter Stoll*, *Markus Templin*, *Thomas Joos*

In classical diagnostic tests two antibodies are employed to detect a protein: one for capture, one for detection. The generation of these binders is expensive and tedious. Antibodies which bind to short terminal sequences are capable of detecting multiple targets. Sequence-based detection allows an in-silico selection using existing sequence databases. Minimizing the number of required antibodies for a given list of targets is an optimization problem. Models can reflect various experimental and budget constraints and are solved by ILP for small and greedy approaches for larger instances.

■ TD-73

Tuesday, 14:30-16:00
R16-3

OR in Agriculture III

Stream: OR in Agriculture, Forestry and Fisheries
Invited session

Chair: *Sergio Maturana*, Ingenieria Industrial y de Sistemas, P. Universidad Catolica de Chile, Casilla 306 Correo 22, Santiago, Chile, smaturan@ing.puc.cl

1 - Milk Collection Using Trucks and Trailers

Urooj Pasha, Høgskolen i Molde, Specialized University in Logistics, Norway, urooj.pasha@himolde.no, *Arild Hoff*, *Arne Løkketangen*

This paper describes a special variant of the Truck and Trailer Routing Problem and deals with deterministic pick-ups where milk is collected from farms and transported to production plants. We solve a real world planning and collection problem for the TINE SA which is the largest dairy company in Norway. A heuristic embedded with tabu search based on a clustering technique is implemented to solve this problem and results are reported.

2 - Optimization in livestock feed distribution: a case study.

M[a] Luisa Carpente, Matemáticas, Universidade da Coruña, Facultade de Informática. Campus de Elviña, 15071, A Coruña, Spain, luisacar@udc.es, *Balbina Casas-Méndez*, *Ana Cerdeira-Pena*, *Juan Ramón Nogueira*

Our work focuses on the distribution problems in a livestock feed factory. Today, this factory produces different types of livestock feed in order to meet the farmers requirements. These requests are supplied as they arise, in an unplanned way. In consequence, the factory timetable turns to be chaotic. However, it is well known that the livestock feed needs are very predictable. Hence we propose a method to optimize the production schedule and the distribution process based on metaheuristic algorithms.

3 - Optimization of the recipient's herd in a program of horse cloning.

Alline Reis, SESG, Agroparistech, Institut National d'Agronomie Paris-Grignon, 16, rue Claude Bernard, 75005, Paris, France, alline.depaulareis@agroparistech.fr, *Michel Nakhla*, *Othman Moumni Abdou*

Equine cloning presents high uncertainty due to low technological efficiency, low demand and high production costs. The latest is partly caused by the important herd of recipient mares necessary to ensure production. We hypothesized that optimizing the herd could reduce production costs. The relaxed solution is not realistic in this domain but was considered as the referential solution. The heuristic solution positively contributed to reduce costs through reduction of the number of mares and the resting period. The average deviation of the heuristic solution to the relaxed solution was 3,6%.

4 - Implementing Balanced Scorecard in Chilean Wineries

Sergio Maturana, Ingenieria Industrial y de Sistemas, P. Universidad Catolica de Chile, Casilla 306 Correo 22, Santiago, Chile, smaturan@ing.puc.cl, *Lionel Valenzuela*

The Balanced Scorecard has become one of the most popular management systems of the world (Rigby 2011). In some industries, however, it has been more difficult to implement. In this work we look into the problem of implementing BSC in Chilean wineries. We first present an analysis of 70 case studies of implementations of BSC in Chile, none of which was in a winery. To understand why BSC seems to be harder to implement in the Chilean wine industry, we carried out an in-depth survey of a representative sample of Chilean wineries. Some preliminary conclusions of this analysis are presented.

■ TD-74

Tuesday, 14:30-16:00
R16-4

Meet with Editors of EJOR

Stream: Journals
Sponsor session

Chair: *Roman Slowinski*, Institute of Computing Science, Poznan University of Technology, Laboratory of Intelligent Decision Support Systems, Street Piotrowo 2, 60-965, Poznan, Poland, roman.slowinski@cs.put.poznan.pl
Chair: *Jean-Charles Billaut*, Laboratoire d'Informatique, University of Tours, 64 av. Jean Portalis, 37200, Tours, France, jean.billaut@univ-tours.fr
Chair: *Immanuel Bomze*, Dept. of Statistics and OR, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, immanuel.bomze@univie.ac.at
Chair: *Robert Dyson*, University of Warwick, United Kingdom, robert.dyson@wbs.ac.uk
Chair: *Lorenzo Peccati*, Institute of Quantitative Methods, Bocconi Unversity, 20136, Milan, Italy, lorenzo.peccati@unibocconi.it

1 - Some Facts about the European Journal of Operational Research (EJOR)

Roman Slowinski, Institute of Computing Science, Poznan University of Technology, Laboratory of Intelligent Decision Support Systems, Street Piotrowo 2, 60-965, Poznan, Poland, roman.slowinski@cs.put.poznan.pl, *Jean-Charles Billaut*, *Immanuel Bomze*, *Robert Dyson*, *Lorenzo Peccati*

The editors of EJOR will give some characteristics of the journal, and will explain their approach to evaluation and selection of articles. They will point out topics of OR which recently raised the highest interest. They will also present the EJOR-R-index that is a quantitative measure proposed and used by them to award 25 best reviewers each year. Two other presentations in the session will be done by authors of representative and highly cited papers published recently in EJOR. The last part of the session will be devoted to discussion about EJOR - some general questions will be welcome.

2 - A survey of berth allocation and quay crane scheduling problems in container terminals

Frank Meisel, Martin-Luther-University Halle-Wittenberg, Gr. Steinstr. 73, 06108, Halle, Germany, frank.meisel@wiwi.uni-halle.de, *Christian Bierwirth*

The planning of container transshipment, transportation, and storage in seaports has received enormous attention by researchers within the last years, leading to a multitude of models and solution methods. In this talk, we present a classification scheme for two of the most investigated seaside planning problems: (i) the allocation of berths to the calling ships and (ii) the scheduling of quay crane operations. Also discussed are integration concepts for these problems. We briefly review our survey published in EJOR in 2010 and identify current research trends from papers published since then.

3 - The Design of Robust Value-Creating Supply Chain Networks: A Critical Review

Walid Klibi, Operations Management and Information Systems Department, BEM / CIRRELT, 680 cours de la Libération, 33405, Bordeaux, France, walid.klibi@bem.edu, *Alain Martel*, *Adel Guitouni*

This talk discusses Supply Chain Network (SCN) design problem under uncertainty, and presents a critical review of the optimization models proposed in the literature. Through an analysis of SCNs uncertainty sources and risk exposures, the talk reviews random environmental factors and discusses the nature of major disruptive events. It also discusses relevant strategic SCN design evaluation criteria, and argues for the assessment of SCN robustness as a necessary condition to ensure sustainable value creation. This work contributes to framing the foundations for a robust SCN design methodology.

Tuesday, 16:30-17:30

■ TE-01

Tuesday, 16:30-17:30
O1-1

Plenary Lectures - George Nemhauser

Stream: Invited Lectures - Plenary
Plenary session

Chair: *David Simchi-Levi*, Civil Eng, MIT, 77 Massachusetts Av, 02139, Cambridge, MA, United States, dslevi@mit.edu

1 - Integer Programming: the Global Impact

George Nemhauser, Georgia Institute of Technology, Atlanta, GA, United States, george.nemhauser@isye.gatech.edu

Integer programming is the (not very appealing or descriptive) name for optimization models and algorithms in which some variables are required to have integer values. Planning and operational problems in energy, finance, health, manufacturing, military, transportation, and in almost any imaginable domain where decisions are made, are formulated and solved using integer programming. For example, most Fortune 500 companies use integer programming in some aspects of their business. Currently available software is capable of solving models with thousands, and sometimes millions, of variables and constraints. We will present some integer programming models in diverse areas whose solutions have had big impact in solving important problems. We will also discuss some recent algorithmic developments from our own research including parallel computing and machine learning that can enhance the possibility of solving very large instances and obtaining provably good solutions quickly. We'll close by speculating on future advances in methodology and applications.

Wednesday, 8:30-10:00

■ WA-02

Wednesday, 8:30-10:00
O1-2

Modeling Sustainable Systems II

Stream: Sustainable Development Modeling with System Dynamics
Invited session

Chair: *Hakim Idjis*, Industrial Engineering Laboratory, Ecole Centrale Paris, Grande Voie des Vignes, 92290, Chatenay Malabry, France, hakim.idjis@ecp.fr

1 - Colombia's greenhouse gas emissions produced by the agricultural sector
Jenny Rocio Rios Martinez, Ciencias de la computación y la decisión, Universidad Nacional de Colombia, Colombia, jrriosm@unal.edu.co, *Orlando ZapataCortes*

Last measurement of Colombia's Greenhouse Gas emissions have shown that they are produced primary by the agricultural sector and that they are continuously growing. Therefore, a simulation model has been developed, using the methodology of System Dynamics, to analyze the influence of different mitigation policies in order to reduce Colombias GHG emissions. This analysis considers three main GHG: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). The model could be applied to other countries that have similar conditions to Colombia's agricultural sector.

2 - Towards sustainable recycling networks for batteries from electric vehicles in EU-27. A system dynamics approach modeling and analysis.
Hakim Idjis, Industrial Engineering Laboratory, Ecole Centrale Paris, Grande Voie des Vignes, 92290, Chatenay Malabry, France, hakim.idjis@ecp.fr, *Asma Ghaffari*, *Sophie Richet*

Since the 2008 crisis, the automotive industry is shifting towards green mobility using mainly lithium batteries. Therefore, the issue of recycling batteries arises for ecological, economic and geostrategic reasons. In this contribution, we will explain how we use System Dynamics to model a sustainable recycling network for batteries, including criteria selection, modeling diagrams (causal loop, stock & flow) and eventually simulation results. Finally, we will highlight the perspectives of this work regarding the integration of SD modeling in the optimization of the network deployment.

■ WA-03

Wednesday, 8:30-10:00
O1-3

Applications of semi-infinite programming

Stream: Semi-Infinite and Semidefinite Optimization and Applications
Invited session

Chair: *Alina Fedossova*, Universidad Nacional de Colombia, Cll 159 No. 56-75, T.9, ap. 1704, 12345, Bogota, Colombia, afedosova@unal.edu.co

1 - Companies which pollute and environmental regulation: solution of this conflict using optimization
Alina Fedossova, Universidad Nacional de Colombia, Cll 159 No. 56-75, T.9, ap. 1704, 12345, Bogota, Colombia, afedosova@unal.edu.co, *Valery Fedosov*

We consider situations in which pollution sources are located within the control area with objects or areas where pollution norms are violated. Normally, the pollution norms dominate and the optimization attempts to reduce pollution of sources to fulfill the contamination regulation. Another formulation consists of finding pollution norms which allow factories to preserve the same production. We use an optimization combined approach for pollution reduction modifying the norms so the conflict between objects is minimized. The contamination maps are also developed after optimization.

2 - Design of robust truss structures for minimum weight using the sequential convex approximation method
Miguel Carrasco, Facultad de Ingeniería y Ciencias Aplicadas, Universidad de los Andes, Santiago, 7620001, Chile, migucarr@gmail.com, *Alfredo Canelas*, *Julio López*

We study the design of robust truss structures under mechanical equilibrium, displacements and stress constraints. Then, our main objective is to minimize the total amount of material or weight, for the purpose of finding the most economic structure which is robust under load perturbations. Therefore, we obtain a non-convex bilevel mathematical program. In order to solve this problem, we use the sequential convex approximation method proposed by A. Beck, A. Ben-Tal, and L. Tetruashvili (2010), in which we approximate the original problem by a sequence of differentiable convex ones.

3 - Calmness of feasible and optimal solution maps for perturbed semi-infinite optimization problems
Diethard Klatte, IBW, Universität Zürich, Moussonstr. 15, CH-8044, Zürich, Switzerland, klatte@ior.uzh.ch

We study a canonically perturbed system of infinitely many inequalities defined by smooth functions in finite or infinite dimension. Calmness of the solution set map of this system is characterized: (i) by uniform linear convergence of a suitable iterative procedure, (ii) by a certain constraint qualification. We also show how to apply this to the optimal set map in semi-infinite optimization, in particular, with respect to linear semi-infinite programs. The results are based on collaboration with Bernd Kummer, Humboldt University Berlin.

4 - Some new reformulations for bilevel problems
Joerg Fliege, University of Southampton, United Kingdom, J.Fliege@soton.ac.uk

We present new approaches for bilevel optimization, derived from an optimality condition for the lower level that leads naturally to one or more nonsmooth equality constraints. Two different approaches will be considered, one of them generalizable to lower level multiobjective problems, the other generalizable to lower level variational inequalities. We consider various semismoothness results for both types of approaches, and provide preliminary numerical results on standard bilevel problems that outline the efficacy of both of them.

■ WA-04

Wednesday, 8:30-10:00
O4-4

Cone Optimization

Stream: Mathematical Programming
Invited session

Chair: *Tamás Terlaky*, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

1 - Proximal Decomposition Method for Convex Symmetric Cone Programming
Julio López, Matemática, Universidad Diego Portales, Av. Ejercito 441, Santiago, Santiago, Metropolitana, Chile, julio.lopez@udp.cl, *Erik Alex Papa Quiroz*

This work is devoted to the study a decomposition algorithm for solving convex symmetric cone programming with separable structure. The algorithm considered is based on the decomposition method proposed by Chen and Teboulle and the proximal generalized distance defined by Auslender and Teboulle. Under suitable assumptions, first it is proven that each limit point of the primal-dual sequences generated by the algorithm solves the problem. Then, the global convergence is established. Some examples of proximal distances is also presented.

2 - Full Characterization of Disjunctive Conic Cuts for Mixed Integer Second Order Cone Optimization
Tamás Terlaky, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

Mixed integer second order cone optimization (MISOCO) problems have a increasing number of applications. In this paper we further analyze the derivation of disjunctive conic cuts for MISOCO problems. We present a full characterization of the disjunctive conic cuts when the disjunctive set considered is defined by parallel hyperplanes.

3 - Use of Slack Variables to Find Alternative Optimal Solutions in Optimization Problems
Özcan Mutlu, Pamukkale University, Turkey, mutlu@pau.edu.tr

In this study a new method is proposed to find alternative optimal solutions in linear programming problems. The proposed method is based on changing the set active constraints in the optimal solutions. In order to change the set of active constraints slack variables are used. The method requires solutions of a series of linear programming problem in order to find some or all of the alternative optimal solutions. The advantage of the proposed method is that it is simple and can also be used to find alternative optimal solutions in the other optimization problems.

4 - Comparison of linear programming and heuristic hybrid methods in preparing flour blend
Mehmet Akif Sahman, Selcuk University, Turkey, asahman@selcuk.edu.tr, *Abdullah Oktay Dundar*, *Mustafa Servet Kıran*, *Adem Alpaslan Altun*

In flour blend problems, raw materials that are contingent upon various conditions enter into the mix in numerous forms and amounts, and therefore the quality and the cost is affected by mixture ratios. For this reason, the main purpose of our problem is to ensure the desired quality values and to achieve the lowest cost. In this study, the flour blend problem in which the requirements of lowest cost and highest quality are met is analyzed using Linear Programming and Heuristic Hybrid methods, then the resulting values presented and the performances of the methods compared.

■ WA-05

Wednesday, 8:30-10:00
O4-1

Marketing

Stream: Optimal Control
Invited session

Chair: *David Hirschmann*, Department of Business Administration, University of Vienna, Bruenner Strasse 72, 1210, Vienna, Austria, david.hirschmann@univie.ac.at

1 - The influence of consumer recommendations on advertising strategies in a optimal goodwill model with market segmentation
Dominika Bogusz, Department of Econometrics, University of Lodz, Rewolucji 1905 str. 39/41, 90-214, Łódź, Poland, bodomi@math.uni.lodz.pl, *Mariusz Górajski*

We propose a new model of product goodwill where the product is sold in many market segments. The main novelty is that the product goodwill in a segment of new consumers depends on: consumer recommendations, and on advertising efforts. In the model, the control variables are the company's advertising efforts in order to maximize its profits. We prove the existence and uniqueness of the optimal solution. Using the Pontryagin maximum principle we obtain numerically the optimal solution. The sensitivity of solutions to different forms of consumer recommendation functions is analysed.

2 - Time-optimal advertising investments in a segmented market
Mariusz Górajski, Department of Econometrics, University of Lodz, Rewolucji 1905 r. 39/41, 90-214, Łódź, Poland, mariuszg@math.uni.lodz.pl, *Dominika Bogusz*

We consider optimal control model of product goodwill with market segmentation. The dynamic of product goodwill is described by the McKendrick type PDE. The level of goodwill in new consumer depends on consumer recommendation about the product quality and advertising efforts. The goal in the model is to achieve the specified level of goodwill in the minimum time. We formulate the necessary conditions for the existence of the time optimal solution. Based on them we build a numerical algorithms to determine the optimal solution of the model.

3 - Optimal quality provision when reputation is subject to random inspections
David Hirschmann, Department of Business Administration, University of Vienna, Bruenner Strasse 72, 1210, Vienna, Austria, david.hirschmann@univie.ac.at

We study the behavior of a firm whose reputation is subject to random inspections. The firm offers products whose quality is not observable but revealed by Poisson distributed inspections. These inspections determine reputation and consequently profits of the firm. We obtain closed form solutions showing that inspections ensure a constant level of quality over time. Adding the word-of-mouth effect, offered quality approaches a long-run optimum but changes discontinuously after an inspection. Reputation and true quality never coincide, but approach each other.

■ WA-06

Wednesday, 8:30-10:00
O4-2

Advances in Nonsmooth Optimization

Stream: Nonsmooth Optimization
Invited session

Chair: *Yalcin Kucuk*, Department of Mathematics, Anadolu University, anadolu Universitesi Fen Fakultesi Matematik Bolumu, 26470, Eskisehir, Turkey, ykucuk@anadolu.edu.tr

1 - Obtaining Quasidifferential via Reduced Weak Exhausters
Mahide Kucuk, Department of Mathematics, Anadolu University, Anadolu Universitesi Fen Fak?ltesi Matematik Bolumu, 26470, Eskisehir, Turkey, mkucuk@anadolu.edu.tr, *Ryszard Urbanski*, *Jerzy Grzybowski*, *Yalcin Kucuk*, *İlknur Atasever Güvenç*, *Didem Tozkan*, *Mustafa Soyertem*

In this study, under some assumptions, we proved that a positively homogeneous function which have weak exhauster is quasidifferentiable and it is also shown that a function which is directionally differentiable and weakly subdifferentiable is quasidifferentiable. Moreover, we obtained a method for both of these types of functions to evaluate the quasidifferential of them by using reduced weak exhausters.

2 - On Reducing of Weak Exhausters
Yalcin Kucuk, Department of Mathematics, Anadolu University, anadolu Universitesi Fen Fakultesi Matematik Bolumu, 26470, Eskisehir, Turkey, ykucuk@anadolu.edu.tr, *Mahide Kucuk*, *Ryszard Urbanski*, *Jerzy Grzybowski*, *İlknur Atasever Güvenç*, *Didem Tozkan*, *Mustafa Soyertem*

In this work, we proved that weak lower exhauster of a positively homogeneous function can be reduced if weak subdifferential can be represented as the sum of a subset of it and weak subdifferential of zero function. Furthermore, if this subset is the set of minimal elements of weak subdifferential with respect to weak subdifferential of zero function, then weak lower exhauster also can be reduced. At the end, some results were given about reduction of weak exhausters.

3 - Some Relations between Recession Cones and Weak Subdifferential
İlknur Atasever Güvenç, Department of Mathematics, Anadolu University, Anadolu Universitesi Fen Fakultesi Matematik Bolumu, 26470, Eskisehir, Turkey, iatasever@anadolu.edu.tr, *Mahide Kucuk*, *Ryszard Urbanski*, *Jerzy Grzybowski*, *Yalcin Kucuk*, *Didem Tozkan*, *Mustafa Soyertem*

In general, recession cone of weak subdifferential of any function is not equal to weak subdifferential of zero function. In this work, we investigated and obtained the equality of weak subdifferential of zero function at zero and recession cone of weak subdifferential of a function that can be written as the difference of two support functions. We also obtained this equality for finite valued functions or the functions that has convex directional derivative at zero.

4 - On Relationships Between Quasidifferential and Weak Exhausters
Didem Tozkan, Department of Mathematics, Anadolu University, Anadolu Universitesi Yunus Emre Kampusu, Fen Fakültesi Matematik Bolumu, 26470, Eskisehir, Turkey, dtokaslan@anadolu.edu.tr, *Mahide Kucuk*, *Ryszard Urbanski*, *Jerzy Grzybowski*, *Yalcin Kucuk*, *İlknur Atasever Güvenç*, *Mustafa Soyertem*

In this study, we investigated a relationship between the quasidifferential of a function and weak exhauster of the directional derivative of this function. By using this relationship, we expressed the quasidifferential in terms of weak exhausters. On the other hand, we proved weakly subdifferentiability of a quasidifferentiable function under some assumptions and we obtain the weak subdifferential of a function by using the quasidifferential.

■ WA-07

Wednesday, 8:30-10:00
O4-3

Polynomial Optimization: (Fractional) Quadratic Problems

Stream: Copositive and Polynomial Optimization
Invited session

Chair: *Immanuel Bomze*, Dept. of Statistics and OR, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, immanuel.bomze@univie.ac.at

1 - Convex envelopes and underestimators for quadratic forms
Marco Locatelli, Ingegneria dell'Informazione, Universita' di Parma, Italy, locatell@ce.unipr.it

In this talk we propose copositive and semidefinite formulations for computing the value of convex envelopes and underestimators of quadratic forms over polytopes. Some of the results are also extended to a broader class of functions.

2 - Copositivity and constrained fractional quadratic problems
Paula Amaral, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Departamento de Matemática, Campo da Caparica, 2829-516, Caparica, Lisbon, Portugal, paca@fct.unl.pt, *Immanuel Bomze*, *Joaquim Judice*

We present an exact completely positive formulation for the Constrained Fractional Quadratic Problem (CFQP). The completely positive condition is relaxed, and a convex semidefinite lower bounding problem is obtained. Dual attainability is discussed as well as applications of the CFQP on the correction of linear systems and symmetric eigenvalue complementarity problem. Computational experience with a set of randomly generated CFQPs is reported, which illustrates the quality of the lower-bounds as compared with those given by BARON and GloptiPoly 3.

3 - Copositivity-based approximations for mixed-binary and ternary fractional quadratic optimization
Immanuel Bomze, Dept. of Statistics and OR, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, immanuel.bomze@univie.ac.at

We propose a copositive reformulation of the mixed-binary fractional quadratic problem under general linear constraints, and for the ternary fractional quadratic optimization problem. The latter consists of minimizing a ratio of quadratic functions in variables taking values in -1,0,1. As shown recently, a subclass of this problem class does not admit a Polynomial-Time Approximation Scheme (PTAS) unless P = NP, in contrast with the Standard Quadratic Problem (StQP) which admits a PTAS. This paper adds to the rich evidence for the versatility of copositive optimization approaches.

■ WA-08

Wednesday, 8:30-10:00
O3-2

Tutorial - G. Raidl

Stream: Invited Lectures - Keynotes and Tutorials
Tutorial session

Chair: *Kenneth Sörensen*, Faculty of Applied Economics, University of Antwerp, Prinsstraat 13, 2000, Antwerpen, Belgium, kenneth.sorensen@ua.ac.be

1 - Metaheuristics and Hybrid Optimization Approaches - A Unifying View
Günther Raidl, Institute for Computer Graphics and Algorithms, Vienna University of Technology, Favoritenstr. 9-11/1861, 1040, Vienna, Austria, raidl@ads.tuwien.ac.at

Which of the manifold kinds of metaheuristics is most promising in a specific situation? Obviously, there is no simple answer to this question. Going even further, the literature frequently suggests to also consider various kinds of combinations of metaheuristics with each other or with algorithms from different fields like mathematical programming. In which cases can we expect such hybrids to perform better than simpler approaches? The huge number of possibilities makes such decisions difficult.

We will start by revisiting the pool template, a common view fitting many types of metaheuristics. It helps in making similarities and different key components explicit. By selecting appropriate parts with desired properties from the toolbox of these key components, compiling an overall meaningful optimization approach becomes more structured and the result frequently is of hybrid nature.

We will then overview popular hybridization approaches by considering a classification as well as prominent design templates. The final part will focus on combinations of metaheuristics with advanced mixed integer linear programming methods in particular. A few case studies of less common but sometimes very powerful strategies such as applying metaheuristics in conjunction with Lagrangian decomposition, column generation, or Benders decomposition will be discussed.

■ WA-09

Wednesday, 8:30-10:00
O3-3

Sponsor - FICO 2

Stream: Sponsors
Sponsor session

Chair: *Giovanni Felici*, Istituto di Analisi dei Sistemi ed Informatica, Consiglio Nazionale delle Ricerche, Viale Manzoni 30, 00185, Roma, Italy, giovanni.felici@iasi.cnr.it

1 - Developing optimization applications - Part 2: Designing interactive user interfaces for optimization models
Oliver Bastert, FICO, Maximilianstr. 35a, 80539, Munich, Germany, oliverbastert@fico.com

The OR community usually focusses on capabilities of optimization solvers and techniques for building optimization models. Little time is spent on modeling technology and the need for rapid development of complete optimization solutions is usually not considered at all. In this second talk of the mini-series, we review possibilities and requirements for the design, implementation and deployment of interfaces for end-user interaction with optimization models. After a review of key paradigms for successful optimization projects and flexible optimization solutions, we shall present examples of applications implemented with FICO Xpress-Insight. During the development of the optimization model in a typical optimization project, interaction with business experts is critical for the success of the project. Visualization of solutions and data management in early stages of the project lifecycle leads to much shorter development times, less modeling errors and strong buy in from the business users. A scalable solution architecture with basically no effort for achieving a first user interface and the maturity and flexibility to grow into the full solution would be the perfect fit. After the initial delivery of a custom optimization solution the optimization model typically undergoes regular updates. Those changes often also require modifications to the graphical user interface. A user interface that is largely auto-configured from the optimization model can automatically adjust to model changes. This leads to quick and cheap iterations of these updates and thus guarantees long term usage of the optimization solution. Different user types want to interact with optimization solutions in different ways. The OR expert wants to have the ability to change the underlying optimization significantly during the life time of the model. The analyst wants to be able configure the model, modify constraints and have direct access to all data. Business users expect an interface which presents the underlying optimization problem in their business context and is very easy to use. Besides providing the described functionality the user interface needs to behave differently depending on the user interacting with it. All users want to be able, among other things, to carry out what-if analysis and evaluate solutions based on visualizations and reports on the solution and input data. This is combined with requirements for collaboration and accessibility of the solution from different environments. Collaborations need a complete authentication and authorization infrastructure, for example, share insight by exchanging scenario and solution data in a flexible but still controlled manner. Different users they might prefer to interact with the solution from the desktop, through a web interface or using their mobile device. Such a solution should be underpinned by excellent modeling and optimization tools which guarantee suitable performance for solving single optimization problems. In the context of an optimization application, many scenarios of different sizes have to be solved at the same time. This means not only queuing these scenarios but also distributing them across a network of local machines or utilizing cloud resources. For illustration purposes, we will demonstrate how these requirements have been implemented in Xpress-Insight, show a number of application examples and also review code example to gain a deeper understanding of its way of functioning.

■ WA-10

Wednesday, 8:30-10:00
G5-1

Network design

Stream: Telecommunications and Network Optimization
Invited session

Chair: *İncİ YÜksel ErgÜn*, Industrial Engineering, Middle East Technical University, Turkey, iyuksel@aselsan.com.tr

1 - Solving the Two-Stage Robust FTTH network design Problem under Demand Uncertainty
Cédric Hervet, Orange Labs/CNAM, France, cedric.hervet@orange.com, *Faye Alain*, *Stanislas Francfort*, *Matthieu Chardy*

For the past few years, telecommunication operators are engaging the deployment of optical networks like the Fiber To The Home Gigabit Passive Optical Network technology, leading to new design problems. Such problem have already been studied. However, to the best of our knowledge, without taking into account the uncertainty in future demands. In this paper, we propose a model for a two-stage robust optimization FTTH network design problem tackling the demand uncertainty. We propose an exact algorithm, based on a column and constraint generation algorithm, and we show some preliminary results.

2 - Incremental Network Design with Maximum Flows
Dmytro Matsypura, Discipline of Business Analytics, Business School, The University of Sydney, Room 478 Merewether Building (H04), 2006, Sydney, NSW, Australia, d.matsypura@econ.usyd.edu.au, *Martin Savelsbergh*, *Thomas Kalinowski*

Network infrastructure upgrades are a common phenomenon and typically occur over time due to various constraints. We introduce a class of incremental network design problems and focus on one of its variants: incremental network design with maximum flows. We consider the complexity of the problem, we analyse the performance of natural heuristics, we derive approximation algorithms, and we study integer program formulations.

3 - Hybridization of Metaheuristics with Branch and Bound for Reliable Communication Network Design
Omer Ozkan, Industrial Engineering, The Aeronautics And Space Technologies Institute, Turkish Air Force Academy Yeşilyurt / Bakirköy, 34149, Istanbul, Turkey, o.ozkan@hho.edu.tr, *Murat Ermis*

The increased complexity of network systems requires new approaches to find an efficient topological design and predict its behavior. The main clue for the behavior of the communication network is reliability. In this paper, we proposed hybridization of Genetic Algorithm with Branch and Bound (B&B) in two different cooperation methodologies and hybridization of Simulated Annealing with B&B in order to find the optimum network topology with reliability constraint, which is a NP-hard problem. The effectiveness of our approaches is presented by numerical experiments.

4 - The Multilayer Telecommunication Network Design Problem
İncİ YÜksel ErgÜn, Industrial Engineering, Middle East Technical University, Turkey, iyuksel@aselsan.com.tr, *Ömer Kirca*, *Haldun Sural*

Telecommunication networks comprise of several interdependent network layers. The multilayer network design problem deals with configuring a stack of networks with different technologies to satisfy customer requirements. Most studies model multilayer networks as a distinct network for each layer. We propose a mathematical model based on a single-graph network representation of multilayer networks. We provide our computational experiments with the model on test instances including challenging three-layered problem and compare the results with existing models in the literature.

■ WA-11

Wednesday, 8:30-10:00
G5-3

Discrete Location Problems

Stream: Location Analysis
Invited session

Chair: *Antonio Manuel Rodriguez-Chia*, Estadistica e IO, Universidad de Cádiz, Facultad de Ciencias, Pol. Rio San Pedro, 11510, Puerto Real (Cadiz), Cadiz, Spain, antonio.rodriguezchia@uca.es

1 - Solving the quadratic assignment problem by neural networks
Enrique Dominguez, Dept. of Computer Science, E.T.S.I.Informatica - University of Malaga, Campus Teatinos s/n, 29071, Malaga, Spain, enriqued@lcc.uma.es

The Quadratic Assignment Problem (QAP) was introduced by Koopmans and Beckmann in 1957. The QAP is NP-hard and one of the fundamental combinatorial optimization problems in the area of facility location. This problem has been solved by many different techniques; but no exact algorithm is known for solving large-sized instances of the QAP in reasonable computational time. In this work, neural networks are proposed for solving large-sized instances of the QAP. Preliminary results show that neural networks are capable to provide good solutions in a low computational time.

2 - Lagrangian approach for equitable tree location
Alfredo Marín, Departamento de Estadística e Investigación Operativa, University of Murcia, Facultad de Matemáticas, Campus de Espinardo, 30100, Murcia, Spain, amarin@um.es

Given an undirected graph with lengths associated to the edges, the problem aims to find a spanning tree which maximizes an equity measure with respect to the lengths of the tree edges. As an example, the objective could be the maximization of the difference between the minimum and the maximum lengths of the edges of the tree. A Lagrangian approach based on an implicit strengthened formulation of the problem is used to generate both upper and lower bounds on the optimal value of the problem.

3 - Solving the p-median problem with uncertain costs
Sergio García Quiles, Kent Business School, University of Kent, Medway Building, Chatham Maritime, ME4 4AG, Chatham, Kent, United Kingdom, S.Garcia-Quiles@kent.ac.uk, *Laureano Fernando Escudero*

Here we study the p-median location problem with the particularity that the cost matrix is uncertain. A formulation, inspired by the radius formulation applied very successfully to solve very large instances of the classical p-median problem, is used to minimize the expected cost over a set of scenarios at the same time that a set of first order stochastic dominance constraints are imposed to reduce the risk on the cost due to non-wanted scenarios. A computational experience is reported.

4 - New results on capacitated p-center problem with failure foresight
Antonio Manuel Rodriguez-Chia, Estadistica e IO, Universidad de Cádiz, Facultad de Ciencias, Pol. Rio San Pedro, 11510, Puerto Real (Cadiz), Cadiz, Spain, antonio.rodriguezchia@uca.es, *Inmaculada Espejo*, *Alfredo Marín*

This work deals with the p-center problem, where the aim is to minimize the maximum distance between any user and his second-closest center. The capacity of each center must suffice to satisfy the demand of all users for which it is the closest center and for the users for which it is the second-closest center because these users will be reallocated to it in case of a failure of their closest center. We consider different formulations for the problem and extensive computational tests are reported, showing the potentials and limits of each formulation on several types of instances.

■ WA-12

Wednesday, 8:30-10:00
G5-4

Shared Mobility Systems 1

Stream: Transportation and Logistics
Invited session

Chair: *Mor Kaspi*, Industrial Engineering, Tel-Aviv University, Ramat Aviv, 69978, Tel-Aviv, Israel, morkaspi@post.tau.ac.il

1 - A Pickup and Delivery Problem for Ridesharing Considering Congestion
Maged Dessouky, Industrial and Systems Engineering, University of Southern California, Los Angeles, United States, maged@usc.edu, *Xiaoqing Wang*, *Fernando Ordonez*

Because of the existence of toll roads and the availability of HOV lanes, ridesharing could provide cost reduction and time savings under congestion. We consider a vehicle pickup and delivery problem with the object of minimizing the total travel cost and the passenger travel time consider congestion. A 0-1 integer programming model is formulated to solve the problem optimally. A heuristic is also developed to solve the problem in a more time efficient way. A waiting strategy is applied in the heuristic with the purpose to satisfy more requests with less cost and time in real-time case.

2 - Demand Modelling as a basis for optimising the redistribution of bikes in the Vienna bicycle sharing system
Christian Rudloff, Mobility Department, AIT Austrian Institute of Technology GmbH, Wien, Austria, christian.rudloff@ait.ac.at, *Bettina Lackner*, *Matthias Prandtstetter*, *Markus Straub*

To optimise redistribution of bicycles in a bike-sharing system it is necessary to understand the inherent demand for bikes and free spaces to return bikes. Different count models and model selection procedures showed that negative binomial models give the best fit for the three years of data from the Viennese bike-sharing system. The model fit can be further improved by including variables showing for each time step if the three closest neighbouring stations are full or empty. We outline how this model can be exploited for redistributing bikes such that all user demands can be fulfilled.

3 - A Clustering Algorithm for the Static Repositioning Problem in a Bike-Sharing System
Iris Forma, Industrial Engineering, Afeka - Tel Aviv Academic College of Engineering, Janusz Korczak 11/48, 42495, Netanya, Israel, irisf@afeka.ac.il, *Tal Raviv*, *Michal Tzur*

We propose a three-step mathematical programming based heuristic to solve the static repositioning problem in a bike-sharing system. First, stations are clustered according to geographic and inventory considerations; then, the vehicles are routed through the clusters; finally, the inventory routing problem is solved for all stations. We show that our approach can solve close to optimality instances of up to 200 stations and three repositioning vehicles within one hour. This approach improves upon the previous introduced solution method which was based on mixed integer linear programming.

■ WA-13

Wednesday, 8:30-10:00
G5-5

Traffic management

Stream: Traffic
Invited session

Chair: *Angélica Lozano*, Engineering Institute, Universidad Nacional Autónoma de México, Mexico, Mexico, alozanoc@iingen.unam.mx

1 - Modelling route choice behaviour in urban networks using Bluetooth sensors data
Gennaro Ciccarelli, Department of Civil, Construction and Environmental Engineering, University of Rome "La Sapienza", via eudossiana, 18, 80014, Giugliano in Campania, Napoli, Italy, gennaro.ciccarelli@uniroma1.it, *Evangelos Mitsakis*, *Josep-Maria Salanova*

The aim of the paper is to calibrate a route choice model with Bluetooth sensors data collected during June 2012-February 2013 in the city of Thessaloniki. The road network consists in 802 links, 290 nodes and 1936 o/d pairs. Decisive for the formation of choice sets is a sampling of heterogeneous alternatives based on some indicators on single and couples of routes. We propose a Path Size Logit model with a new Path Size attribute to capture the topological correlation among alternatives. Other attributes are route length, travel time and number of left turns and traffic lights.

2 - Optimizing the Maintenance Network for Complex Engineering Systems
Chefi Triki, Department of Engineering, University of Salento, 73100, Lecce, Italy, chefi.triki@unisalento.it, *Abdallah Alalawin*, *Gianpaolo Ghiani*, *Emanuele Manni*
This talk deals with the problem of designing the logistics support of complex engineering systems, with the aim of determining the spare parts stock and the maintenance resources capacity, as well as the level of repair. The problem is modeled as an integer program with a probabilistic constraint on the expected availability. We use an optimization via simulation approach, in which the search space is efficiently explored through an approximated neighborhood evaluation mechanism. Experimental results on a number of instances show the effectiveness of the proposed approach.

3 - A bilevel formulation for the traffic assignment problem on urban time-dependent networks
Angélica Lozano, Engineering Institute, Universidad Nacional Autónoma de México, Mexico, Mexico, alozanoc@iingen.unam.mx, *Gloria Londoño*
We present a bilevel formulation for the traffic assignment problem, whose objective function is to minimize the network total travelled time which depends on both link flow and queue length on the arcs, considering user equilibrium. The upper problem obtains length of the queue on link, subject to limits on links length. The lower problem is a time-dependent user equilibrium assignment problem, which obtains flow on links. The link travel time function depends on flow, characteristics of traffic signal time (green interval and cycle length), queue's length and congestion time.

4 - Port stakeholders analysis: Container terminal of Radès Tunisia
Wided Bedoui, Computational Mathematics Laboratory, Faculty of Economic Sciences and Management, University of Sousse, Sousse, Sousse, Tunisia, bedoui_wided@yahoo.fr
This paper focuses on broader analysis of the stakeholder theory and how it could be relevant in mapping stakeholders within port system. We attempt to identify and assess the influence and importance of key seaport stakeholders which may significantly impact the performance of container terminal of Radès. Whereof,the stakeholder theory is briefly presented and a review of the relevant literature on port stakeholder analysis is shown. Then, a framework for analyzing port stakeholder power and importance is developped.

■ WA-14

Wednesday, 8:30-10:00
G5-6

Maritime Shipping Applications

Stream: Matheuristics
Invited session

Chair: *Stefan Voss*, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de
Chair: *Vittorio Maniezzo*, dept. Computer Science, University of Bologna, via sacchi 3, 47521, Cesena, – Please Select (only U.S. / Can / Aus), Italy, vittorio.maniezzo@unibo.it

1 - Optimal Scheduling for the Inland Transport of Containers: Facing the Trade-off of Costs and Service Level
Stefano Fazi, Technische Universiteit Eindhoven, Den Dolech 2, P.O Box 51, Eindhoven, The Netherlands, Netherlands, s.fazi@tue.nl, *Tom Van Woensel*, *Jan C. Fransoo*
We present an allocation model for a particular container supply chain where multiple sea terminal quays and a hinterland terminal are considered. From the moment a container is dropped off from the vessel at the sea-terminal, several options for the transportation to the hinterland are available. The logistic planner decides the best allocation of the containers to the fleet in order to minimize the costs for the transportation and guarantee a on-time delivery. We propose a case-study in the Netherlands and we show the application of the model. Some data-sets are then solved heuristically.

2 - An adaptive large neighborhood search heuristic for the berth allocation problem
Geraldo Mauri, Department of Computing, Federal University of Espírito Santo - UFES, Alto Universitário s/n, 29500-000, Alegre, Espírito Santo, Brazil, mauri@cca.ufes.br, *Glaydston Ribeiro*, *Luiz A. N. Lorena*, *Gilbert Laporte*

The Berth Allocation Problem (BAP) consists of assigning ships to berthing areas along a quay in a port. The choice of "where" and "when" the ships shall moor is the main decision to be made in this problem. In this paper, the ships are represented as rectangles to be placed into a space x time area avoiding overlaps and satisfying time window constraints. To solve the BAP, an Adaptive Large Neighborhood Search heuristic (ALNS) is proposed for the discrete and continuous cases which provides good solutions, outperforming recent methods found in the literature.

■ WA-15

Wednesday, 8:30-10:00
G5-2

Metaheuristics for scheduling applications

Stream: Metaheuristics (contributed)
Contributed session

Chair: *Onder Bulut*, Bilkent University, 06800, Ankara, Turkey, onderb@bilkent.edu.tr

1 - Robotic Cell Scheduling In Hybrid Flexible Flow Shops
Gul Didem Batur Sir, Industrial Engineering, Gazi University, Gazi University Engineering Faculty, Industrial Engineering Department, 06570, Ankara, Turkey, dbatur@gazi.edu.tr, *Serpil Erol*

In this study, we focused on the scheduling problem arising in hybrid flexible flow shops in which a set of multiple part-types is repeatedly produced, and the part movements are performed by the help of a robot. Considered manufacturing cells contain multiple parallel machines per stage and some jobs are allowed to skip one or more stages. A simulated annealing based algorithm is proposed in order to solve the problem of determining the best solution which composes of three components: robot move cycle, part sequence and part-machine allocations for each stage.

2 - Assignment and Scheduling in DYO Paint Filling Machines Unit
Damla Kızılay, Yasar University, Turkey, damla.kizilay1@stu.yasar.edu.tr, *M. Fatih Tasgetiren*, *Onder Bulut*, *Bilgehan Bostan*

This study is carried out in "DYO Paint factory in Cigli, Izmir". In the DYO paint filling machines unit, there are three types of filling machines groups, namely, automatic, semiautomatic and manual. In each group, there is a certain number of identical machines. The problem will be handled by first assigning jobs to machine groups and then scheduling the partial jobs in each machine group. We develop a variable neighborhood search algorithm to solve this assignment and scheduling problem under the performance measures of makespan and total weighted tardiness.

3 - A Multineighborhood Search for Scheduled Service Network Design Problems with Resource-balance and Synchronization Constraints
Kristina Sharypova, Eindhoven University of Technology, P.O. Box 513, 5600MB, Eindhoven, Netherlands, k.sharypova@tue.nl, *Teodor Gabriel Crainic*, *Tom Van Woensel*, *Jan C. Fransoo*

In recent years much attention has been paid to the development of service network design problems with resource—balance constraints and their solution methods. However, multiple resources and their schedule synchronization have not been considered. This paper presents a

matheuristic for the solution of scheduled service network design problems with resource—balance and synchronization constraints, based on the very large-scale neighborhood search. Our preliminary results show that the proposed method outperforms a state-of-the-art solver.

4 - An Artificial Bee Colony Algorithm for the Economic Lot Scheduling Problem

Onder Bulut, Industrial Engineering, Yasar University, Selcuk Yasar Kampusu, Agacli Yol, Bornova, 35100, Izmir, Turkey, onder.bulut@yasar.edu.tr, *M. Fatih Tasgetiren*

We present an Artificial Bee Colony (ABC) algorithm for the Economic Lot Scheduling Problem (ELSP) modeled through the Extended Basic Period (EBP) approach. We allow both power-of-two and non-power-of-two multipliers in the solution representation. We develop mutation strategies to generate neighboring food sources for the ABC algorithm and these strategies are also used to develop two different variable neighborhood search (VNS) algorithms to further enhance the solution quality. Experimental results show that the proposed algorithm performs better than the existing ones.

■ WA-16

Wednesday, 8:30-10:00
G5-7

Emergency transportation logistics

Stream: Routing Problems
Invited session

Chair: *Elise Miller-Hooks*, University of Maryland, Civil and Environmental Engineering Dept., Parkville, 20742, College Park, MD, United States, elisemh@umd.edu

1 - A Heuristic Approach for the Emergency Medical Service Location Problem

Ecem Konak, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu Caddesi No:43, 06560, Ankara, Turkey, ekonak@etu.edu.tr, *Berrin Aytac*

This study models an emergency medical service location problem as a capacitated fixed charge facility location problem. Given the importance of quick response to an emergency, the model determines the optimal locations and capacities of the service locations that result in minimum cost within a maximum service response time limit. The model assumes that an emergency call can be assigned to more than one service locations. As the solution approach, a two-phased heuristic is proposed; its performance is tested in terms of both solution quality and run time using a variety of problem instances.

2 - A two-stage stochastic programming model for a comprehensive disaster management problem

Alper Döyen, HEC Management School, University of Liege, 14 rue Louvrex, 4000, Liege, Belgium, doyenalper@gmail.com, *Yasemin Arda*

A periodic disaster preparedness model that incorporates mitigation, response, and recovery related decisions is proposed. The objective is to minimize the total cost of relief item transportation and shortage as well as recovery costs of buildings and links under a limited retrofitting budget. The problem is formulated as a two-stage stochastic programming model. While retrofitting decisions are the binary first-stage variables, relief flows and shortage amounts constitute continuous second-stage variables. An efficient solution approach that employs the integer L-shaped method is proposed.

3 - A planning and routing problem for transportation of patients in health care

Jessica Raffaelli, Department of Information engineering and mathematical science, University of Siena, Siena, Italy, Italy, raffaelli@dii.unisi.it, *Alberto Coppi*, *Paolo Detti*

A problem concerning the planning of health care services and transportation of patients, in not urgent conditions, in health care is addressed. The problem arises from a real world context, namely, the health care system of an Italian region. The problem integrates the routing of the vehicles with the planning of the visits timetable. The objective is the minimization of the transportation costs. An approach based on the column generation technique is proposed for the problem.

4 - Optimal deployment of emergency medical service stations and its verification using computer simulation

Ludmila Janosikova, Department of Transportation Networks, University of Zilina, Univerzitna 1, 01026, Zilina, Slovakia, Ludmila.Janosikova@fri.uniza.sk, *Michal Zarnay*, *Peter Marton*, *Marek Kvet*

The access of patients to the emergency medical service depends mainly on the station deployment. Different variants of the station location can be proposed using mathematical programming. However, since emergency calls arise randomly and an ambulance is not always available, the real accessibility can differ significantly from the computed one. Therefore, performance characteristics of the system should be evaluated using computer simulation to choose the best alternative. The paper presents the methodology and the results of simulation experiments in the area of the Slovak Republic.

■ WA-17

Wednesday, 8:30-10:00
G5-8

Maritime transportation: sustainable shipping

Stream: Maritime Transportation
Invited session

Chair: *Harilaos N. Psaraftis*, Technical University of Denmark, Evrota 20, 15451, Neo Psychico, Greece, hnpsar@gmail.com

1 - The Economic Speed Problem in a Dynamic Setting

Evangelos F. Magirou, Informatics, Athens University of Economics, Patission 76, N/A, Athens, Greece, efm@aueb.gr, *Harilaos N. Psaraftis*

Dantzig et al. showed how to determine the ports a Tramp Vessel facing constant rates should visit to maximize revenue per unit time. The analysis was extended to various stochastic rate models. However, in all approaches speed was exogenous, thus ignoring fuel and environmental factors. We allow speed selection, bunker price being deterministic or stochastic. The optimal policy is derived by dynamic programming. It is shown that for constant fuel price the optimal speed is independent of the charter rate: a laden vessel and one in ballast should operate at roughly the same speed.

2 - Analysing cost structures of container shipping and their impact on liner strategies

Michael Tasto, Institute of Shipping Economics and Logistics, 28359, Bremen, Germany, tasto@isl.org, *Hans-Dietrich Haasis*, *Burkhard Lemper*

The cost structure of the liner shipping industry is relatively transparent: Capital costs can be researched with moderate industry and economic knowledge. Voyage costs are slightly more delicate - yet not impossible - to compute. Operation costs are covered at length in industry studies. Thus it seems that liner shipping is a prime candidate for OR — if it was not for the constant and massive fluctuation in the ratio of capital and voyage costs. In this presentation, the authors examine said ratios for standard container vessels during recent shipping cycle peaks and troughs.

3 - Optimizing vessels air emission regulations compliance under uncertainty

Kjetil Fagerholt, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz vei 3, 7491, Trondheim, Norway, kjetil.fagerholt@iot.ntnu.no, *Stein Ove Erikstad*, *Océane Balland*, *Stein W. Wallace*

Uncertainty in the reduction effects of different existing air emission controls is high and makes their selection for vessels emission regulations compliance a challenging process. We develop a stochastic optimization model that addresses this uncertainty for planning the installation of air emission control for a vessel to comply with regulation requirements in the most cost-efficient way. The approach is applied to a case study with real data. The solution exposes the important impact of uncertainty on this problem.

4 - The Greening of the Maritime Supply Chain: Trade-offs and Win-Win Scenarios
Harilaos N. Psaraftis, Technical University of Denmark, Evrota 20, 15451, Neo Psychico, Greece, hnpsar@gmail.com
The objective to attain an acceptable environmental performance of the maritime transportation supply chain, while at the same time respecting traditional economic performance criteria, is likely to be a central goal for both industry and policy-makers in the years ahead. Related measures and policies may have important side-effects as regards the economics and logistics of the supply chain. This paper takes a look at the various tradeoffs that are at stake and takes stock at models that can be used to evaluate these tradeoffs and identify win-win scenarios.

■ WA-18

Wednesday, 8:30-10:00
G5-9

Stochastic Modeling: Industrial Applications

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Quay crane scheduling problem with considering system reliability by simulation
Kang-hung Yang, Industrial and Systems Engineering, Chung Yuan Christian University, Taiwan, kanghungyang@cycu.edu.tw
Traditional system reliability or availability estimated by a static analysis or by Markov analysis is not adequate for a quay cranes working system. For example, two quay cranes process unloading jobs, and one crane is out of order but the other cannot take over its job because of the physical size limitation. Therefore, the redundant strategy does not work for this kind of system. A new technique called simulated reliability is proposed to solve quay crane scheduling problem with considering reliability events by simulation software and results show that the validity of this new technique.

2 - Forecasting manpower demand for airport ground service staff: A simulation approach
Yi Gao, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, PO Box 218, 3122, Hawthorn, Victoria, Australia, ygao@swin.edu.au, *Youzhi Cui*
The planning and scheduling of many positions in the airline industry are subject to fluctuating demands that are uncertain, mainly caused by flight delays. With flight schedules and historical on-time performance as inputs, this study used simulation to project the range of future manpower demands for ground service staff. The projected demands were later used in a manpower-scheduling model to generate weekly rosters for staff. The simulation approach was found to be more robust to flight delays than the deterministic approach by validating generated rosters with actual flight record.

3 - Comparison of Fitting Methods for the Generalized Lambda Distribution
Melike Meterelliyoz, Business Administration, TOBB ETU, Turkey, mkuyzu@etu.edu.tr, *Canan Gunes Corlu*
We consider the Generalized Lambda Distribution (GLD) - a popular distribution in simulation input modeling due to its flexibility in representing a wide variety of distributional shapes. We describe the implementation of genetic algorithm for estimating the parameters of GLD and perform a comprehensive numerical study to compare the goodness-of-fits of several fitting methods. We further investigate the performances of the favored methods in fitting the daily exchange rates of major currencies.

4 - Stochastic decomposition for the retrial queues
Nawel Arrar, Mathematics, Badji Mokhtar-Annaba University, BP.12, 23000, Annaba, Algeria, nawel.arrar@univ-annaba.org, *Djellab Natalia*
The study of retrial queues presents great analytical difficulties. The results are usually particularly complex and thus limited interpretation in practice. To solve this difficulty, we often use an approach based on the stochastic decomposition property that can have a model. It offers the advantages of simplified resolution of complex models. In this work, we review the stochastic decomposition property of some results related to vacations server and retrial queueing systems and establish the property in question for the model MX / G / 1 retrial queue with impatient customers.

■ WA-19

Wednesday, 8:30-10:00
G5-10

Planning

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Suzanne Marcotte*, ESG-UQAM, Case postale 8888, succursale Centre-ville, H3C 3P8, Montreal, Quebec, Canada, suzanne.marcotte@cirrelt.ca

1 - New formulations of districting problems with contiguity constraints
Carmela Piccolo, Department of Business and Management Engineering, University of Naples Federico II, via Cristoforo Colombo 19, 80030, Castello di Cisterna, Italy, carmela.piccolo@unina.it, *Giuseppe Bruno*, *Andrea Genovese*
Districting problems consist in partitioning a given region into smaller areas, according to some criteria such as size, compactness and contiguity. Unlike the others, the contiguity criterion is difficult to be included in mathematical formulations as an explicit constraint; therefore, it is generally taken into account only a posteriori. In this work, an explicit formulation of the contiguity constraint is provided. Then, in order to test it, an experimental analysis is conducted on a set of randomly generated instances. Results are then analyzed and commented.

2 - Region Segmentation and Workload Distribution: A Case Study
Billur Ecer, Industrial Engineering, Gazi University, Faculty of Engineering, Department of Industrial Engineering, Faculty of Engineering, Gazi University, Maltepe, 06570, Ankara, Turkey, billurecer@gazi.edu.tr, *Serpil Erol*
Logistics of fast food chains has gained a remarkable importance in last few decades. As known, these chains are served by numerous stores located in different regions in a city. This study is motivated by the lack of optimized workload assignment to the individual stores of the chain. As a case study, the city of Ankara is partitioned in terms of customers' order frequency, feedbacks, and traffic conditions in order to cluster the neighbourhoods of the city. The purpose of the study is to assign the neighbourhoods to the existing stores properly. In conclusion stores' workload is optimized.

3 - Simulated Annealing Algorithm to Solve Transportation Problem of Cross-Docking Network Design with Two-Dimensional Trucks
Ilker Küçükoğlu, Industrial Engineering, Uludag University, Uludag University Campus, Bursa, Turkey, ikucukoglu@uludag.edu.tr, *Nursel Ozturk*
This paper addresses the transportation problem of cross-docking network design in order to minimize logistics costs. Two-dimensional truck loading constraints are considered to find exact capacity of each truck in basis of each product. The problem is formulated using mixed integer programming and solved using simulated annealing meta-heuristic algorithm. Proposed algorithm is performed for several randomly generated examples and results show that our approach exposes efficient solutions for transportation problem of cross-docking network design with two-dimensional loading constraints.

4 - Evaluation of Integrated Shared Storage Spaces in Holographic Refurbishing and Recycling Facilities
Suzanne Marcotte, ESG-UQAM, Case postale 8888, succursale Centre-ville, H3C 3P8, Montreal, Quebec, Canada, suzanne.marcotte@cirrelt.ca, *Benoit Montreuil*

We previously proposed a refurbishing and recycling facilities design methodology integrating buffer storage grouping and location decisions. In refurbishing and recycling facilities, work-in-process inventory are needed between several steps of the manufacturing process. Buffer storage spaces are thus needed between the workstations. Therefore, we focused on designing holographic facilities strategically distributing both the processing workstations and the shared buffer zones. Following our preliminary results, we provide comprehensive empirical results and insights in this paper.

■ WA-20

Wednesday, 8:30-10:00
G5-11

Public Transport: Other Modes and Maintenance

Stream: Optimization in Public Transport
Invited session

Chair: *Leo Kroon*, Rotterdam School of Management, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, lkroon@rsm.nl

1 - Innovative Operating Strategies for Paratransit Services
Luca Quadrifoglio, Civil Engineering, Texas A&M University, CE/TTI Bldg. Room 301-I, 3136 TAMU, 77843-3136, College Station, Texas, United States, quadrifo@tamu.edu

A significant inefficiency of ADA Paratransit services using zoning strategies is related to the large amount of empty trip miles driven for serving cross-zonal customers. We explore innovative strategies for operating them by enabling providers to serve both trips of these customers in need of round trip rides and quantify the potential benefits in terms of a significant reduction of the empty trip miles driven (and their associated costs) and an improvement of the level of service provided to customers. We will investigate both static and dynamic scheduling scenarios for a variety of cases

2 - Optimizing the level of service quality for a bike-sharing system: the case of Palma
Jose M. Belenguer, Estadistica i Investigació Operativa, Universitat de València, Facultat de Matemàtiques, Dr. Moliner 50, 46100, Burjassot, Valencia, Spain, jose.belenguer@uv.es, *Ramon Alvarez-Valdes*, *Enrique Benavent*, *José D. Bermúdez*, *Facundo Muñoz*, *Enriqueta Vercher*, *Francisco José Verdejo Máñez*

Public bike-sharing programs have been deployed in hundreds of cities worldwide. However, the quality of the service is drastically affected by imbalances in the distribution of bikes among stations. We face this problem in two stages. First, we estimate the unsatisfied demand (lack of free docks or lack of bikes) at each station for a given time period and for each possible number of bikes at the beginning of the period. In a second stage, we use these estimations to guide our redistribution algorithms. Computational results using real data from Palma bike-sharing system are reported.

3 - Optimization models for railway freight transportation
Tibor Illés, Differential Equations, Budapest University of Technology and Economics, Egry J. u. 1., 1111, Budapest, Hungary, illes@math.bme.hu

Freight and passenger railway transportation has many common features. However there is at least one major difference: no fixed time table for railway freight transportation exit. Railway freight transportation is based on orders that may change even few hours before the planned leaving time. Under these uncertain conditions: (i) develop planning models for train and duty assignments for a month, (ii) due to the fact that the changes in ordered trains are quite regular, develop re-optimization model for train assignment. Models and methods will be illustrated on real-life examples.

4 - Multi-level railway maintenance scheduling
François Ramond, Innovation & Research, SNCF, 40 avenue des Terroirs de France, 75611, PARIS Cedex 12, France, francoisramond@gmail.com, *Francis Sourd*, *Bathilde Vasselle*

Railway maintenance scheduling is complex because many aspects must be taken into account: due dates for safety reasons, machine availability and travels, network topology, impact on commercial traffic .... Moreover, it requires to consider simultaneously different time horizons. To be valid, the schedules should both consider long-term aspects over large networks (e.g., national networks over a few years), as well as constraints on local perimeters (a few km) over a few hours. Within the EU-supported project AUTOMAIN, we propose to combine these different problems into an integrated approach.

■ WA-21

Wednesday, 8:30-10:00
G6-1

Machine Scheduling Problems 1

Stream: Scheduling
Invited session

Chair: *Anis Kooli*, Ecole Supérieure des Sciences Economiques et Commerciales de Tunis, 60, Rue Khadija Bent Khoualed. Menzeh 9C., 1013, Menzeh 9, Tunisia, anis.kooli@gmail.com

1 - Algorithmic strategies to single and parallel machine scheduling problems with earliness-tardiness penalties
Rosiane deFreitas, Institute of Computing, UFAM / UFRJ, Brazil, rosiane@icomp.ufam.edu.br, *Rainer Xavier de Amorim*, *Bruno Cardoso Dias*, *Eduardo Uchoa*

Scheduling problems which involve due dates represent very important conditions of the real world, because when manufactured products are finished before its due date, this can bring undesirable costs such as inventory holding, and if products are finished after its due date, it can brings undesirable costs such as break of contracts. We discuss on these problems to propose some algorithmic strategies involving exact and heuristic methods. Computational experiments involving instances from the literature, with up to 300 jobs, and single and multi-machines with up to 10.

2 - Common Due Date, Early/Tardy Scheduling on a Single Machine with Deteriorating Jobs and Deteriorating Maintenance
Mehmet Taner, Industrial Engineering, TED University, TED University,, Ziya Gokalp Cad. No:48, Kolej, Ankara, Turkey, mehmet.taner@tedu.edu.tr, *Fatma Sirvan*

We study an NP-hard scheduling problem with position-dependent deteriorating jobs and a rate modifying activity (RMA) with the objective of minimizing the total weighted earliness and tardiness costs. A solution specifies the job sequence, the location of the RMA and the starting time of the schedule. We provide polynomial time solutions for some special cases, develop a mixed integer programming model for the general problem and a heuristic for larger instances. Computational results show that the proposed approach performs well in terms of both solution quality and computational efficiency.

3 - Bounds for the two-machine flowshop scheduling problem with minimum time lags
Hajer Amdouni, Laboratory of Operations Research for Industry (ROI), Polytechnic School of Tunisia, , Marsa - B.P. 743 2078, Tunisia, hajerelamdouni@yahoo.com, *Talel Ladhari*

In this work, we are concerned with developing new bounds for the two-machine flow shop scheduling problem with minimum time lags. In fact, we provide a new priority rule, a lower bound, a constructive heuristic and an iterated greedy local search procedure. In order to evaluate the performance of the proposed algorithms and lower bound we carried out a series of experiments based on a large set of randomly generated instances. The experimental results show that the proposed methods consistently yield near-optimal solutions in moderate CPU time.

4 - A new exact method for the single machine problem subject to release dates
Anis Kooli, Ecole Supérieure des Sciences Economiques et Commerciales de Tunis, 60, Rue Khadija Bent Khoualed. Menzeh 9C., 1013, Menzeh 9, Tunisia, anis.kooli@gmail.com, *Mehdi SErairi*

The single machine total completion time subject to unequal release dates is one of the most intensively investigated scheduling problems. It requires scheduling a set of jobs where each job is available at its release date and has to be processed, without preemption, during its processing time. We propose a new exact method based on a previously mathematical model. Valid inequalities are added in order to enhance the model representation. Experimental results show that our method exhibits a good performance and outperforms the best known branch-and-bound procedure found in the literature.

■ WA-22

Wednesday, 8:30-10:00
G6-2

Planning and Scheduling in Healthcare

Stream: Scheduling II
Invited session

Chair: *Johann Hurink*, Department of Applied Mathematics, University of Twente, P.O. Box 217, 7500 AE, Enschede, Netherlands, j.l.hurink@utwente.nl

1 - Comparing models for ambulance planning on the strategic and tactical level
Theresia van Essen, University of Twente, Postbus 217, 7500 AE, Enschede, Netherlands, j.t.vanessen@utwente.nl, *Melanie Reuter*, *Stefan Nickel*, *Johann Hurink*

Ambulance planning is done on different levels. The decision for base locations is usually made for a very long time (strategic level), but the number and location of used ambulances can be changed per year (tactical level). We present possible formulations for the problems on the different levels and discuss solution approaches that solve both levels either simultaneously or separately.

2 - A two-step patient scheduling procedure
Michael Samudra, Faculty of Economics and Business, KU Leuven, Naamsestraat 69 - bus 3555, 3000, Leuven, Belgium, samudra@kuleuven.be, *Erik Demeulemeester*, *Brecht Cardoen*

Traditionally, surgeries are scheduled directly to slots (OR and day). A substitute, a two-step procedure, schedules patients to a surgery week first and, in a second step, to an exact day and OR. The first step, the week assignment, is carried out at the moment the decision for surgery is made. The second step, the within week scheduling, is carried out every Friday afternoon collectively for all the patients assigned to the following week. We discuss the implications of applying this two-step procedure using the real data and the managerial insights from one of Europe's largest hospitals.

3 - Robust operating room schedules considering multiple stakeholders' interests
Brigitte Werners, Fac. of Management and Economics, Ruhr-University Bochum, Universitätsstr, 44780, Bochum, Germany, or@rub.de, *Sebastian Rachuba*

Uncertain demands such as surgery durations or emergency patients have a major impact on operating room schedules and their performance with respect to different stakeholder's interests. We investigate different robust schedules at an operational planning level in terms of the objectives waiting time, overtime and the number of patients treated. We propose a new fuzzy multicriteria optimization approach to determine robust schedules. Randomly generated scenarios indicate that these robust schedules are very close to individually optimal objective values and provide an excellent compromise.

4 - Clustering Clinical Departments for Wards to Achieve a Prespecified Blocking Probability
Johann Hurink, Department of Applied Mathematics, University of Twente, P.O. Box 217, 7500 AE, Enschede, Netherlands, j.l.hurink@utwente.nl, *Theresia van Essen*

When the number of available beds in a hospital is limited and fixed, it can be beneficial to cluster several clinical departments such that the probability of not being able to admit a patient is acceptably small. The clusters are then assigned to the available wards such that enough beds are available to guarantee a blocking probability below a prespecified value. We give an exact formulation of the problem and introduce two heuristic solution methods. Furthermore, we present some computational results based on data of a Dutch hospital.

■ WA-23

Wednesday, 8:30-10:00
G6-3

Neural Networks and Applications

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Hans-Jörg von Mettenheim*, Leibniz Universität Hannover, Institut für Wirtschaftsinformatik, Königsworther Platz 1, 30167, Hannover, Germany, mettenheim@iwi.uni-hannover.de

1 - Modeling and Trading the EUR Exchange Rates with NNs and Hybrid Genetic Algorithms — Support Vector Regression Forecast Combinations
Georgios Sermpinis, University of Glasgow, G12 8QQ, Glasgow, United Kingdom, Georgios.Sermpinis@glasgow.ac.uk, *Andreas Karathanasopoulos*, *Charalampos Stasinakis*

The motivation of this paper is to introduce a hybrid Genetic Algorithm — Support Vector Regression (GA-SVR) model for optimal parameter selection and feature subset combination. Our algorithm is applied to the task of forecasting and trading the EUR/USD, EUR/GBP and EUR/JPY exchange rates. The proposed model genetically searches over a feature space (pool of individual forecasts) and then combines the optimal feature subsets (SVR forecast combinations) for each exchange rate. The individual forecasts are derived from several linear and non-linear models such as four NNs.

2 - Forecasting short-term oil prices using a combination of data mining models
Sylvain Barthélémy, TAC sas, La Saigeais, 35140, Saint Hilaire des Landes, France, sylvain.barthelemy@tac-financial.com, *Thierry Apoteker*, *Benjamin Trempont*

It is when the complexity of causal chains between macro events and oil prices is at a peak that the use of formal quantitative tools can be most helpful. The paper presents a short-term oil price forecasting tool that combines Self-Organizing Maps, Support Vector Machines and Random Forest. Back tested since 2000, the model gives impressive results over the 6-months horizon. It captures very large short-term gyrations, but it is also useful in the evaluation of the respective roles of the different forces affecting oil prices (supply/demand, speculative aspects, ...).

3 - Pricing and Forecasting of High-Frequency Options on Currency Futures with Fast Neural Networks
Christian von Spreckelsen, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, 30167, Hannover, Germany, spreckelsen@iwi.uni-hannover.de, *Hans-Jörg von Mettenheim*, *Michael H. Breitner*

Due to the difficulty of option valuation, we provide an alternative heuristic option pricing approach with neural networks. We show that the use of neural networks is not only suitable in generating fast runtime option pricing evaluation, but also in predicting future prices. An essential advantage of our approach is the simultaneous pricing across different strike prices and parsimonious use of input variables. To achieve this, we conduct an empirical simulation with a tick data set of EUR/USD options on currency futures of four weeks.

4 - Directional Forecasts of Financial Markets with Neural Network Ensembles
Hans-Jörg von Mettenheim, Leibniz Universität Hannover, Institut für Wirtschaftsinformatik, Königsworther Platz 1, 30167, Hannover, Germany, mettenheim@iwi.uni-hannover.de

Traditional forecasting application often focus on point forecasts. Correspondingly these applications use the sum of squared errors (or a similar measure) to assess the error. For financial applications it is rather the economic performance of the forecast that counts. That means that we should evaluate the forecast with respect to risk-adjusted return. Neural network ensembles offer a straightforward way of combining both approaches. On the one hand the traditional point forecast is possible. On the other hand the distribution of outcomes helps in assessing the behavior of the time series.

■ WA-24

Wednesday, 8:30-10:00
G6-4

General Employee Scheduling

Stream: Timetabling and Rostering
Invited session

Chair: *Nysret Musliu*, Vienna University of Technology, 1040, Wien, Austria, musliu@dbai.tuwien.ac.at

1 - Analyzing the Features of Employee Scheduling Problems
Nysret Musliu, Vienna University of Technology, 1040, Wien, Austria, musliu@dbai.tuwien.ac.at

We analyze the existing benchmark examples in the literature for employee scheduling. Our primary domains are areas of work that include one or more of these problems: shift scheduling, break scheduling, and workforce scheduling. We extract the common constraints and objectives that are used in these problems and propose a formulation of generalized employee scheduling problem that covers different problems that appear in practice. This is necessary to be able to develop solving methods that can be used in a broad range of domains.

2 - Using the PEAST algorithm to solve all the phases of the workforce scheduling process
Kimmo Nurmi, Research and Development, Satakunta University of Applied Sciences, Tiedepuisto 3, 28600, Pori, Finland, cimmo.nurmi@samk.fi, *Nico Kyngäs*, *Jari Kyngas*

Workforce scheduling is a difficult and time consuming problem that every company that has employees working on shifts or on irregular working days must solve. The process includes seven phases: workload prediction, preference scheduling, shift generation, days-off scheduling, resource analysis, partitioning and staff rostering. We use the PEAST algorithm to solve all the phases of the workforce scheduling process. The algorithm has been integrated into market-leading workforce management software in Finland. We will present some real-world cases the algorithm has been used to solve.

3 - StaffLogic - workforce optimization solution
Peep Miidla, Institute of Mathematics, University of Tartu, Liivi 2, 50409, Tartu, Estonia, peep.miidla@ut.ee, *Marko Saviauk*

Workforce scheduling is a known issue, important for increasing the efficiency of enterprises. This procedure draws together enterprise management, human resources and budgeting. StaffLogic (http://www.stafflogic.eu/) is a WFO software that allows automated shift scheduling, analytics management reporting and payroll system integration. In this ACO algorithm is realised. StaffLogic offers corporations of all sizes a scheduling and reporting procedure. It also consolidates data for employment planning, scheduling, reporting and analysis. Proven results are up to 10% savings in labor cost.

4 - A three-stage model for scheduling and rostering of ground-handling personnel in an International Airport
Pablo A. Rey, Industrial Engineering, Universidad Diego Portales, Vergara 432, Santiago, Chile, pablo.rey@udp.cl, *Cristián Cortés*, *Juan Pablo Cavada*, *Gustavo Henríquez*

We deal with the personnel scheduling and rostering problems of the main ground-handling operator at the Santiago international airport. Our objective is to find a monthly schedule for more than seven hundred employees with different skills and tasks. The schedule must satisfy operational requirements and comply with life quality constraints. We split the problem in three stages, solved sequentially: daily shift-planning, monthly rostering and shift assignment. All stages are integer programming models. Results are promising and outperform the current company planning in many aspects.

■ WA-25

Wednesday, 8:30-10:00
G9-1

Artificial Intelligence

Stream: Artificial Intelligence, Fuzzy systems (contributed)
Contributed session

Chair: *Ozge Surer*, Industrial Engineering, Istanbul Technical University, ITU Isletme Fakultesi, Macka, 34357, Istanbul, Turkey, surer@itu.edu.tr

1 - Composition of web services for passage in the ladder by finites states automats
Nadia Halfoune, Computer Science Department,, A/Mira University of Béjaia, Route de Targua Ouzemour, A/Mira University of Béjaia, 06000, Bejaia, Algeria, n_halfoune2011@yahoo.fr, *Khaled Sellami*, *Rachid Chelouah*, *Djamal Dris*, *Hubert Kadima*

The main goal of our work is to ensure a precise composition of business services. We use business protocols to model the exchanges between the different entities (supplier, consumer, intermediaries). Our work is based on the technology of Web services and the finite state machines to define our approach of services composition. In this work, we present an improvement of an existing algorithm of consumer-server composition. Then, we develop two new algorithms of composition: series composition and parallel composition of Web services.

2 - Identical Parallel Machine Scheduling To Minimize Total Tardiness
Serafettin Alpay, Industrial Engineering, Eskisehir Osmangazi University, Meselik, 26480, ESKÝÞEHÝR, Turkey, salpay@ogu.edu.tr

In this study, an identical parallel machine scheduling problem with the objective of minimizing of total tardiness is addressed while considering a job splitting property of the jobs. Because the problem is NP-hard, an hybrid genetic algorithm (HGA) is proposed. Several test problems are solved via HGA and its performance is compared to solutions obtained via other search heuristics from the literature. The results indicate that the total tardiness performance of HGA is superior to that of other heuristics for all test problems.

3 - Simulated Annealing Algorithm with Variable Cluster Number and Comparison with K-Means Algorithm
Ozge Surer, Industrial Engineering, Istanbul Technical University, ITU Isletme Fakultesi, Macka, 34357, Istanbul, Turkey, surer@itu.edu.tr

The clustering problem is known to be an NP-complete problem. Heuristic algorithms are applied to overcome the disadvantages of K-means algorithm which is the most common clustering algorithm. Although we don't know the exact number of cluster numbers, K-means algorithm requires a user to give out the number of clusters at the beginning of the clustering algorithm. In order to solve this problem, simulated annealing algorithm with variable string length is offered. The proposed algorithm can find an appropriate number of clusters by maximizing the similarities between the data.

4 - Risk Analysis with Prat and Fuzzy Logic
Nilsu Abalı, industrial engineering, pamukkale university, Erenler district 318 Street no: 11 yavuz apartment Floor: 3 Servergazi, 20055, denizli, Turkey, nil_su_1991@hotmail.com, *Aliye Ayca Supciller*

The biggest problem all over the world in terms of the increasing industrialization of risks to which the employer has a legal obligation and businesses around the world have been risk analysis. PRAT risk analysis methods used in this study. This method scoring factors vary from person to person. So, this method can be subjectively. Fuzzy logic is used for the prevention of subjectivity. The values which obtained from PRAT is used in fuzzy logic. MATLAB program was used for all fuzzy logic operations. Finally, the results of the two application methods are compared.

■ WA-26

Wednesday, 8:30-10:00
G9-7

Combinatorial Optimization Problems in Transportation

Stream: Combinatorial Optimization I
Invited session

Chair: *Valentina Cacchiani*, DEI, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, valentina.cacchiani@unibo.it

1 - Configuring a MILP formulation for rail traffic management
Paola Pellegrini, IFSTTAR, France, paola.pellegrini@ifsttar.fr, *Grégory Marlière*, *Joaquin Rodriguez*

Rail traffic management consists in optimizing perturbed traffic selecting train routing and scheduling. In this study, we propose different sets of valid inequalities for boosting the performance of a MILP formulation in terms of computation time. We apply an automatic algorithm configuration procedure for selecting both the appropriate sets of inequalities and the solver parameter settings to be applied for tackling traffic perturbations in different infrastructures. Our results show that the performance of the formulation improves significantly when the appropriate configuration is used.

2 - Ultra short term rescheduling of railway rolling stock
Gabor Maroti, Logistics, Innovation and Information, VU University Amsterdam, De Boelelaan 1105, 1105 HV, Amsterdam, Netherlands, g.maroti@vu.nl

Exceptional weather can severely disrupt busy railway networks. Even if a forecast is available beforehand, the planning process takes weeks, thus the adjustments are usually done in real-time dispatching, often leading to insufficient seat capacities.

In this talk we show how advanced OR models help the Dutch railway operator NS to reschedule the rolling stock with a through-put time of less than a day. The main goal is to match the allocated seat capacity to the demand figures. The method was implemented in the winter of 2013.

3 - Resource Constrained Shortest Paths with Side Constraints and Non Linear Costs
Stefano Gualandi, Matematica, Università di Pavia, via Ferrata, 1, 27100, Pavia, Italy, Italy, stefano.gualandi@gmail.com, *Federico Malucelli*, *Samuela Carosi*, *Francesco Bernazzani*

Several transportation problems require the solution of Resource Constrained Shortest Paths problems with Side Constraints and Non Linear Costs. This path problems arise, for instance, as subproblems in Column Generation approaches to Vehicles and Crew Scheduling. We present a constrained path solver that exploits as much as possible cost fixing procedures based on the solution of Lagrangian relaxations. We present computational results on real life instances obtained by a commercial Crew Scheduler that embeds our path solver in a Column Generation algorithm.

4 - Models and heuristic algorithms for an integrated fleet-assignment, aircraft-routing and crew-pairing problem
Valentina Cacchiani, DEI, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, valentina.cacchiani@unibo.it, *Juan José Salazar González*

We study an integrated fleet-assignment, aircraft-routing and crew-pairing problem of an airline flying between Canary Islands. There are two bases. The company is subdivided in three operators. There are no flights during the night. A crew route leaves from and returns to the same base. An aircraft route starts from one base and arrives at the other base due to maintenance requirements. Therefore some crews must change aircrafts, which is an undesired operation. We present mathematical models and heuristic algorithms for the problem. Computational results on real-world instances are given.

■ WA-27

Wednesday, 8:30-10:00
G9-8

Robust Combinatorial Optimization

Stream: Combinatorial Optimization II
Invited session

Chair: *Ivana Ljubic*, Department of Statistics and Operations Research, University of Vienna, Bruennerstr. 72, 1210, Vienna, Austria, ivana.ljubic@univie.ac.at

1 - On Exact Solutions for the Minmax Regret Spanning Tree
Eduardo Álvarez-Miranda, Dipartimento di Elettronica, Informatica e Sistemistica, Università di Bologna, Viale del Risorgimento 2, 40136, Bologna, BO, Italy, e.alvarez@unibo.it, *Francisco Javier Pérez Galarce*, *Alfredo Candia-Véjar*, *Paolo Toth*

We study the Minmax Regret Spanning Tree (MMR-ST) problem. This is a generalization of the well-known Minimum Spanning Tree problem, which considers uncertainty in the cost function. It is assumed that the cost associated with each edge is an interval whose lower and upper limits are known, and the Minmax Regret is the optimization criterion. The MMR-ST problem is an NP-Hard optimization problem for which exact and heuristic approaches have been proposed. We computationally compare several exact algorithms and we show that a proposed branch-and-cut approach outperforms the other approaches.

2 - Robust Round Weighting with Traffic Uncertainty in Wireless Mesh Networks
Christelle Caillouet, Univ. Nice Sophia Antipolis, France, christelle.caillouet@inria.fr, *Arie Koster*

Wireless Mesh Networks have attracted attention because of the advantages of these broadband access networks. The Round Weighting Problem has been addressed as an effective relaxation of the joint routing and scheduling in the case of steady state operating networks. We propose a new robust model considering traffic demand uncertainty,

efficiently solved by column generation, and quantify the price of robustness, i.e., the additional cost to pay in order to obtain a feasible solution for the robust scheme. Results show that the robust approach has the potential to outperform existing methods.

3 - Valid inequalities and lifting for the 0-1 Gamma-robust knapsack problem
Stefano Coniglio, Lehrstuhl II fuer Mathematik, RWTH Aachen University, Wüllnerstr. 5b, 52062, Aachen, Germany, stefano.coniglio@gmail.com, *Christina Büsing*, *Arie Koster*
We consider the 0-1 Gamma-robust knapsack problem where the knapsack weights are random variables with known given nominal values and where at most Gamma of them are allowed to simultaneously deviate up to given upper bounds. We present a new valid inequality which, although connected to robust covers, differs from robust cover inequalities. We address robust lifting for (robust) cover inequalities aiming at extending superadditive lifting from the nonrobust to the robust case. Similar techniques are also studied to extend (a stronger version of) weight inequalities to the Gamma-robust case.

4 - Multiband Robust Optimization
Fabio D'Andreagiovanni, Department of Optimization, Zuse-Institut Berlin (ZIB), Takustrasse 7, 14195, Berlin, Germany, d.andreagiovanni@zib.de, *Christina Büsing*
Multiband Robust Optimization (Büsing & D'Andreagiovanni 2012) is a new approach to optimization under uncertainty, that refines the classical Bertsimas-Sim model (BS). The basic idea is to break the single band of BS into multiple bands, so to allow a less conservative representation of arbitrary-shaped uncertainty distributions. We show that: 1) the robust counterpart of an MIP is compact and linear; 2) the separation of robustness cuts can be formulated as a min-cost flow problem. We also present special properties of uncertain 0-1 Programs and probability bounds of constraint violation.

■ WA-28

Wednesday, 8:30-10:00
G9-2

Stochastic optimization in telecommunications and ICT economics

Stream: Stochastic Programming
Invited session

Chair: *Alexei Gaivoronski*, Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz vei 1, 7491, Trondheim, Norway, alexei.gaivoronski@iot.ntnu.no

1 - Target Costing under Uncertainty and Risk - An Application to ICT Services
Denis Becker, Trondheim Business School, HIST, Norway, Denis.Becker@hist.no, *Alexei Gaivoronski*
Target costing is an important methodology to manage a firm's future profits by explicitly including target costs in the product or service development process. The purpose of this paper is to integrate target costing with modern concepts for modeling uncertainty and risk management. We develop several decision support models for risk management in the context of target costing and apply it to the provision of advanced ICT services where the level of uncertainty is considerable.

2 - Stochastic Programming Approaches for Workforce Scheduling of Call-Centers under Uncertain Demand Forecasts
Mathilde Excoffier, Informatique, LRI (Paris-Sud-CNRS), Batiment 650, Université Paris, 91405, Orsay Cedex, France, mathilde.excoffier@lri.fr, *Celine Gicquel*, *Abdel Lisser*
Call centers are essential infrastructures but loom large in a company budget. An important way to reduce costs is the staffing optimization: how many agents should be hired to minimize costs without penalizing the expected Quality of Service? We model a call-center after a queueing system and consider the distribution of arrival times as a computed forecast subjected to uncertainty. We chose a stochastic programming approach to propose a staffing solution, first with a disjoint chance-constraint formulation and then with a joint chance-constraint formulation. Preliminary results are given.

3 - Stochastic Vehicle Routing
Nadine Wollenberg, Mathematic, Universitiy of Duisburg-Essen, Germany, nadine.wollenberg@uni-due.de, *Rüdiger Schultz*
In this talk stochastic programming is adapted to a special class of vehicle routing problems (VRP). The underlying deterministic basic model is an extension of the VRP involving both delivery and pickup points. For the stochastic model we assume that the quantities to be delivered are fixed and known in advance, whereas the quantities to be picked up are uncertain. Solution approaches are based on Lagrangean relaxation of nonanticipativity leading to a scenario decomposition. The single scenario subproblems are solved with column generation.

■ WA-29

Wednesday, 8:30-10:00
G9-3

Queues with strategic customers

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Apostolos Burnetas*, Mathematics, University of Athens, Panepistemiopolis, 15784, Athens, Greece, aburnetas@math.uoa.gr

1 - Wait or share service? Customers' choice at the equilibrium
Erim Kardes, ozyegin university, Turkey, erim.kardes@ozyegin.edu.tr
Consider a duopoly where one firm processes orders according to a first-come first-served discipline and the other serves all orders simultaneously. Considering customers who individually wish to minimize the expected time until the end of their service, we model the situation in terms of a stochastic game among the customers. If a Nash equilibrium exists, it is shown that it is the unique equilibrium point. It turns out that the firm sharing its resources must serve at a speed at least 15% faster than its competitor to guarantee a minimum market share of 50%.

2 - Strategic Behavior in a Queueing System in Random Environment
Athanasia Manou, Department of Mathematics, University of Athens, Greece, athmanou@math.uoa.gr, *Antonis Economou*
We consider an M/M/1-type queueing system evolving in a random environment, modeled by a CTMC with finite number of states. This random environment influences the arrival and service rates. We assume that the arriving customers decide whether to join the system or balk, based on a natural cost-reward structure which is imposed on the system. We study the balking behavior of customers under various level of information.

3 - Strategic Customers In Queues Considering Quality Issues
Fikri Karaesmen, Dept. of Industrial Engineering, Koc University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, fkaraesmen@ku.edu.tr, *Görkem Sarıyer*, *Zeynep Aksin*
We consider queueing models with strategic customers where we allow for the possibility of an unsatisfactory service: a customer receives satisfactory service with probability q, while with the probability 1-q, she leaves the system unsatisfied. We then consider different possibilities for resolution: customers returning to the same server or to the same pool of servers, and customers being escalated to another server subsequent to service failure. With the assumption of a profit maximizing service provider, we explore optimal pricing and quality decisions for service failure resolution.

4 - Customer Equilibrium Policies in Observable Queues for Multiple Periods
Apostolos Burnetas, Mathematics, University of Athens, Panepistemiopolis, 15784, Athens, Greece, aburnetas@math.uoa.gr

We consider a Markovian queue which operates in a finite number of periods, reaching steady state within each period. Arriving customers observe the queue length upon arrival and decide whether to join the queue, or not join and postpone the decision for the next period. In the last period the decision is join/balk. We show that there exist multi-period equilibrium threshold strategies. We also consider the problem of social welfare maximization and the relationship between equilibrium and optimal strategies.

■ WA-30

Wednesday, 8:30-10:00
G9-10

In memory of Francesco Maffioli

Stream: Graphs and Networks
Invited session

Chair: *Edoardo Amaldi*, DEI, Politecnico di Milano, Piazza L. Da Vinci 32, 20133, Milano, Italy, amaldi@elet.polimi.it
Chair: *Federico Malucelli*, Elettronica ed Informazione, Politecnico di Milano, Via Ponzio 34/5, 20133, Milano, Italy, malucell@elet.polimi.it

1 - FlowLoc: Simultaneous Solution of Flow and Location Problems
Horst W. Hamacher, Mathematics, University of Kaiserslautern, 67653, Kaiserslautern, Germany, hamacher@mathematik.uni-kl.de, *Stephanie Heller*

In FlowLoc problems we consider optimal network flows computed before a location decision and afterwards. The goal is to find a location decision minimizing the difference between the resulting two objective values. We propose solution algorithms for maximal, multiterminal and min cost FlowLoc problems, discuss their theoretical complexity and present results of numerical tests. After generalizing flow network to regular matroids, matroidal FlowLoc problems and their special cases (e.g. TensionLoc) are presented.

2 - A new formulation for the tool switching problem
Martine Labbé, computer Science, Université Libre de Bruxelles, CP210/01, Boulevard du Triomphe, 1050, Bruxelles, Belgium, mlabbe@ulb.ac.be, *Daniele Catanzaro*, *Luís Gouveia*

Assume that N jobs must be processed on a machine having a magazine that can contain at most C tools. If the tools needed for a job are not in the magazine, then one or more tool switches must occur before the job can be processed. The tool switching problem consists in determining the sequence of jobs which minimizes the number of switches and can thus be seen as a variant of the TSP with a special objective. We present an new formulation for this problem and show that it is much more efficient than an existing formulation, previously proposed by Laporte et al. (IIE Transactions, 2004).

3 - Formulations and Solution Algorithms for the Minimum 2-Connected Dominating Set Problem
Nelson Maculan, UFRJ-COPPE / PESC, Universidade Federal do Rio de Janeiro, 21941-972, Rio de Janeiro, RJ, Brazil, maculan@cos.ufrj.br, *Abílio Lucena*, *Vinicius Leal do Forte*

Abstract The Minimum 2-Connected Dominating Set Problem is to find a 2-connected dominating sets of minimum cardinality. Applications of this problem can be found in the design of ad-hoc wireless sensor networks, in the design of defense strategies against the attack of worms in peer-to-peer networks, and as models to investigate protein-protein interactions. Three mixed integer programming formulations, valid inequalities, a primal heuristic, and Branch-and-Cut algorithms for this problem will be presented.

4 - Optimizing Automated Packing Lines
Mauro Dell'Amico, DISMI, University of Modena and Reggio Emilia, Via Amendola 2, 42122, Reggio Emilia, Italy, dellamico@unimore.it, *Enrico Bartolini*

Identical packing machines are arranged on a line above a conveyor-belt which transports items from left to right. Boxes are transported by a second belt moving in the opposite direction. Each machine consists of a robotic arm that can grab an item at a time from the first belt and pack it into a box on the second belt. The objective is to pack as much items as possible. We model the problem as a 3-dimensional assignment problem with special objective function. We study the computational complexity, derive special easy cases and propose solution methods.

5 - Network routing subject to max-min fair flow allocation
Edoardo Amaldi, DEI, Politecnico di Milano, Piazza L. Da Vinci 32, 20133, Milano, Italy, amaldi@elet.polimi.it, *Stefano Coniglio*, *Leonardo Taccari*

Max-Min Fairness (MMF) is attracting a growing attention in multi-commodity networks. Since the MMF paradigm allows to approximate the TCP flow allocation when the routing paths are given and the flows are elastic, we address the problem where, given a graph with arc capacities and a set of origin-destination pairs with unknown demands, we must route each commodity over a single path so as to maximize the throughput, subject to the constraint that the flow allocation is MMF. We discuss properties of the problem, describe a column generation approach and report computational results.

■ WA-31

Wednesday, 8:30-10:00
G9-11

Retail Inventory Management II

Stream: Demand and Supply Planning in Consumer Goods and Retailing
Invited session

Chair: *Alexander Hübner*, Operations Management, Catholic University Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, Germany, alexander.huebner@ku-eichstaett.de

1 - Dynamic expiration dates for perishables
Michael Ketzenberg, Information and Operations Management, Texas A&M University, 320H Wehner, 4217 TAMU, 77843-4217, College Station, Texas, United States, mketzenberg@tamu.edu

We address the value of information to manage perishables in the context of a retailer that sells a random lifetime product under periodic review. The information available to the retailer corresponds to the time and temperature history that product experiences in the supply chain. Since this information largely determines product shelf life and is unique to the units of inventory flowing through the supply chain, the retailer can set expiration dates dynamically, based on known environmental conditions.

2 - A Two-Period Analysis for A Substitutable Product Inventory Control Problem with A Customer Satisfaction Measure
Genco Fas, Mathematics and Computer Sciences, Bahcesehir University, Ciragan Caddesi, Besiktas, 34353 , Istanbul, Turkey, gencofas@gmail.com, *Taner Bilgic*

We consider single and two-period formulations of a substitutable product inventory control problem with a customer satisfaction measure. Game starts with two given inventory and customer satisfaction levels for retailers. Players aim to maximize their profit and achieve the highest customer satisfaction to increase the market value of their companies. We investigate existence and uniqueness of best response functions as we consider three possible cases of effective demand and respective customer satisfaction. We show uniqueness of the NE under various conditions on the demand distribution.

3 - Constant approximation algorithms for the one warehouse multiple retailers problem with backlogging or lost-sales
Guillaume Massonnet, Grenoble INP, France, guillaume.massonnet@grenoble-inp.fr, *Jean-Philippe Gayon*, *Christophe Rapine*, *Gautier Stauffer*

The One Warehouse Multi-Retailer (OWMR) problem and its special case the Joint Replenishment Problem (JRP) have been studied extensively in the classical case when demand has to be satisfied on time, but there are few results in the case where either backlogging or lost-sales are allowed. This work aims to fill this gap and present a simple algorithm that has a performance guarantee of three for the OWMR problem with backlogging, with mild assumptions on the cost structure. The guarantee of our algorithm is also improved to two in the case of immediate lost-sales or JRP with backlog.

4 - Dynamic replenishment policy with inventory-based financing
Jiye Xue, Decision Science and Managerial Economics, Chinese University of Hong Kong, PGH6, B103, CUHK, Hong Kong, Hong Kong, xjy1987112@gmail.com

In this paper, we address a classical multi-period inventory problem where a retailer can replenish its inventory using inventory-based financing scheme. The retailer's replenish decisions depend on her on-hand cash, current debt and inventory level. The objective is to maximize the retailer's expected terminal wealth at the end of the planning horizon. We derive structural properties of the optimal inventory and financing policies in ways that are useful to a business decision maker.

■ WA-32

Wednesday, 8:30-10:00
G8-1

Supply Chain Optimization I

Stream: Supply Chain Optimization
Invited session

Chair: *Ioannis Fragkos*, Management Science and Innovation, UCL, Spencer Park 10, Flat 8, SW1 2SX, London, United Kingdom, i.fragkos@ucl.ac.uk

1 - Shall we dance? A game theoretic approach to coordinate the transportation and quantity discounts
Ginger Ke, Faculty of Business Administration, Memorial University of Newfoundland, St. John's, NL, Canada, gke@mun.ca, *James Bookbinder*

Although quantity discounts on purchased materials have been broadly examined, its analysis and coordination with the transportation discount is still in its infancy. Here we develop a tri-level programming approach to coordinate the supplier's and carrier's decisions on discount policies, when the quantity demanded is price-elastic. We show that this price-sensitivity is a key motivation for the supplier and carrier to offer discounts, and propose an algorithm to assist the two parties in establishing their discount schemes with consideration of the buyer's best response.

2 - Supply Chain Coordination using Automated Negotiations
Matthias Lech, Chair of Supply Chain Management, Europa-Universität Viadrina, Germany, Lech@europa-uni.de, *Christian Almeder*

The purpose of this research is the analysis of agent-based, automated negotiation schemes for supply chain coordination on an operational level. The idea is to provide a framework for fast coordination between independent members of a supply chain in order to improve the overall performance while avoiding exchanging sensitive information between the members. We investigate different negotiation schemes with and without mediator and study the effects of a mediator. Using various ideas from metaheuristics a new scheme is proposed and compared with existing ones.

3 - Determining optimal number of operators for the machine interference problem with several service types
Yossi Hadad, Industrial Engineering and Management, SCE - Shamoon College of Engineering, Balik Bazel, 8 Peretz Lasker St., Beer Sheva 84519, Israel, 84100, Beer Sheva, Israel, yossi@sce.ac.il, *Gregory Gurevich*, *Baruch Keren*, *Lea Friedman*

This research proposes a novel multinomial model for a special case of the machine interference problem, where each of N identical machines randomly requests several different service types. The model requires as inputs only the machine runtime and the average time of each service type that is needed to produce one unit of a product, and enables practitioners to determine the optimal numbers of operators that are needed for each service type in order to minimize the cost or maximize the profit. To demonstrate the applicability of the model a theoretical analysis and a case study are presented.

4 - Scheduling Maritime Transhipment Operations using Mathematical Programming
Ioannis Fragkos, Management Science and Innovation, UCL, Spencer Park 10, Flat 8, SW1 2SX, London, United Kingdom, i.fragkos@ucl.ac.uk, *Bert De Reyck*

We present a modelling framework for the scheduling of maritime transhipment operations of the Noble Group, a global supply chain manager of energy products, operating in 140 locations. We focus on coal operations, where coal is transported from mines to vessels using barges and floating cranes. Noble pays millions of dollars in penalties for delays, as well as for additional resources hired to minimize the impact of delays. Using a column-generation approach, we reduce the joint cost of penalties and additional resources, and improve the overall efficiency of the transhipment operations

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■ WA-33

Wednesday, 8:30-10:00
G8-3

Lot-Sizing and Related Topics 2

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Wilco van den Heuvel*, Econometric Institute, Erasmus University Rotterdam, P.O. Box 1738, 3000DR, Rotterdam, Netherlands, wvandenheuvel@ese.eur.nl

1 - A static-dynamic uncertainty strategy for the stochastic lot sizing problem with piecewise linear concave ordering costs
Onur A. Kilic, Department of Management, Hacettepe University, Turkey, onuralp@hacettepe.edu.tr, *Huseyin Tunc*, *Armagan Tarim*, *Burak Eksioglu*

We implement the static-dynamic uncertainty strategy in stochastic lot-sizing problems with piecewise linear concave ordering costs by employing the (R,S) policy as an alternative to the optimal (s,S) policy. This policy provides a rigid replenishment schedule while allowing flexibility in order quantities, and has the advantage of being free from setup-oriented nervousness. We present a computational method for the (R,S) policy, and conduct an experimental study reflecting upon the trade-off between setup-oriented nervousness and cost optimality under piecewise linear concave ordering costs.

2 - A two-phase iterative heuristic approach for the Production Routing Problem
Nabil Absi, Ecole des Mines de Saint-Etienne, EMSE - CMP - Site Georges Charpak, 880 route de Mimet, 13541 , GARDANNE, France, absi@emse.fr, *Claudia Archetti*, *Stéphane Dauzere-peres*, *Dominique Feillet*

We investigate the integrated optimization of production, distribution and inventory decisions related to supplying multiple retailers from a central production facility. A single-item uncapacitated lot-sizing problem is defined for optimizing production decisions and inventory

management. The optimization of daily distribution is modeled as a vehicle routing problem. A two-phase iterative method, from which several heuristics are derived, is proposed that iteratively focuses on lot-sizing and routing decisions. Computational results show that our best heuristic outperforms existing methods.

3 - Extending the Two-Period Convex Hull Closures for Lot-Sizing: Strengthening, Lifting and Computation
Kerem Akartunali, Management Science, University of Strathclyde, University of Strathclyde, Dept. of Management Science, G1 1QE, Glasgow, United Kingdom, kerem.akartunali@strath.ac.uk, *Ioannis Fragkos*

In recent work, a framework called 'two-period convex hull closure' was proposed for big-bucket lot-sizing problems, where the convex hull closures of the single-machine, multi-item, two-period subproblems are approximated to generate valid inequalities for the higher dimensional lot-sizing problem. In this talk, we discuss various strategies to strengthen the inequalities generated by this framework (particularly using coefficient strengthening and lifting), and present some computational results and experiences, along with some theoretical results. Joint work with A.J. Miller and T. Wu.

4 - Solving a multi-level lot-sizing problem with inventory bounds
Wilco van den Heuvel, Econometric Institute, Erasmus University Rotterdam, P.O. Box 1738, 3000DR, Rotterdam, Netherlands, wvandenheuvel@ese.eur.nl, *Hark-Chin Hwang*, *Stéphane Dauzere-peres*, *Albert Wagelmans*

We consider a serial supply chain with production at the first stage, warehouses at the intermediate stages and a retailer at the final stage. The retailer has a deterministic demand over a discrete and finite time horizon. One warehouse is the bottleneck with respect to inventory capacity. The goal is to find a minimal cost production and transportation plan. By exploiting the structure of extreme point solutions, we develop a polynomial time algorithm using a dynamic programming approach. Because of the high degree polynomial, we perform computational tests to examine its applicability.

■ WA-34

Wednesday, 8:30-10:00
G8-4

Supply chains: Coordination

Stream: Supply Chain Planning
Invited session

Chair: *Werner Jammernegg*, Department of Information Systems and Operations, Vienna University of Economics and Business, Nordbergstrasse 15, A-1090, Wien, Austria, werner.jammernegg@wu-wien.ac.at

1 - Power Structure and Profitability in Assembly Supply Chains
Lucy Gongtao Chen, NUS Business School, National University of Singapore, 15 Kent Ridge Drive, 119245, Singapore, Singapore, bizcg@nus.edu.sg, *Ding Ding*, *Jihong Ou*

This paper studies the impact of supply chain power structure on firms' profitability in an assembly system with one assembler and two suppliers. Between the assembler and each of her suppliers, either the supplier has dominating power and acts as the Stackelberg leader to set the wholesale price, or the assembler is more powerful and dictates the wholesale price paid to the supplier. We consider two power regimes and for each regime three power structures. We find that in assembly systems, firms should sometimes strategically yield the power.

2 - Centralized versus Decentralized Supply Chain
Eftychia Kostarelou, Mechanical Engineering, University of Thessaly, 38334, Volos, Greece, ekostarelou@yahoo.gr, *Georgios K.D. Saharidis*, *George Liberopoulos*

A good planning must be beneficial for the whole supply chain and for each participating company. As each company tends to optimize its own production unit and the centralized strategy cannot be applied in most cases, qualitative and quantitative analysis of the comparison of centralized and decentralized strategies is important. Three supply chains, with two or more stages in series and in parallel, have been studied. The results determine the conditions under which the two cases give the same optimal solution for each problem.

3 - Decentralized supply chain planning: a state-of-the-art
Atour Taghipour, Faculty of International Business, University of Le Havre, 24 Frederick Lemaitre, 76600, Le Havre, France, atour.taghipour@univ-lehavre.fr

Supply chain operations are generally planned hierarchically, through the central corporate planning unit, with a high degree of information exchanges. This lead to difficulties when independent members do not want to share information, such as cost, profit margin, inventory level or capacity utilization. In order to address these difficulties, decentralized approaches of coordination based on some minimal information sharing have been proposed in many academic disciplines. This paper first proposes a systematic review of these approaches, and then outlines some research opportunities.

4 - An Adaptive Large Neighborhood Search for the Environmentally-Extended Inventory Routing Problem
Stefan Treitl, Information Systems and Operations, WU Vienna University of Economics and Business, Nordbergstrasse 15, 1090, Vienna, Austria, stefan.treitl@wu.ac.at, *Pamela Nolz*, *Werner Jammernegg*

Inventory management is one of the crucial areas in petrochemical distribution systems. Especially the distribution of fuel to filling stations necessitates a detailed planning. In this work, we model the final leg of a (real) petrochemical supply chain, namely the delivery from depots to filling stations, by an Inventory Routing Problem. The model is extended to include environmental aspects of transportation and solved using an Adaptive Large Neighborhood Search algorithm. The results of the analysis underline the advantages of Vendor Managed Inventory for this type of distribution system.

■ WA-35

Wednesday, 8:30-10:00
G8-2

Network and capacity planning

Stream: OR Applications in the Automotive Industry
Invited session

Chair: *Achim Koberstein*, Business Administration, Goethe-University of Frankfurt, Grueneburgplatz 1, 60323, Frankfurt am Main, Germany, koberstein@wiwi.uni-frankfurt.de

1 - Multi- Period, Multi-Stage Supply Chain Design: Decomposition Approach
Amirhossein Sadoghi, Finance Department, Frankfurt School of Finance & Management, Sonnemannstraße 9-11, 60314, Frankfurt am Main, Germany, a.sadoghi@fs.de, *Helene Lidestam*

In this research, we propose the primal and dual decomposition methods for capacitated, multi-commodity, multi-period, multi-stage facility location problem. With increased number of facilities and time periods in the arc based or path based model, models becomes large and using efficient large scale optimization techniques to obtain a solution within limited time for the entire planning period is necessary. The numerical results of applying these techniques regarding to produce, distribute of forest residues are to be converted into fuel in the case of forest fuel supply chain are presented.

2 - Automotive Sector's Supply Chain Flexibility Metrics Measurement

Müjde Erol Genevois, Industrial Engineering, University of Galatasaray, Ciragan Cad. No. 36 Ortaköy, 34357, Istanbul, Turkey, merol@gsu.edu.tr, *H. Ziya Ulukan*

In an uncertain environment, flexibility is one of the most important firm capabilities needed to achieve competitive advantage. The possible behaviors of the company are called flexibility levers. In a supply chain the flexibility of one entity is highly dependent on the flexibility of upstream entities. It is a natural area for metrics which is a standard of performance measurement of the supply chain processes. This study aims to determine and evaluate the automotive sector supply chain flexibility metrics in order to calculate the benefit of preferring a flexibility levers to another one.

3 - A Hybrid Optimization-Simulation Modeling Approach for Stochastic Assembly Line Balancing

F. Tevhide Altekin, Sabanci School of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, altekin@sabanciuniv.edu

The stochastic assembly line balancing problem seeks a feasible assignment of tasks with stochastic task times to stations and involves incompletions whenever the work content of a station is not completed within the given cycle time. In this study, we assume task times are normally distributed and the objective is to minimize the expected total cost that involves both the station costs and incompletion costs. A hybrid optimization-simulation modeling approach that iteratively uses a MIP model and simulation is proposed. The results of our computational study are also presented.

4 - Integrated Strategic Planning of Global Production Networks and Financial Hedging under Uncertain Demand and Exchange Rates

Achim Koberstein, Business Administration, Goethe-University of Frankfurt, Grueneburgplatz 1, 60323, Frankfurt am Main, Germany, koberstein@wiwi.uni-frankfurt.de, *Elmar Lukas*

We present a multi-stage stochastic programming model for integrated planning of strategic production network design and financial hedging under uncertain demand and exchange rates. Financial portfolio planning decisions on two types of financial instruments, namely forward-contracts and options, are explicitly represented by multi-period decision variables and a multi-stage scenario tree. On the basis of an illustrative case study we show that the integrated model can result in better strategic planning decisions compared to traditional modelling approaches.

■ WA-36

Wednesday, 8:30-10:00
G7-1

Cutting and Packing 3

Stream: Cutting and Packing
Invited session

Chair: *Aline Leão*, Universidade de São Paulo, Rua Achille Bassi, 2717, ap.18, 13560-530, São Carlos, São Paulo, Brazil, aasleao@gmail.com

1 - Usable leftovers for two-dimensional cutting stock problems

Adriana Cherri, Mathematics, UNESP - Bauru, Av. Eng. Luiz Edmundo Carrijo Coube, 14-01, 17033-360, Bauru, SP, Brazil, adriana@fc.unesp.br, *Andréa Vianna*

The two dimensional cutting stock problem is taken into account where leftovers can be used in the future to meet new demands. Available retails in stock (objects that are leftovers from previous periods) are cut with higher priority in relation to others objects. To solve this problem, alterations were made to the AND/OR Graph approach and to some heuristic procedures of the literature. The performance of the proposed heuristics is analyzed on solving practical instances and randomly generated instances.

2 - An Iterated Greedy Algorithm for the Nesting Problem

Antonio Martinez Sykora, 3Departament d'Estadística i Investigació Operativa, Universitat de València, 46100, Valencia, Spain, antonio.martinez-sykora@uv.es, *Ramon Alvarez-Valdes*, *Maria Antónia Carravilla*, *A. Miguel Gomes*, *José Fernando Oliveira*, *Jose Tamarit*

We have developed an Iterated Greedy Algorithm for solving Nesting problems, that is, strip packing problems with non-rectangular pieces. The IGA combines a constructive algorithm (CA) based on the insertion of the pieces one at a time, a destructive phase and a local search phase. Since for each insertion a Mixed Integer Programming (MIP) model is solved to optimality, some parameters of the CA are changed along the process in order to adjust the complexity of the MIP model. Computational results show that IGA is competitive and improves the best known solution on several instances.

3 - Case study: the irregular cutting stock problem in shipbuilding

Wei-Chu Weng, Systems Engineering and Naval Architecture, National Taiwan Ocean University, No. 2, Pei-Ning Rd., 202, Keelung, Taiwan, Taiwan, pw@mail.ntou.edu.tw

An irregular cutting stock problem is to layout as many shapes as possible on a material sheet. In shipbuilding, the arranged shapes are very large so as to strengthen the ship hull. In addition, many of the shapes are concave. A two-stage nesting procedure is proposed to improve the result obtained by nesting all shapes once at a time. We use the NEST system as the tool. The NEST system is a compiled program embedded on AutoCAD. It uses BLF algorithm for nesting procedure and has been proved satisfying.

4 - A new mathematical formulation for the nesting problem

Aline Leão, Universidade de São Paulo, Rua Achille Bassi, 2717, ap.18, 13560-530, São Carlos, São Paulo, Brazil, aasleao@gmail.com, *José Fernando Oliveira*, *Franklina Toledo*

In nesting problems a big object with a fixed width and an infinite length has to be cut into a set of irregularly shaped small pieces, while minimising the object's used length. Due to its intrinsic difficulty, most of the methods proposed in the literature are heuristics. There exists only one integer linear model capable of evaluating the optimality gap and proving optimality for some well-known instances. An alternative continuous formulation is used to solve subproblems embedded in heuristics. We propose a new discrete-continuous formulation combining these two modelling approaches.

■ WA-37

Wednesday, 8:30-10:00
G7-4

Multicriteria Decision Making and Its Applications VIII

Stream: Multicriteria Decision Making II
Invited session

Chair: *Margaret Wiecek*, Department of Mathematical Sciences, Clemson University, Martin Hall O-208, 29634, Clemson, SC, United States, wmalgor@clemson.edu
Chair: *Yeliz Yolcu Okur*, Financial Mathematics, Middle East Technical University, Uygulamali Matematik Enstitüsü, S-Binasi, Ankara, Turkey, yyolcu@metu.edu.tr

1 - New Aspects of Expert Group Structuring in Multicriteria Decision Analysis

Mariya Sodenkamp, Business Information Systems, University of Paderborn, Warburger Str. 100, 33098, Paderborn, NRW, Germany, sodenkamp@dsor.de, *Leena Suhl*

We address the issue of group structuring and attempts to shed more light on the problem of decision makers' (DM) competences formalization. We distinguish among the alpha-, beta- and gamma-level DMs

responsible for a value system establishment, alternatives assessment and auxiliary objects evaluation. Experts can belong to either one or several task areas. The triples of alpha-, beta- and gamma-voting power indices assigned to the individuals depend on their authority. They are employed for scaling the priorities obtained from subjective judgments within the MCDA aggregation procedure.

2 - Multicriteria Modeling and Optimization of a market place of leads
Manel Maamar, Laboratoire Genie Industriel, Ecole Centrale Paris/Centrale Recherche, Grande Voie des Vignes, 92290, Châtenay-Malabry, France, manel.maamar@ecp.fr, *Vincent Mousseau*, *Wassila Ouerdane*

Place of Leads is a market place of "lead". This one faces a complex problem namely, "the assignment of the leads to the customers". The challenge with this problem is to take into account at the same time the optimization of multiple objectives and the real time aspect as well. To do that, we propose to formulate this problem as a multi-objective mathematical program and consider a stochastic model of the offer and request in the optimization step in order to take into account the continued evolution of flows of offer and request.

3 - A Dynamic Approach to Optimal Peer Selection in Peer-to-Peer Video-on-Demand Systems
Thibaud Rohmer, LISSI, UPEC, 122 Rue Paul Armangot, 94440, Vitry Sur Seine, France, thibaud.rohmer@gmail.com, *Amir Nakib*

Peer-to-Peer Video-on-Demand systems are rising as a new way to distribute video content. Although this approach improves the overall system scalability, it still poses new challenges such as peer resource allocation. Most work approach the problem with static strategies that fail to adjust in face of changing content demand. The proposed resource allocation system dynamically switches between strategies to optimally respond to predicted content popularity. The results show that using a dynamic resource allocation reduces the rejection rate while maintaining high diversification.

4 - Airport Site Selection Based on Choquet Integral: The Case of the Third Airport in Istanbul
Ömer Onur Kaya, Department of Industrial Engineering, Yildiz Technical University, Barbaros Bulvarı, Yıldız, 34349, Istanbul, Turkey, onurkay@gmail.com, *Nihan çetin Demirel*

As one of the most popular international tourist destinations, Istanbul currently has two airports which are insufficient to meet growing air traffic. Therefore, government officials have announced that they are planning to build the third airport, which will be the world's biggest. The announcement fires up debates over the location of the new airport. In this study, firstly, the potential alternative airport sites are determined by taking into account different aspects and then these alternatives are evaluated by using Choquet Integral in order to choose the most appropriate site.

■ WA-39

Wednesday, 8:30-10:00
G7-3

Regularity of vector optimization problems and applications and Optimality Conditions in Multicriteria Optimization

Stream: Vector- and Setvalued Optimization and Applications
Invited session

Chair: *Constantin Zalinescu*, Mathematics, University Al.I.Cuza Iasi, Bd. Carol I, nr. 11, 700506, Iasi, Romania, zalinesc@uaic.ro
Chair: *Marius Durea*, Mathematics, University Al. I. Cuza, 700506, Iasi, Iasi, Romania, durea@uaic.ro

1 - Calculus of tangent sets and derivatives of set-valued maps under metric subregularity conditions
Marius Durea, Mathematics, University Al. I. Cuza, 700506, Iasi, Iasi, Romania, durea@uaic.ro

In this talk we present some calculus rules for tangent sets in the sense of Bouligand and Ursescu, as well as for corresponding derivatives of set-valued maps. Both first and second-order objects are envisaged and the assumptions we impose are in terms of metric subregularity of the assembly of the initial data. This approach allows us to avoid compactness conditions. An application to a vector optimization problem is given and a special attention is paid for the case of perturbation set-valued maps which naturally appear in optimization problems.

2 - Metric regularity of composition set-valued mappings. Applications to vector optimization
Radu Strugariu, Mathematics, Technical University of Iasi, Carol 1 Bld., nr. 11, 700506, Iasi, Romania, rstrugariu@tuiasi.ro

The aim of the talk is to present recent developments regarding the regularity of some special types of multifunctions. We present a new method to obtain the openness at linear rate/metric regularity of composition set-valued mappings on metric spaces, based on several important concepts, such as the error bounds, the lower semicontinuous envelope of a set-valued map, and the local composition stability of multifunctions. Finally, we present some applications to multicriteria optimization problems.

3 - Fenchel-Rockafellar type formulas for the approximate weak subdifferential of set-valued mappings
Constantin Zalinescu, Mathematics, University Al.I.Cuza Iasi, Bd. Carol I, nr. 11, 700506, Iasi, Romania, zalinesc@uaic.ro

Recently, several authors have provided formulas (estimates) for the approximate weak subdifferential of the sum of two convex set-valued mappings. It is our aim to provide estimate for the approximate weak subdifferential of set-valued mappings of the type F + GoS with S a linear continuous operator under interiority and Attouch-Brezis qualification conditions; in the case of the sum our estimates improve the existing ones. As a byproduct, we deduce estimates for the strict subdifferential as well as for the Benson subdifferential.

4 - Location Problems with Attraction and Repulsion Points
Andrea Wagner, Mathematics, Martin-Luther-University Halle - Wittenberg, Theodor-Lieser-Straße 5, 06120, Halle/Saale, Germany, andrea.wagner@mathematik.uni-halle.de

We consider the problem of locating a new facility amongst a given number of attraction and repulsion points. The goal is to minimize the weighted sum of distances to attraction points and to maximize the weighted sum of distances to repulsion points. The corresponding objective function can be formulated as a d.c. function. We formulate a dual problem to the primal d.c. optimization problem and give some duality statements as well as optimality conditions.

■ WA-40

Wednesday, 8:30-10:00
Y12-1

DEA Applications I

Stream: DEA and Performance Measurement
Invited session

Chair: *Luka Neralic*, Faculty of Economics and Business, University of Zagreb, J. F. Kennedy 6, Stefaniceva 7, 10000, Zagreb, Croatia, lneralic@efzg.hr

1 - Performance of general insurance companies and life insurance in colombia, measured in an environment of relative efficiency
Gloria Rodriguez Lozano, Faculty of Economics Sciences, National University of Colombia, Ciudad Universitaria, Facultad de Ciencias Económicas Edificio 311 Of. 308, Bogota, Colombia, girodriguezl@unal.edu.co

To evaluate the good performance of the economy of a country, it is important to visualize the behavior of these companies, because they bear an important aspect of the economic future. This research shows the indicators DEA (Data Analysis Envelopment) on efficiency and productivity of these companies, with inputs and outputs extracted from reported financial statements for each entity supervising the Colombian.

2 - Preprocessing DEA: Point Domination
Athanasios Valiakos, Department of Informatics, University of Piraeus, 80 Karaoli & Dimitriou Str., 18534, Piraeus, Attiki, Greece, avaliakos@unipi.gr

In Non-Parametric Linear Problems, such as DEA, early identification of the group of efficient units would be of great advantage to decrease the number of LPs needed to be solved. Preprocessors are simple procedures that can provide initial information regarding the efficiency of a unit. By excluding inefficient ones, the efficiency frontier remains intact and the computational time is decreased. In this paper, a technique is proposed to detect and reject inefficient units by point domination. The number of the comparisons required is decreased from other approaches in literature.

3 - Isoefficiency in Production Possibility Set
Hirofumi Amatatsu, IT DHARMA Ltd, 1-14-12 Takara, 2720122, Ichikawa, Chiba, Japan, amatatsu@mint.ocn.ne.jp, *Tohru Ueda*

For any fixed efficiency score theta, the set of input x and output y vectors, where x produces y and efficiency score is theta, is called the theta level isoefficient. We present an algorithm to find the isoefficient set of vectors (x, y) and draw the sets in Production Possibility Sets. The algorithm provides all reference points to managers of DMU, which are theta level isoefficient although almost DEA models provide only one reference point. The isoefficiency algorithm also reveals the competitive structure among DMUs.

4 - An Application of Window Analysis of Data Envelopment Analysis
Luka Neralic, Faculty of Economics and Business, University of Zagreb, J. F. Kennedy 6, Stefaniceva 7, 10000, Zagreb, Croatia, lneralic@efzg.hr, *Dubravko Hunjet*, *Richard E. Wendell*

This paper studies the dynamic relative efficiency of 127 selected towns in the Republic of Croatia using window analysis of DEA. The towns, represented as DMUs, are characterized into four categories according to their respective populations. Using the number of employed workers and employed assets as inputs and income as an output, for each category window analysis is considered in the period 2004 - 2009 for some DEA models. The paper presents and analyses computational results on the dynamic relative efficiency of the towns.

■ WA-41

Wednesday, 8:30-10:00
Y12-5

Challenge EURO/ROADEF - Presentation 2

Stream: Challenge EURO/ROADEF
Sponsor session

Chair: *Eric Bourreau*, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr

1 - 2014 ROADEF/EURO Challenge start : Trains don't vanish !
Eric Bourreau, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr, *Christian Artigues*, *Safia Kedad-Sidhoum*, *Vincent Jost*, *François Ramond*

This challenge is an international contest aiming at solving an industrial optimization problem. Between duties, trains never vanish. Unfortunately, this aspect is often neglected in railway optimization approaches. In the past, rail networks had enough capacity to handle all trains without much trouble but this is not true anymore. This challenge propose by SNCF, the French railway company, consists in finding the best way to handle trains between their commercial duties, including temporary parking, shuntings on railway infrastructure facilities, using different storage facilities and tracks

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■ WA-42

Wednesday, 8:30-10:00
Y12-3

Policy Analytics 2

Stream: Policy Analytics
Invited session

Chair: *Giulia Lucertini*, Università degli Studi di Padova, via venezia 1, 35131, Padova, Italy, Italy, giulialucertini@hotmail.com

1 - How to improve decision making in public processes and public policy design
Clara Pusceddu, Department of Architecture, University of Sassari, 07041, Alghero, Italy, puscedd@uniss.it, *Paolo Mattana*, *Garau Giorgio*

In this paper we propose a critical assessment of the main results of the evaluation process carried forward by the Autonomous Region of Sardinia (Italy) in compliance with the Regional Policy Evaluation Plan (RPEP). The RPEP is a document providing guidance for the execution of ex post and in itinere impact evaluations of public choices. As such is required by the National Strategic Framework and is designed to identify objects and timesheets of the evaluation activities.

2 - A methodology to support a concerted approach when the context is non-collaborative
Maria Franca Norese, DISPEA Production Systems and Economics, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129, Torino, Italy, mariafranca.norese@polito.it, *Roberto Galliano*, *Diana Rolando*

A rigorous and flexible methodology can support the preliminary phases of complex public projects facilitating the operational steps and preparing the ground for a shared acceptance. Strategic Choice Approach helps to shape the problem, design and compare feasible solutions and control and risks. SCA has been applied to structure the decision process of a public project involving several towns in the Turin Province. We describe how this approach can be proposed in uncooperative contexts facilitating communication and collaboration among the Public Administrations and the involved stakeholders.

3 - Cognitive mapping for decision aiding: an application to the design of a vehicle sharing service
Alberto Colorni, Department of Industrial Design, delle Arti e della Comunicazione, Politecnico di Milano, c/o Metid, p.zza Leonardo da Vinci 32, 20133, Milano, Italy, alberto.colorni@polimi.it, *Alessandro Luè*, *Roberto Nocerino*

Green Move is a project aimed to design a vehicle sharing service for Milano. Four specific innovative service configurations have been identified, which may answer to different mobility pattern demand. In order to support the design of the configurations, we set up a multicriteria analysis, structured by means of cognitive maps. The structuring phase supported the mutual understanding between the researchers with different expertise and the territorial stakeholders, and the identification of causal networks to estimate the effects of the options.

4 - Facilitated Modelling workshops to face the Corridor 24 strategic development
Isabella Lami, Polytechnic of Turin, 10125, Turin, Italy, isabella.lami@polito.it, *Felix Guenther*, *Ilaria Tosoni*, *Francesca Abastante*, *L. Alberto Franco*

Starting from the study of the recent literature where the Facilitated Modelling (FM) workshops is the main focus of investigation (Rouwette, Franco 2011; Franco, Montibeller 2010, Rouwette et al 2002), we illustrate a series of workshops carried out in the last three years within a European project on the strategic development of portions and the whole Corridor Rotterdam-Genoa. The work describes

how different aspects of the problem situation were introduced, developed, and agreed upon by group members; and assess how the deployment of a particular FM workshop design affected this process.

■ WA-43

Wednesday, 8:30-10:00
Y12-2

Knowledge Management & Decision Systems

Stream: Decision Support Systems
Invited session

Chair: *Shaofeng Liu*, School of Management, University of Plymouth, PL4 8AA, Plymouth, United Kingdom, shaofeng.liu@plymouth.ac.uk
Chair: *Fatima Dargam*, SimTech Simulation Technology, Ries Strasse 120, 8010, Graz, Austria, F.Dargam@SimTechnology.com

1 - A BI integrated platform to support dynamic and global resources allocation decisions
Isabelle Linden, Departement of Business Administration, University of Namur, 8 rue Rempart de la Vierge, 5000, Namur, Belgium, isabelle.linden@fundp.ac.be, *Shaofeng Liu*

Most commonly used Business Process Management Engine are focused on the control-flow management. Regarding resources management, the modelling languages mainly focus on role-defined human resources allocation. At run-time, the resource allocation is managed at case level. By integrating a Business Intelligence tool in a resource-aware business process management platform, we offer global views on resource occupation and aim to enhance decision support regarding both human and non-human resources management at run-time.

2 - Knowledge Network Modelling to Support Decision Making for Strategic Intervention in IT Project-Oriented Change Management
Ali ALkhuraiji, School of management, University of Plymouth, University of Plymouth, Cookworthy Building, PL4 8AA , Plymouth, Devon, United Kingdom, ali.alkhuraiji@plymouth.ac.uk, *Shaofeng Liu*, *Fenio Annansingh*, *Jiang Pan*

This research is concerned with knowledge management to enhance decision support for strategic intervention in IT project-oriented change management. Three key issues are identified: insufficient knowledge traceability based on the relationships between knowledge elements; lack of procedural knowledge to provide adequate policies to guide implementation; and lack of "lessons learned" documentation. A Change Management Knowledge Network Model is proposed to provide traceability and connection of procedural knowledge to "lessons learned". Practitioners can use it to improve decision making.

3 - Knowledge Management: An Empirical Analysis of Reuse
Daniel OLeary, University of Southern California, United States, oleary@usc.edu

Researchers have noted that there is limited knowledge reuse in knowledge management systems. Accordingly, this paper investigates factors associated with reuse in order to facilitate better understanding of that issue. In particular, this paper empirically investigates the reuse of knowledge using three different sets of real-world data gathered by a large information technology consulting firm for internal purposes.

4 - Optimising Inventory Level of Global Critical Knowledge for Integrated Decision Support
Jiang Pan, Business School, Plymouth University, 203 Citadel Road East, Hoe, Plymouth, UK, PL1 2JF, Plymouth, Devon, United Kingdom, jiang.pan@plymouth.ac.uk, *Shaofeng Liu*, *Sarah Tuck*, *Ali ALkhuraiji*

Too much unnecessary knowledge held and maintained in an organisation is a type of waste. This problem deteriorates in the context of global supply chain management. In order to deal with this problem, this paper proposes a lean knowledge inventory model (Lean-KIM) which integrates the Lean philosophy into knowledge management to support coherent decision making across global supply chains. Facilitated by this model, the critical knowledge will be captured, retained and updated at an optimised inventory level. Therefore, the efficiency and effectiveness of decision making can be improved.

■ WA-45

Wednesday, 8:30-10:00
Y10-3

Applications of cooperative games

Stream: Cooperative Game Theory
Invited session

Chair: *Sirma Zeynep Alparslan Gok*, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and Sciences, Suleyman Demirel University, Department of Mathematics, 32260, Isparta, Turkey, zeynepalparslan@yahoo.com
Chair: *Osman Palanci*, Mathematics, Suleyman Demirel University, Suleyman Demirel University, Department of Mathematics, 32260, Isparta, Turkey, osmanpalanci@sdu.edu.tr

1 - On minimum cost spanning tree problems considering cooperation structures
Yoshifumi Kusunoki, Osaka University, Japan, kusunoki@eei.eng.osaka-u.ac.jp, *Tetsuzo Tanino*

A minimum cost spanning tree problem (mcstp) deals with a situation where agents intend to be connected to a source at connection costs as cheap as possible. Conventional studies for mcstp implicitly assume cooperation among any coalition of agents. In this study, we consider cooperation structures where some coalitions are infeasible. Such structures are represented by feasible coalition systems, which have been studied in cooperative game theory. We define feasible trees or networks derived from feasible coalitions, and discuss cost allocation for mcstp with feasible coalition systems.

2 - Grey Based Cooperative Inventory Games
Mehmet Onur Olgun, Industrial Engineering, Süleyman Demirel University, Turkey, onurolgun@sdu.edu.tr, *Sirma Zeynep Alparslan Gok*, *Osman Palanci*

The purpose of inventory management is to minimize the avarage cost per time unit acquired by the inventory system, while guranteeing a pre-specified minimal level of stock material. In this study we examine an economic order quantity (EOQ) inventory model handled with grey system approach and cooperative interval games. A new model named grey based cooperative inventory game is introduced.

3 - Cooperative interval games: mountain situations with interval uncertainty
Sirma Zeynep Alparslan Gok, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and Sciences, Suleyman Demirel University, Department of Mathematics, 32260, Isparta, Turkey, zeynepalparslan@yahoo.com, *Osman Palanci*, *Mehmet Onur Olgun*

A connection situation takes place in the presence of a group of agents, each of which needs to be connected to a source. If links are costly, then agents will evaluate the opportunity of cooperating in order to reduce costs. In the sequel we model mountain situations, where the edges of the costs are affected by interval uncertainty. Further, we use the notion of cooperative interval games to tackle the interval cost sharing problem to a mountain situation with interval uncertainty.

4 - Interval obligation rules for minimum interval cost spanning trees
Osman Palanci, Mathematics, Suleyman Demirel University, Suleyman Demirel University, Department of Mathematics, 32260, Isparta, Turkey, osmanpalanci@sdu.edu.tr, *Sirma Zeynep Alparslan Gok*

As in the classical case, where edge costs are real numbers, also in the situation where edge costs are intervals of real numbers a cost allocation problem arises. With the goal to study this kind of cost allocation problems, we extend the notion of obligation rule for minimum cost spanning tree situations by using interval calculus, and we study some cost monotonicity properties under interval uncertainty conditions. It turns out that cost monotonicity, under interval uncertainty conditions, provides population monotonic interval allocation scheme.

■ WA-46

Wednesday, 8:30-10:00
Y10-1

Applications in Network Design and game theory

Stream: Game Theory and Combinatorial Optimization
Invited session

Chair: *Ashwin Arulselvan*, Institut für Mathematik, Technische Universität Berlin, Germany, ashwin.arulselvan@gmail.com

1 - Algorithms to find stable network flows

Ágnes Cseh, Technische Universität Berlin, 10623, Berlin, Germany, cseh@math.tu-berlin.de

The well-known notion of stable matchings can be extended to network flows. In this problem, the vendors have preference lists on possible deals. We talk about stability when there is no pair of vendors who mutually want to change the current flow. Just like stable matchings, stable flows also always exist. In this talk, we will show two algorithms to find such flows. One of them is a generalization of the classical Gale-Shapley algorithm. The core of the second algorithm is a technique to speed up the first one, gaining strongly polynomial running time instead of exponential.

2 - An incremental algorithm for the uncapacitated facility location problem

Olaf Maurer, Institut für Mathematik, Technische Universität Berlin, Straße des 17. Juni 136, 10623, Berlin, Berlin, Germany, maurer@math.tu-berlin.de, *Ashwin Arulselvan*

We study the incremental facility location problem, wherein we are given an instance of the uncapacitated facility location problem. We seek an incremental sequence of opening facilities and an incremental sequence of serving customers along with their fixed assignments to open facilities. Our aim is to have the intermediate solutions obtained for l=1,...,n customers be competitive with the optimal solution to serve any l customers. We provide an incremental framework that provides an overall competitive factor of 8 and a worst case instance that provides the lower bound of 3.

3 - Approximation algorithms for facility location with depth-bounded trees

Jannik Matuschke, Institut für Mathematik, Technische Universität Berlin, Germany, matuschke@math.tu-berlin.de, *Andreas Bley*, *Benjamin Müller*

We consider a generalization of the Uncapacitated Facility Location problem that occurs in planning of optical access networks in telecommunciations. Clients are connected to open facilities via depth-bounded trees. The total demand of clients served by a tree must not exceed a given tree capacity. We provide hardness results and approximation algorithms for different variants of the problem, combining techniques for the simultaneous approximation of shortest path and minimum spanning trees with a Steiner tree based clustering approach.

4 - Combinatorical approach to study a game on a triangular board

Kin Keung Poon, Mathematics and Information Technology, Hong Kong Institute of Education, 10 Lo Ping Road, Tai Po, Hong Kong, kkpoon@ied.edu.hk

Modern game theory began with the idea regarding the existence of mixed-strategy equilibrium in two-person zero-sum games and its proof by Von Neumann. His proof used Brouwer's fixed-point theorem on continuous mappings into compact convex sets, which became a standard method in game theory and mathematical economics. This talk will focus on the combinatoric approach to study a game on the triangular board. With the use of Sperner's lemma, we can prove that the first player always has a winning strategy and some optimal moves will be discussed.

■ WA-47

Wednesday, 8:30-10:00
Y10-2

Airline Applications in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Nursen Aydin*, Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, nursenaydin@sabanciuniv.edu

1 - Decision support in flight business travel procurement

Kathrin Armborst, Faculty of Management and Economics, Ruhr-University Bochum, Chair of Operations Research and Accounting, 44780, Bochum, Germany, Kathrin.Armborst@ruhr-uni-bochum.de, *Brigitte Werners*

Flight business travel has a high relevance in performing business tasks and leads to enormous costs for internationally operating service corporations. The developed decision support system assists in their optimal airline selection and flight contingent allocation. The focus is on the structured decision process supporting corporations to negotiate prices and discount conditions during annual contract negotiations with airlines. The developed process and MILP model provide the basis for a comparison of annual contingent contracting with buying cheapest available tickets during the year.

2 - An Option-based Capacity Control Mechanism for Strategic Airline Alliances

Xiaojia Wang, Systems Engineering and Engineering Management, City University of Hong Kong, Flat A, 14/F, Palatial Stand,, 118 Wuhu Street, Hung Hom, Kowloon, 999077, Hong Kong, Hong Kong, xiaojia.wang@my.cityu.edu.hk, *Richard Y. K. Fung*

For the case of two airlines forming an alliance, an innovative option-based capacity control mechanism is proposed to overcome the drawbacks of traditional approaches. The proposed procedure incorporates the concept of straddle, an advanced options strategy in finance, and allows alliance members to adjust booking limits easily during the booking process. The new scheme can significantly increase the revenue of small airlines currently adopting blocked seat allotment. The effectiveness of the developed approach is expressed in analytical models and visualized in the simulation results.

3 - Optimal Policy Structure for Risk-Sensitive Airline Revenue Management

Onur Tavaslioglu, Industrial Engineering, Middle East Technical University, METU IE Department Room:222, Cankaya, 06800, Ankara, Ankara, Turkey, otavasli@metu.edu.tr, *Zeynep Müge Avşar*

A dynamic programming formulation is given in this study in order to investigate the optimal policy structure for risk-sensitive airline revenue management. The risk measure considered is the mean lower semi-deviation from a target revenue. Structural characteristics of the optimal risk-sensitive and risk-neutral policies are compared.

4 - Delayed Purchase Options in Single-Leg Revenue Management

Nursen Aydin, Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, nursenaydin@sabanciuniv.edu, *S. Ilker Birbil*, *Huseyin Topaloglu*

Many airline companies offer commitment option to potential passengers. This allows passengers to reserve a seat for a fixed duration before making a purchase decision. In this study, we develop single-leg revenue management models that consider such decisions. First, an exact dynamic programming model is presented. Since this model has an intractable state space, we propose an alternate dynamic programming model. In addition, we present linear programming models that yield upper bounds on the optimal expected revenue of the exact model. We complement our discussion with a computational study.

■ WA-48

Wednesday, 8:30-10:00
Y11-1

Financial Mathematics and OR 2

Stream: Financial Mathematics and OR
Invited session

Chair: *Erdem Kilic*, Business Administration, Yeditepe University, İnönü Mah. Kayışdağı Cad., 26 Ağustos Yerleşimi, Ataşehir, 34755 , Istanbul, Turkey, rdmklc@gmail.com
Chair: *Sevtap Kestel*, Actuarial Sciences, Applied Mathematics Institute, Middle East Technical University, Institute of Applied Mathematics, 06531, Ankara, Turkey, skestel@metu.edu.tr

1 - Volatility of stock market indices conditional on ise sectoral indices, gold and oil prices: an evidence from istanbul stock exchange market

Hatice Gaye Gencer, Business Administration, Yeditepe University, Turkey, gaye70@yahoo.com, *Erdem Kilic*

The aim of this research is to expand the literature of market return volatility of the ISE index and its subindices by analyzing the conjoint impact of oil and gold returns and their volatilities. This study conducts M-GARCH-analyses in the examination of 27 sectoral subindices in ISE for the period between January 2003 and July 2012. The multidimensional structure of this study differentiates it from the others in the sense that it may reveal under which circumstances, previous theories, explanations and models are valid; instead of concentrating on only whether the models work or not.

2 - Market Response to the Financial Regulations

Sung Ook Park, school of management, kyung hee university, seoul, seoul, Korea, Republic Of, sopark@khu.ac.kr

This paper investigates the economic impact of the financial regulations that aimed to control the housing market in Korea. We test for the validity of the general prediction that the financial regulations in the form of the Loan-to-Value (LTV) and Debt-to-Income (DTI) restrictions would have adverse impacts on the value of the firms operating in the mortgage-lending industry. Overall, the DTI restrictions adversely affect only those banks that possess relatively large amount of mortgage loans in their asset portfolio.

3 - Quantile Regression for Index Tracking and Enhanced Indexation

Hakim Mezali, Mathematical Science, Brunel university, John Crank Building, Brunel University, UB8 3PH, Uxbridge, Middlesex, United Kingdom, hm2908@gmail.com, *J. E. Beasley*

In this presentation we apply quantile regression to two problems in financial portfolio construction, index tracking and enhanced indexation. Index tracking is the problem of reproducing the performance of a stock market index and enhanced indexation deals with the problem of out-performing the index. We present a mixed-integer linear programming formulation of these problems based on quantile regression.

4 - Stochastic Hybrid Systems in Portfolio Optimization: Parameter Estimation and Simulation

Azar Karimov, Financial Mathematics, Institute of Applied Mathematics, Middle East Technical University, Eskishehir road, 06530, Ankara, Turkey, azer.kerimov@gmail.com, *Erdem Kilic*, *Gerhard-Wilhelm Weber*

We present applications of Stochastic Hybrid (SH) models in finance which also accounts for regime switching dynamics. We implement SH models with insider information in framework of portfolio optimization with optimal investment and consumption strategies. The article ends with the parameter estimation and also stochastic simulation based on calibration, and on comparing the synthetic data from simulations with actual data. Analogously to these considerations, numerical implementations of specified SH System models have been done for the data taken from economics and finance fields.

■ WA-49

Wednesday, 8:30-10:00
Y11-2

Data Mining and Shipping

Stream: Data Mining in the Financial Sector
Invited session

Chair: *Marcus Hildmann*, Information Technology and Electrical Engineering, ETH Zurich, ETL G 24.2, Physikstrasse 3, 8092, Zürich, Switzerland, hildmann@eeh.ee.ethz.ch
Chair: *Dejan Stokic*, tbd, 60386, Frankfurt, Germany, sdeyan@gmail.com

1 - A heuristic algorithm for efficient forwarding of shipments in South East Europe via combined transport

Christina Arampantzi, Department of Financial & Management Engineering, University of the Aegean, Greece, fmem11005@fme.aegean.gr, *Panagiotis Otapasidis*, *Vasileios Zeimpekis*, *Ioannis Minis*

Moving freight along a large region is a complex task due to multiple criteria that should be taken into consideration including environmental issues that should be also taken into account. This paper describes an algorithm that identifies efficient ways for forwarding shipments in the South East Europe area by using combined transport and by taking into consideration transportation cost, trip duration and risk, as well as the carbon footprint of the transportation modes. The results provide alternative solutions based on the balance of objectives set by the user.

2 - Fleet Deployment Optimization in Liner Shipping with Spot Voyages

Vinícius Armentano, Faculdade de Engenharia Elétrica e de Computação, Universidade de Campinas, FEEC-UNICAMP, Av. Albert Einstein 400, 13083-852, Campinas, São Paulo, Brazil, vinicius@densis.fee.unicamp.br, *Rodrigo Branchini*

We address a tactical planning problem faced by liner shipping companies that are committed to carry out contract voyages, while trying to serve optional spot voyages to increase its revenue. The problem is modeled as a mixed integer programming based on a directed graph where nodes represent contract and spot voyages and arcs denote sequences of voyages. The decisions include the number and type of vessels deployed, the assignment of vessels to contractual and spot voyages and the determination of vessel routes and schedules in order to maximize the profit. Computational results are reported.

3 - Impact of Port Costs on the Competition for Container Carriers

Byung-In Park, Department of Logistics and Transportation, Chonnam National University, Daehak-rd 50, 550-749, Yeosu, Chonnam, Korea, Republic Of, bipark@chonnam.ac.kr, *Souk-Kyung Sung*

This paper examines a competitive shipping market to explore how container carriers make decisions on a ship's sailing and to assess the impact of port costs. Game theory is applied to model the transportation volumes, freight rates, costs, and market shares of service routes. According to the equilibrium solutions, carriers' decisions and the impacts of port costs vary depending on sailing distance, transport demand, and freight rates. Therefore, carriers and ports should take advantage of optimal equilibriums and consider various decision factors when formulating network strategies.

4 - A new multi-criteria routing algorithm for model trains in railway networks
Daniel Pöhle, I.NMF 3, DB Netz AG, Theodor-Heuss-Allee 7, 60486, Frankfurt am Main, Germany, daniel.poehle@deutschebahn.com, *Reyk Weiß*, *Jens Opitz*

For the generation of timetables by DB Netz AG, the most important rail infrastructure company in Germany, having model trains is a necessity, which combine all needed information of the operating lines. In this paper, a special routing algorithm will be presented, in order to find automatically a well-suited train path in the railway network. Therefore, a multi-criteria approach is introduced that considers travel time, distance and the train path's quality etc. Furthermore, this innovative technique reasons in only a few seconds computation time to solve the real-world model trains' routing.

■ WA-50

Wednesday, 8:30-10:00
Y11-3

Financial Modeling

Stream: Financial and Commodities Modeling
Invited session

Chair: *Stavros A. Zenios*, University of Cyprus, 2122, Nicosia, Cyprus, zenioss@ucy.ac.cy
Chair: *Yeliz Yolcu Okur*, Financial Mathematics, Middle East Technical University, Uygulamali Matematik Enstitüsü, S-Binasi, Ankara, Turkey, yyolcu@metu.edu.tr

1 - A Survey on the Analysis of Financial Markets with Asymmetric Information
Yeliz Yolcu Okur, Financial Mathematics, Middle East Technical University, Uygulamali Matematik Enstitüsü, S-Binasi, Ankara, Turkey, yyolcu@metu.edu.tr

Detection of an insider has been a big issue in financial market analysis. The aim of this study is to give an extensive survey on financial markets in presence of an insider. We examine the problem of choosing optimal portfolio and consumption choices in stochastic control problem. We conclude by giving some examples (joint work with D. David).

2 - Analysis of Volatility Dynamics via Parametric and Non-Parametric Methods
Alper Inkaya, Middle East Technical University, Institute of Applied Mathematics, METU Üniversiteler Mah. Dumlupınar Blv. No:1, Çankaya, 06800, Ankara, Turkey, ainkaya@metu.edu.tr

Modeling volatility of return is a fundamental issue in asset pricing and risk management. Two important concepts in volatility modeling are volatility feedback and leverage effects. Volatility models that take these effects into account can better model volatility and market dynamics (Engle, 2004). In this study, we employ both parametric methods such as EGARCH, FIGARCH and FIEGARCH non-parametric method of Malliavin and Mancino (Malliavin and Mancino, 20021) to compare their performances in estimating volatility feedback and leverage effects and in terms of forecasting ability.

3 - Application of the Malliavin Calculus for Computation of Greeks in Black-Scholes and Stochastic Volatility Models
Bilgi Yilmaz, Financial Mathematics, IAM, Institute Of Applied Mathematics/METU, ÇANKAYA, 06800, ANKARA, Turkey, ybilgi@metu.edu.tr, *Alper Inkaya*, *Yeliz Yolcu Okur*

The Greeks of options are problematic to calculate both numerically and analytically when the structure of the payoff function of option is complex. This problem can be solved by employing Malliavin calculus. In this study, we summarize the fundamentals of Malliavin Calculus which are useful for computing the sensitivities of options. Then, we use these fundamentals to derive explicit formulas for the Greeks of European and Asian options for the Black-Scholes model and Heston stochastic volatility model. Further, we numerically compute the Greeks of options on ISE and illustrate our results.

4 - Distribution of Maximum Loss for Fractional Brownian Motion
Ceren Vardar, Department of Mathematics, TOBB Economy and Technology University, Sogutozu caddesi no: 43, 06560, Ankara, Turkey, cvardar@etu.edu.tr

In finance, the price of a volatile asset can be modeled using fractional Brownian motion (fBm) with Hurst parameter H> 1/2. In this paper, we find bounds on the distribution of the maximum decrease which is a measure of risk for fractional Brownian motion with H>1/2. We derive estimates on its tail probability. Asymptotically, the tail of the distribution of maximum loss over [0,t] behaves like the tail of the marginal distribution at time t.

■ WA-51

Wednesday, 8:30-10:00
Y11-4

Computational Finance

Stream: Financial Optimization
Invited session

Chair: *Yuying Li*, Computing and Financial Management, University of Waterloo, N2L 3G1 , Waterloo, Ontario, Canada, yuying@uwaterloo.ca

1 - Numerical algorithms for R&D stochastic control models
Yue Kuen Kwok, Mathematics, Hong Kong Univ of Sci & Tech, Dept of Math, HKUST, Clear Water Bay, 99999, Honf Kong, Hong Kong, maykwok@ust.hk

We consider the optimal strategy of R&D expenditure adopted by a firm that engages in R&D to develop an innovative product. The firm faces with technological uncertainty associated with the success of the R&D effort and market uncertainty of the stochastic revenue flow generated by the new product. The firm's knowledge accumulation has impact on the R&D progress. We propose efficient finite difference schemes that solve the HJB formulation of the resulting finite time R&D stochastic control. Theoretical studies on the convergence properties of the numerical schemes are also presented.

2 - Preservation of Scalarization Optimal Points in the Embedding Technique for Continuous Time Mean Variance Optimization
Yuying Li, Computing and Financial Management, University of Waterloo, N2L 3G1 , Waterloo, Ontario, Canada, yuying@uwaterloo.ca

A continuous time mean-variance problem optimizes the bi-objective criteria using variance and expected value. An embedding technique has been proposed to generate the set of MV scalarization optimal points. However, the frontier generated by the embedding technique may contain spurious points which are not MV optimal. We propose a method to eliminate such points and we show that the original MV scalarization optimal objective set can be preserved. We apply the proposed method to an optimal execution problem.

3 - A Gradual Non-Convexation Penalty Method for Minimizing VaR
Thomas Coleman, Combinatorics and optimization, U. Waterloo, 200 unuiversity ave w, n2l 3g1, waterloo, ontario, Canada, tfcoleman@uwaterloo.ca

Computing an optimal portfolio with minimum value-at-risk (VaR) is computationally challenging since there are many local minimizers. We consider a nonlinearly constrained optimization formulation directly based on VaR definition in which VaR is defined by a probabilistic inequality constraint. We compute an optimal portfolio using a sequence of smooth approximations to the nonlinear inequality constraint.

4 - Robust Portfolio Optimization with Copulas, creating a portfolio strategy for periods of crisis
Iakovos Kakouris, Computing, Imperial College London, Imperial College London, Exhibition Road, SW7 2AZ, London, United Kingdom, iak05@ic.ac.uk, *Berc Rustem*

Conditional value-at-risk (CVaR) is widely used in portfolio optimization as a measure of risk. We provide the copula formulation of the CVaR. Given the critical dependence of CVaR on the underlying distribution, we use a robust framework to extend our approach to Worst Case CVaR (WCVaR). WCVaR is achieved through the use of rival copulas. These rival copulas have the advantage of exploiting a variety of dependence structures, symmetric and not. We further extend our research to an empirical study of application in portfolio optimization where a WCVaR will be more suitable.

■ WA-52

Wednesday, 8:30-10:00
B13-1

Forecasting I

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Antonio Rodrigues*, CIO-FCUL, University of Lisbon, Edificio C6, Campo Grande, 1749-016, Lisboa, Portugal, ajrodrigues@fc.ul.pt

1 - Is implied correlation predictable?
Chrysi Markopoulou, Management Science and Technology, Athens University of Economics and Business, 47A Evelidon str, Athens, Attica, Greece, cmarkopoulou@aueb.gr, *Vasiliki Skintzi*, *Apostolos Refenes*

In this paper, we infer an option-implied model-free estimator of the market wide correlation and study the existence of predictable patterns in the dynamics of the series. We employ alternative time-series specifications and assess the statistical and economic significance of out-of-sample forecasts. The statistical measures provide strong evidence in favour of existing predictable pattern in the S&P 100 option market. A trading strategy designed to exploit daily changes in the series can yield abnormal profits, which, however, disappear when transaction costs are incorporated.

2 - A forecast competition for car markets: does expert judgment outperform statistical time series forecasting?
Lennart Blech, Ph.D. student in Economics (Applied Econometrics), University of Basel, Arminstraße 49, 70178, Stuttgart, BW, Germany, lennart.blech@unibas.ch

This paper evaluates the accuracy of 1,900 judgmental forecasts (JF) for yearly car sales from the Economics and Sales departments of an automotive OEM. ARIMA and VAR models based on monthly data perform worse, whereas exponential smoothing (ETS) forecasts are more accurate. The accuracy gap to ETS is smaller for longer forecast horizons, but JF are most accurate when contextual information is available. Sales departments' forecasters are more likely to display judgmental biases. But due to validity checks, forecasts are not significantly less accurate than from the Economics department.

3 - Failure in the Banking Sector: A review of forecasting techniques
Christina Konstantinidou, Electrical and Computer Engineering, National Technical Univercity of Athens, Greece, ckonstantinidou@fsu.gr, *Pavlos Gkologiannis*, *Vassilios Assimakopoulos*

In this research we review highly influential works on various forecasting models that apply statistic techniques such as regression analysis, multiple discriminant analysis, logit or probit analysis and ANN backpropagation. The variables that have been used in most models were either the traditional CAMEL ones or macro-economic factors. These methods differentiate sound banks and troubled ones and identify causes of failure. We concluded presenting which method improves the forecasting accuracy and which parameters contribute to bank failure and commenting proposals for future research

4 - Turning point detection using Curvilinear Exponential Smoothing
Paulo Freitas, CIO-FCUL, University of Madeira, Centro de Ciencias Exactas e da Engenharia, Campus Universitario da Penteada, 9000-390, Funchal, Portugal, paulo@uma.pt, *Antonio Rodrigues*

Curvilinear Exponential Smoothing is an extension of Holt's method that includes the estimation of a time-varying curvature parameter. It is useful for forecasting time series with relatively complex trend patterns, namely with either non-periodic or quasi-periodic variations in convexity. We demonstrate how it can be used as a simple approach for the detection of turning points in a series, including those related to business cycles.

■ WA-53

Wednesday, 8:30-10:00
B13-2

Analysis of Investments in Intermittent Generation

Stream: Stochastic Modeling in Energy Planning
Invited session

Chair: *Athena Wu*, Engineering Science, The University of Auckland, Auckland, New Zealand, a.wu@auckland.ac.nz

1 - Low carbon technologies and the future of UK generating portfolios
Suriya Ruangpattana, SPRU–Science and Technology Policy Research, University of Sussex, Jubilee Building, Room 329, BN1 9SL, Brighton, East Sussex, United Kingdom, s.ruangpattana@sussex.ac.uk, *Jim Watson*

This study involves a mean-variance portfolio analysis of future UK generating portfolios. The MVP approach implies the selection of a mix of generation technologies for long-term electricity generation to explore the trade-offs between overall costs and overall risks. It entails a mathematical method for determining the optimal mix of fuels-technologies that minimizes average system cost and the volatility of cost. Results will help understand the cost and risk profile of the generating portfolios for the UK as a whole rather than considering individual generating plant options in isolation.

2 - Renewable Energy Credit forecasting and real-options contracts for solar installations
Diego Klabjan, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, IEMS, 60208-3119, 60208, Evanston, IL, United States, d-klabjan@northwestern.edu

Companies typically employ standard contracts for renewable installations. We present an option contract relying on volatility of renewable energy credits. In addition to presenting the model, we also exhibit a stochastic forecasting model to predict renewable energy prices. A case study based on real world data is also presented.

3 - Using Approximate Dynamic Programming to Assess Investment Options in Long-term Energy Transitions
Will Usher, UCL Energy Institute, University College London, Central House, 14 Upper Woburn Place, WC1H 0NN, London, United Kingdom, w.usher@ucl.ac.uk

This paper describes the adaption of the existing Energy System Model Environment (ESME), a UK energy system model, to an Approximate Dynamic Programming formulation. A limited number of uncertainties are propagated through the model, and a series of preliminary tests demonstrate desirable and expected results such as technological diversity in response to uncertain resource costs. An overview of the technical aspects is given, including the construction of the value function approximation, and some of the challenges associated with solving the approximate dynamic program.

4 - Evaluating Investment Options with Renewable-induced Uncertainty using Markov Decision Processes
Athena Wu, Engineering Science, The University of Auckland, Auckland, New Zealand, a.wu@auckland.ac.nz, *Andy Philpott*, *Golbon Zakeri*

Classical capacity planning models become problematic when evaluating investment facing renewable generation intermittency. We describe a model treating the uncertainty in renewable supplies as a Markov Chain and the short-term operation of electricity plant as an average reward MDP. This problem's LP formulation can be augmented by binary variables defining investment actions, leading to a mixed-integer program. The impact of increasing renewable penetration and project location choice on generation capacity and transmission asset investments are explored.

■ WA-54

Wednesday, 8:30-10:00
B14-1

Mathematical Modelling in Renewable Energy

Stream: Energy, Environment and Climate
Invited session

Chair: *Ulf Kasper*, Institute of Power Systems and Power Economics, RWTH Aachen University, Schinkelstraße 6, 52062, Aachen, Germany, uk@iaew.rwth-aachen.de

1 - Geothermal energy applications in turkey and environmental impacts of geothermal fluid
Öner Atalay, PAMUKKALE UNIVERSITY ENGINEERING FACULTY, Turkey, oatalay@pau.edu.tr, *Ahmet Yilanci*

Energy is becoming more important day by day in the world. Geothermal energy is considered as a clean energy source because of low CO2, NOx, SOx gas emissions. Geothermal energy includes direct or indirect benefit from any kind of geothermal sources. 55% of geothermal fields in Turkey are suitable for heating applications. In this study, geothermal applications in Turkey are discussed; moreover, the methods and optimal use of resources based on the temperature values and the environmental impacts of geothermal fluids are dealt with.

2 - Assessment of Extreme High Energy Sites and the Implications for Maintenance Operations at Offshore Wind Farms
Fiona Devoy McAuliffe, Hyrdraulics and Maritime Research Centre, University College Cork, Youngline Industrial Estate, Pouladuff Road, Cork, Ireland, f.devoymcauliffe@ucc.ie, *Keith OSullivan*, *Jimmy Murphy*

Applying a newly developed O&M modelling tool to extreme marine conditions, this paper will assess the implications of future high energy sites on maintenance operations for offshore wind farms. The model uses existing technology and results will initially be validated against UK Round 1 Wind Farm figures. It will then be applied to assess and compare O&M requirements in the increasingly harsh environment of Round 3 locations based on real data from North Atlantic Ocean sites. The model will be used as a decision making tool to determine the most efficient and cost-effective O&M strategies.

3 - Incorporating uncertainties in current integrated city and territory energy planning studies, main requirements
Atom Mirakyan, European Institute for Energy Research, Karlsruhe, Germany, Atom.Mirakyan@eifer.uni-karlsruhe.de, *Roland De Guio*

Several kinds of uncertainties are linked to Integrated Energy Planning (IEP) for cities and territories models and activities. Review of the literature shows that few studies explicitly include uncertainty analysis in their IEP process. Moreover, the analyses presented in these studies do not cover all types of uncertainties encountered in IEP. The paper presents issues of uncertainty in model based IEP; identifies and localise different types of uncertainties in IEP process; shows how uncertainty issues are addressed in current studies and proposes requirements that need detailed attention.

4 - Optimization of Power Plant Trading Decisions on Markets for Scheduled Energy and Reserve
Ulf Kasper, Institute of Power Systems and Power Economics, RWTH Aachen University, Schinkelstraße 6, 52062, Aachen, Germany, uk@iaew.rwth-aachen.de, *Albert Moser*

After the liberalization of the European power system, new markets for power generation companies have evolved. Due to these different short-term trading possibilities, identifying the optimal unit dispatch has become a challenging task. This motivates a new modeling approach of the hydrothermal unit commitment, especially considering the temporal dependencies between different markets for scheduled energy and system reserve as well as the particular price uncertainties. By analyzing different trading decisions, dependencies between trade risks and contribution margin can be evaluated.

■ WA-55

Wednesday, 8:30-10:00
B14-2

Decision Making and Data Processing

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Ekaterina Alekseeva*, INRIA, Parc Scientifique de la Haute Borne 40, avenue Halley, BatA, Park Plaza, 59650, Villeneuve d'Ascq, France, katerina.alekseeva@gmail.com
Chair: *Mikhail Kuznetsov*, Moscow Institute of Physics and Technology, Russian Federation, mikhail.kuznecov@phystech.edu

1 - The development of a robust multicriteria classification model for monitoring the postoperative condition of heart patients
Michael Doumpos, Dept. of Production Engineering and Management, Technical University of Crete, University Campus, 73100, Chania, Greece, mdoumpos@dpem.tuc.gr, *Sotiris Xidonas*, *Panagiotis Xidonas*, *Yannis Siskos*

This paper presents a multicriteria methodology for the development of a model for monitoring the postoperative condition of patients that have received treatment for atrial fibrillation (AF), which is the most common form of cardiac arrhythmia. The model classifies the patients in 7 groups according to their relapse risk, on the basis of 7 criteria related to the AF type and pathology conditions, the treatment received by the patients and their medical history. A two-stage robust multicriteria model development procedure is used to minimize the number and magnitude of the misclassifications.

2 - A hybrid matheuristic for the leader-follower facility location problem with two follower's objectives
Ekaterina Alekseeva, INRIA, Parc Scientifique de la Haute Borne 40, avenue Halley, BatA, Park Plaza, 59650, Villeneuve d'Ascq, France, katerina.alekseeva@gmail.com, *El-ghazali Talbi*

A leader and a follower compete to serve customers by opening facilities in turn. The players maximize their own objectives in cooperative manner, but the follower has two objectives. We propose a metaheuristics for the leader's problem. For a given leader's solution we need the best follower's solution on a Pareto front. This problem is presented as a mixed integer linear program with the large number of constraints. Based on this formulation we design a new iterative exact method. Computational results for Euclidean test instances are discussed.

3 - Intellectual Property Strategies and Patent Litigations: Econometric Decision Support Models
Ilan Vertinsky, Sauder School of Business, University of British Columbia, 2053 Main Mall, V6T1Z2, Vancouver, B.C., Canada, ilan.vertinsky@ubc.ca, *Steven Minns*

Using insights from network theories, Industrial Organization and organizational behavior we developed and tested econometric models which 1) assess the general vulnerability of firms to patent infringement claims by rivals; 2) assess the propensity of specific rivals to pursue aggressive patent litigation; 3) identify strategic moves that increase a firm's abilities to deter patented rivals' lawsuits, thus increasing its strategic resilience; and 4) identify the characteristics of technology areas that are particularly prone to risks of litigation.

4 - Multi-objective decision support for IT security control selection
Elmar Kiesling, Information & Software Engineering Group, Vienna University of Technology, Favoritenstrasse 9-11/188, 1040, Vienna, Austria, elmar.kiesling@tuwien.ac.at, *Andreas Ekelhart*, *Bernhard Grill*, *Christine Strauss*, *Christian Stummer*

Identifying an optimal sets of security controls to protect complex information systems is a challenging problem. The aim of the research project MOSES3 is to develop and implement a framework that supports decision-makers in this task. Our approach rests upon comprehensive modeling of security knowledge, dynamic attack tree generation techniques, discrete event simulation of sophisticated attacks that exploit emergent weaknesses, and multi-objective optimization of security control portfolios. In our talk we outline the overall framework and present preliminary results.

■ WA-56

Wednesday, 8:30-10:00
B15-3

Applied Mathematics Desk: Industrial Experiences and Success Cases in Italy - Session I

Stream: OR Applications in Industry
Invited session

Chair: *Antonino Sgalambro*, Istituto per le Applicazioni del Calcolo "Mauro Picone", National Research Council (CNR), Via dei Taurini 19, 00185, Roma, Italy, a.sgalambro@iac.cnr.it

1 - Mathematical Desk for Italian Industry
Maurizio Ceseri, IAC - CNR, via dei Taurini 19, 00185, Roma, Italy, m.ceseri@sportellomatematico.it, *Antonino Sgalambro*, *Mario Santoro*, *Francesco Visconti*

Mathematical Desk for Italian Industry is an italian CNR project whose mission is to build a concrete bridge of common interests between the italian scientific community of applied mathematics and the world of the enterprises. The main goal of the Mathematical Desk is to develop industrial research projects and encourage enterprise innovation, thanks to a fruitful cooperation with a network of italian excellence centers of industrial mathematics. In this talk we briefly introduce the Mathematical Desk for Italian Industry, its objectives and its main activities.

2 - A rolling-horizon MIP approach to a large scale aggregate planning problem
Davide Anghinolfi, DIBRIS, University of Genova, Via Opera Pia 13, 16100, Genoa, Italy, davide.anghinolfi@unige.it, *Massimo Paolucci*

We face the planning problem of a real world mixed-model assembly manufacturing system, producing high volume and variety of agricultural tractors. The plans determine the models to be assembled in each weekly time bucket. The production strategy is assembly-to-order and we consider both customer and forecast demand. Technological and custom constraints, as well as optimization objectives with configurable priorities, are taken into account. The developed approach integrates in an Advanced Planning System a MIP model, solved by a new iterative heuristic. Some computational results are shown.

3 - Success Cases in Forecasting Traffic Flow on Networks
Emiliano Cristiani, IAC, CNR, Via dei Taurini, 19, 00185, Rome, RM, Italy, e.cristiani@iac.cnr.it

In this talk we review the collaborations between the traffic research group at IAC-CNR and some Italian companies which manage real traffic data from fixed and mobile (GPS) sensors. We aim at showing the potential of mathematical models in forecasting traffic flow on large networks in real time.

4 - Acid Mine Drainage treatment with Calcium Carbonate: a mathematical model
Lorenzo Fusi, Matematica, Universita' degli Studi di Firenze, V.le Morgagni 67/a, 50134, Firenze, Italy, speranza@math.unifi.it

The problem concerns the process of neutralization of an acid solution by means of a reactant material. Main practical applications consist on acid mine drainage remediation (AMD), i.e. the treatment of acidic streams from abandoned mines. The aim of the model is to give qualitative and quantitative information aimed at optimizing reactive cartridges to be used for treating acid waste-water of mining plants. The mathematical model is based upon simple approximation of reactive flux in composite porous medium. Simulations show good agreement with real data.

■ WA-57

Wednesday, 8:30-10:00
B15-4

Green OM/Marketing Strategies

Stream: Operations/Marketing Interface
Invited session

Chair: *Pavankumar Murali*, IBM Research, 1101 Kitchawan Road, 04-024, 10598, Yorktown Heights, NY, United States, pavanm@us.ibm.com

1 - Using the Newsvendor Game as a new research environment for behavioral OM and Marketing
Abraham Seidmann, University of Rochester, 14627, Rochester, NY, United States, seidmannav@simon.rochester.edu, *Tong Wu*

The newsvendor problem has become a canonical framework for teaching the core Manufacturing and Marketing issues associated with the management of perishable goods in the supply chain. 'In this talk, we are going to discuss the research and teaching role of a new experimental system called the Newsvendor game, which is a part of the Tradewindbusiness software. We plan to report on its use in teaching the newsvendor problem at various MBA programs, and present some preliminary research results which are corroborating, and at times, conflicting prior studies of that topic.

2 - Optimizing Skippable and Non-Skippable Advertisements for Video Sharing Websites
Soumyakanti Chakraborty, Information Systems, XLRI School of Business and Human Resources, India, soumyakciimc@gmail.com, *Sumanta Basu*, *Megha Sharma*

Revenues of video sharing websites have received a big boost with in-video skippable ads. This allows users to skip an ad and therefore advertisers pay only if the ads are viewed by interested users. Thus advertisers would be ready to pay more for a skippable ad vis-à-vis a non-skippable ad. We first determine the conditions under which advertisers will switch from non-skippable to skippable ads. As the users would dislike a proliferation of non-skippable ads, we then determine an optimal ratio of non-skippable and skippable ads which maximizes revenue and also minimizes user dissatisfaction.

3 - New product pricing policy and reward programme in the existence of taste effect and word of mouth effect
Wu Lingli, operation management, shcool, Huazhong University of Science and Technology, wuhan, China, lingliwu202@gmail.com

We intend to design pricing policies and reward programme of innovation products in two selling periods to maximize seller's revenue.Because customers may not be familiar with products when products first show,they get an inaccurate perceived value of products,thus they may change their perceived value after tasting,here we call taste effect.Also someone who doesn't taste products in first period could be influenced as word of mouth effect.We discuss situations when only taste effect exists and when both exist.

■ WA-58

Wednesday, 8:30-10:00
B15-6

Real Implementation Optimization 2

Stream: OR and Real Implementations
Invited session

Chair: *Ben Lev*, Decision Sciences, Drexel University, LeBow College of Business, 101 N. 33rd st., 19104, Philadelphia, Pa, United States, blev@drexel.edu

1 - A General Approach to Importance Measures for Components of Binary Coherent Systems without Renewal
Frank Beichelt, School of Statistics and Actuarial Science, University of the Witwatersrand, Private Bag 3, WITS 2050, 2050, Johannesburg, South Africa, Frank.Beichelt@wits.ac.za

Components of a complex system have different degrees of influence on its performance. This influence is e.g. interesting with regard to: How varies the system availability in dependence on the availability of a component and what component contributes most likely to a system failure? Criteria, which quantify such influences are called importance measures. A general measure is proposed, which contains many of the established ones as special cases.

2 - A Forecasting Methodology for Adaptively Estimated New Product Growth Models
Ceren Kolsarici, School of Business, Queen's University, 143 Union Street, Goodes Hall, K7L3N6, Kingston, Ontario, Canada, ckolsarici@business.queensu.ca, *Demetrios Vakratsas*

Although adaptive estimation methods have become prevalent in studying dynamic marketing phenomena, such as new product growth, they suffer in multi-period forecasting. We propose an updating methodology based on Chebyshev's approximation to circumvent this problem. Our empirical application to the sales growth of the leading brands in two categories shows that the proposed method exhibits superior performance compared to an alternative stochastic parameter update, a "simpler' Koyck model and heuristic methods using the average and last estimated parameters in the pre-forecasting window.

■ WA-59

Wednesday, 8:30-10:00
B15-5

Dynamics of Model Use in Problem Structuring Workshops

Stream: Soft OR / Systems and Multimethodology
Invited session

Chair: *L. Alberto Franco*, Hull University Business School, University of Hull, Management Systems, Cottingham Road, HU6 7RX, Hull, United Kingdom, alberto.franco@hull.ac.uk

1 - Recent contributions to the evaluation of group model building
Etienne Rouwette, Nijmegen School of Management, Radboud University Nijmegen, 6500 HK, Nijmegen, Netherlands, e.rouwette@fm.ru.nl

Evaluation of group model building has studied the impact of the method on participants in modelling sessions. Evaluation studies first focused on the receiver (highlighting e.g. consensus and commitment) and more recently switched to the sender and interaction between sender and receiver. This paper reviews recent empirical and theoretical work related to the impact of group model building.

2 - Knowledge production patterns in facilitated modelling workshops
Thanos Papadopoulos, Hull University Business School, University of Hull, HU6 7RX, Hull, United Kingdom, a.papadopoulos@hull.ac.uk, *L. Alberto Franco*

The paper focuses on model-supported knowledge production within facilitated modelling (FM) workshops. Based on the micro-level analysis of video data from a single FM workshop, we show a causal map was created using different model-supported knowledge production patterns that had implications for the the novelty of the knowledge produced. We also show how the affordances of the model created enabled these different knowledge production patterns. Implications of our findings for the research and practice of facilitated modelling will then be discussed.

3 - Assessing the productivity of group dialogue in problem structuring workshops
Elena Tavella, Department of Food and Resource Economics, University of Copenhagen, Denmark, eta@foi.dk, *L. Alberto Franco*

Problem structuring methods (PSMs) are claimed to have positive effects on the productivity of group dialogue. We explore this claim through a micro-analysis of the dialogue transcript from a PSM workshop held within a local food network in the UK. Drawing on Tsoukas' (2009) conceptualisation of dialogue and Thomas' et al. (2011) communicative practices we assess the productivity of dialogue, how it relates to PSM-supported interactions and the workshop outcomes. Our analysis identifies three types of dialogue, implying different links to PSM-supported interactions and workshop outcomes.

■ WA-60

Wednesday, 8:30-10:00
B15-7

Decision Making Models with Uncertainty and/or Ambiguity

Stream: Information and Intelligent Systems
Invited session

Chair: *Takashi Hasuike*, Graduate School of Information Science and Technology, Osaka University, 2-1 Yamadaoka, 565-0871, Suita, Osaka, Japan, thasuike@ist.osaka-u.ac.jp
Chair: *Hiroaki Kuwano*, Kanazawa Gakuin University, Sue 10, 920-1392, Kanazawa, Ishikawa, Japan, kuwano@kanazawa-gu.ac.jp

1 - Interactive optimization of pin probe positions in printed circuit board
Hideki Katagiri, Hiroshima University, Japan, katagiri-h@hiroshima-u.ac.jp, *Hiroshi Hamori*, *Kosuke Kato*, *Masashi Morisawa*

Pin probe inspection methods have been widely used in printed circuit board electrical inspection. Due to the miniaturization of electronic devices, it is very important to set pin probes properly, namely, to exactly contact each of them with the corresponding bulged part of a wiring in order to implement precise inspections. In this research, we develop a new pin probe position optimization system that?automatically and repeatedly calculates an optimal correction amount?and direction of the pin probe unit and moves it through interactive processes between an operator and the system.

2 - Multi-Period Clearance Pricing Considering Reference Price Effect
Takeshi Koide, Konan University, 8-9-1, Okamoto, Higashinada-ku, 658-8501, Kobe, Japan, koide@konan-u.ac.jp, *Hiroaki Sandoh*

Daily perishable products are sometimes sold at a discount price just before closing time. The clearance pricing can increase revenue of the day, but an excess discounting diminishes long-term profit because of reclined reference prices of consumers. This paper discusses the clearance pricing on perishable products in multiple periods considering the reference price of consumers. A mathematical analysis is conducted to show the concavity of a total expected profit function. Numerical study investigates the contour of the profit function and optimal pricings and maximum expected profit.

3 - Flexible Route Planning for Sightseeing under Uncertain Conditions
Takashi Hasuike, Graduate School of Information Science and Technology, Osaka University, 2-1 Yamadaoka, 565-0871, Suita, Osaka, Japan, thasuike@ist.osaka-u.ac.jp, *Hideki Katagiri*, *Hiroe Tsubaki*, *Hiroshi Tsuda*

This paper proposes a route planning problem for sightseeing to be flexibly prepared for various weather and traffic conditions considering satisfaction values of sightseeing places according to the tourist's preference. Specifically, in the case that the weather condition worsens or the road is increasingly jammed, a route planning problem using Time-Expanded Network to represent these conditions dependent on the day of time is formulated to ensure a route to arrive at some alternative sightseeing places in a given time from the usual route.

4 - On some derivatives for fuzzy set-valued mappings
Hiroaki Kuwano, Kanazawa Gakuin University, Sue 10, 920-1392, Kanazawa, Ishikawa, Japan, kuwano@kanazawa-gu.ac.jp, *Masamichi Kon*

Our aim is to construct set-valued analysis approaches to the mathematical optimization problems with fuzzy set-valued mappings. However, there is little research movement about them so far. In this presentation, for our aim, we introduce five derivatives – fuzzy contingent derivative, Dini-type fuzzy lower derivative, Ursescu-type fuzzy derivative, fuzzy upper semi-derivative and fuzzy lower semi-derivative – for fuzzy set-valued mappings. Then we investigate their properties and the relation among them.

■ WA-62

Wednesday, 8:30-10:00
R18-1

Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks (COST TD1207)

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Armin Fügenschuh*, Optimierung, Zuse Institut Berlin, Takustraße 7, 14195, Berlin, Germany, fuegenschuh@zib.de

1 - Operation and Optimization of Gas Transmission Networks
Jonas Schweiger, Optimization, Zuse Institute Berlin (ZIB), Takustr. 7, 14195, Berlin, Germany, schweiger@zib.de, *Armin Fügenschuh*, *Benjamin Hiller*, *Jesco Humpola*, *Thorsten Koch*, *Ralf Lenz*, *Robert Schwarz*

Gas transmission networks are complex structures that consist of passive pipes and active, controllable elements such as valves and compressors. Operating a large-scale gas network is a challenging task: Find settings for all active elements such that a nominated amount of gas can be transmitted through the network, without violating physical or operational constraints. In this talk, we present a nonlinear mixed-integer model. We point to model extensions to related problems such as network topology planning which will be covered by the other talks in this session.

2 - Checking feasibility in real-world gas transportation networks
Claudia Stangl, Mathematics, University of Duisburg-Essen, Butlerstrasse 10, 47058, duisburg, Germany, claudia.stangl@uni-due.de

Checking feasibility of transportation requests belongs to the key tasks in gas pipeline operation. In its basic form, the problem is to decide whether a certain quantity of gas can be sent through the network from prescribed entries to prescribed exits. In the stationary case, the physics of gas flow together with technological and commercial side conditions lead to a pretty big nonlinear, mixed-integer inequality system. The approach presented here relies on transforming nonlinearities into a more accessible form. This idea is embedded into a heuristic for finding switching decisions.

3 - Optimal Looping of Gas Pipelines
Ralf Lenz, Optimization, Zuse Institute Berlin, Takustraße 7, 14195, Berlin, Germany, lenz@zib.de, *Robert Schwarz*

Gas transportation companies often need to extend their networks in order to enable feasible operations. A common method in practice is to build new pipes in parallel to existing ones, also called looping. For every pipe one has to decide whether to loop it and choose a partial length as well as a diameter from a discrete set. Due to the nonlinear pressure loss and flow relationship, these diameters do not explicitly correspond to flow capacities. We present a reduced MINLP model that accounts for the tradeoff between length and diameter and conclude with computational results.

4 - Capacity Inequalities for Gas Transmission Networks
Jesco Humpola, Optimization, Zuse Institute Berlin, Takusstrasse 7, 14159, Berlin, Berlin, Germany, humpola@zib.de, *Armin Fügenschuh*

The topic of this talk is topology extension planning of large-scale, real-world gas transmission networks. Given a balanced allocation of source and sink flows, we look for a cost optimal selection of pipe capacities such that the requested amount of gas can be transmitted through the network without violating physical or operational constraints. The problem is modeled as a nonlinear mixed-integer optimization problem. We formulate a new class of valid inequalities (or cutting planes) which reduce the overall solution time when added to the formulation.

■ WA-63

Wednesday, 8:30-10:00
R18-2

Logistics and Maritime I

Stream: OR and Maritime Studies
Invited session

Chair: *Dongping Song*, School of Management, University of Plymouth, Drake Circus, PL4 8AA, Plymouth, United Kingdom, dongping.song@plymouth.ac.uk

1 - Modelling of complex globalized supply chains: Synergy between economic, social and environmental performance metrics
Luisa Huaccho Huatuco, Leeds University Business School, University of Leeds, Woodhouse Lane, Leeds, LS2 9JT, Leeds, West Yorkshire, United Kingdom, lh2@lubs.leeds.ac.uk, *Jairo Montoya-Torres*, *Thomas F. Burgess*

This paper presents the first three months of research carried out during the FP7 Marie Curie International Incoming Fellowship project "DISRUPT: Quantitative Modelling of sustainable supply chains under major disruptions' (grant No. ESR- 299255). The research project uses conceptual analysis and simulation modelling to address both sustainability and resilience issues in complex global supply chains subject to disturbance. This paper focuses on combining the metrics within the three dimensions of sustainability: economic, social and environmental; to evaluate overall performance.

2 - Modelling air cargo forwarding problems
Lin Zhu, Management School, University of Southampton, University Road, SO17 1BJ, Southampton, Hampshire, United Kingdom, lz1d10@soton.ac.uk, *Yue Wu*, *Honora Smith*

This research aims to help the forwarders to book air containers in advance in order to ship the cargoes from different regions to different destinations via a hub, where the cargoes need to be repacked and consolidated before leaving. Therefore, how to rent containers from the regions and hub, and how to load cargoes becomes an important issue. The problem becomes more complicated when the number of cargoes is uncertain at the time of decision-making. We propose a two-stage stochastic model to deal with the uncertainty. The computational results demonstrate the effectiveness of this model.

3 - Joint ship scheduling and dedicated terminal selection to optimize service reliability and fuel consumption in liner shipping with uncertain port times
Dongping Song, School of Management, University of Plymouth, Drake Circus, PL4 8AA, Plymouth, United Kingdom, dongping.song@plymouth.ac.uk, *Xiangtong Qi*, *Chen Li*

This paper considers the joint ship scheduling and dedicated terminal selection problem in order to simultaneously optimize the service reliability and the fuel consumption in liner shipping with uncertain port times. The problem is formulated mathematically as a stochastic multi-objective optimization problem, and solved by using a simulated-based non-dominated sorting genetic algorithm. The case study illustrates the results and generates useful managerial insights.

■ WA-64

Wednesday, 8:30-10:00
R18-3

Algorithms in Continuous Optimization

Stream: Algorithm and Computational Design
Invited session

Chair: *Basak Akteke-Ozturk*, Department of Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, bozturk@metu.edu.tr

1 - A global optimization method for a quadratic programming problem with the reverse convex constraint
Syuuji Yamada, Graduate School of Science and Technology, Niigata University, 8050 IKarashi-2nocho, 9502181, Niigata, Japan, yamada@math.sc.niigata-u.ac.jp, *Tamaki Tanaka*, *Tetsuzo Tanino*

In this talk, we propose a global optimization algorithm for a mathematical programming problem (QP) with convex and reverse convex constraints, where all constraints are defined by quadratic functions. To solve (QP), we consider another problem (P) to minimize the convex constraint function over the boundary of the reverse convex set. It is proven that there exists at least one solution satisfying KKT conditions for (P) over every maximum connected subset of the feasible set of (QP). Hence, we propose an algorithm for calculating an approximate solution of (QP) by listing KKT points of (P).

2 - Global Optimization of Mixed-Integer Bilevel Programming Problem
Zhaohui Xu, Fakultät für Mathematik, Technische Universität Chemnitz, Reichenhainer Str. 41/718 D-09107, Chemnitz, Sachsen, Germany, zhaohui.xu@mathematik.tu-chemnitz.de

This paper is concerned with mixed-integer nonlinear bilevel programming problem, which has a nonlinear objective function and one parameter on the right-hand sides of the constraints in the lower level problem. We propose an algorithm via an approximation of the optimal value function of the lower level problem to solve the bilevel programming problem globally.

3 - On the complexity of steepest descent algorithms for minimizing quadratic functions
Clovis Gonzaga, Dept. of Mathematics, Federal Univ. of Santa Catarina, Cx. postal 5210, Florianópolis, SC, Brazil, 88040-970, Florianópolis, SC, Brazil, ccgonzaga1@gmail.com

We discuss the question of how fast a steepest descent algorithm can be for minimizing a quadratic function. We do not tackle the general case of convex differentiable functions, which is more difficult. Steepest descent methods differ exclusively on the choice of step length at each iteration, and the order in which these steps are taken is irrelevant. We examine patterns in the distribution of these step lengths for minimizing a convex quadratic function, showing how a large number of short steps are needed, and how these relate to the much smaller number of large steps.

■ WA-65

Wednesday, 8:30-10:00
R18-5

Advances in Quality Control

Stream: OR in Quality Management
Invited session

Chair: *Yeliz Buruk*, Industrial Engineering, Eskisehir Osmangazi University, Eskisehir Osmangazi University, Department of Industrial Engineering, Meselik, M3 Building, 26480, Eskisehir, Turkey, yelizburuk@gmail.com

1 - Optimal determination of p-chart parameters by controlling production quantities in automobile manufacturing
Elif Elcin Gunay, Industrial Engineering, Sakarya University, Sakarya, Sakarya, Turkey, eekabeloglu@gmail.com, *Ufuk Kula*, *Beyazıt Ocaktan*

In automobile industry control charts are commonly used to control defects in paint shop. Our study jointly determines the optimal number of production quantities and attribute chart parameters when the average defect rate of the process is a random variable. When the defect rate is above the upper control limit, process is halted and all the newly painted cars are inspected which may cause late customer order deliveries. We formulate the problem as a two-stage stochastic programming problem, and solve by using sample approximation algorithm.

2 - A Multivariate EWMA Control Chart for Controlling the False Discovery Rate
Chi-Hyuck Jun, Industrial & Management Engineering, POSTECH, San 31 Hyoja-dong, 790784, Pohang, Korea, Republic Of, chjun@postech.ac.kr, *Jangho Park*

A new type of multivariate EWMA control chart is considered for detecting the process mean shift, which is based on the series of T-square statistics. A multiple hypothesis testing is established, where the false discovery rate is used as the error to be controlled via Benjamini-Hochberg procedure. A nonparametric density estimation based on the Parzen windows is adopted to approximate the distribution of the T-square statistics, from which the p-values are calculated. The performance of the proposed control charts is evaluated in terms of the average run lengths according to mean shifts.

3 - Design and analysis of tolerances, using Generalized Lambda Distribution GLD
Mohammad Mehdi Movahedi, Management Department, Islamic Azad University, Firoozkooh Branch, Firoozkooh Iran., Management Department, Firouzkoh Branch, Islamic Azad University, Firouzkoh, Iran, No. 442, Interance 13, first fase, Shahrak Ekbatan, Tehran, Iran, 1394753919, Tehran, Tehran, Iran, Islamic Republic Of, m_m_movahedi@iaufb.ac.ir, *Mohammad Bamenimoghadam*

The mechanical tolerances are set to restrict too large dimensional in a product, and have to be set in such manner that manufacture ability, interchangeability, costs, and functionality are optimized and balanced between each other. Apart from the available tolerance design techniques, statistical tolerance design is emphasized because statistical behavior describes the nature of the manufacturing processes more realistically than available methods. For this purpose, after recognizing the underlying probability distribution function, by GLD, we can use these results for design of tolerance.

4 - Enhancing the Anti-Wear Performance of Nano-oil Additives by Using Mixture Design and Multi-Objective Optimization

Yeliz Buruk, Industrial Engineering, Eskisehir Osmangazi University, Eskisehir Osmangazi University, Department of Industrial Engineering, Meselik, M3 Building, 26480, Eskisehir, Turkey, yelizburuk@gmail.com, *Ezgi Aktar Demirtas*, *Nimetullah Burnak*, *Osman Nuri Celik*

This paper describes an application of the simplex-lattice mixture design method in the development of a new formulation for oil-additives. The anti-wear performance of the formulation was analyzed by using AISI 4140 steel as substrate. Specific wear rate and wear trace length that are important quality characteristics were considered as responses. By using Design Expert, a model was established as a function of mixture variables namely, Zinc Oxide, Silicon Nitride and Carbon Nanotube. Multi-objective optimization was applied for the first time to the area of wear reduction on materials.

■ WA-66

Wednesday, 8:30-10:00
R18-4

Sustainable Management for Resources, Conservation and Recycling II

Stream: Optimization for Sustainable Development
Invited session

Chair: *Sadia Samar Ali*, Operations Management, Fortune Institute of International Business , New Delhi - 110057, India, Plot No.5 Rao Tula Ram Marg, Opp Army R&R Hospital, Vasant Vihar, New Delhi - 110057, 201009, New Delhi, India, sadiasamarali@gmail.com

1 - Green innovation abilities of companies in turkish manufacturing industry

Bahadır YÖrÜr, Industrial Engineering, University of Kocaeli, Department of Industrial Engineering, Engineering Faculty, University of Kocaeli, Umuttepe Campus, 41380, Kocaeli, Turkey, bayorur@kocaeli.edu.tr, *Gülşen Akman*

Achieving to eco-innovation is important for manufacturing companies because of creating difference among rivals and legal necessities with a whole-life-cycle minimal use of natural resources. This is only possible with green innovative abilities of companies. In this study, we evaluate green innovative abilities of manufacturing companies in Turkey. For this reason, first a survey was performed, than results were evaluated statistically. Finally, companies are clustered by using appropriate clustering methods and multi-criteria decision making methodologies, and results were discussed

2 - The Lean-and-Green Supply Chain Debate: An Australian Case Study

Behnam Fahimnia, UTS Business School, Management Disciplinary Group (MDG), University of Technology Sydney, Office 5C-04-09, 2000, Heymarket, New South Wales, Australia, behnam.fahimnia@uts.edu.au, *Joseph Sarkis*, *Ali Eshragh*, *Mohsen Varsei*

We introduce a tactical supply chain planning model that presents tradeoffs between cost and environmental degradation including carbon emissions, energy consumption and waste generation. A novel solution methodology, named Nested Integrated Cross-Entropy (NICE) method, is developed to solve the resulting MINLP model. The utility of the model and solution method is investigated using actual Australian case data. Analysis of the numerical results demonstrates how the proposed model can be used as a practical tool for investigating the relationship between lean practices and green outcomes.

3 - Identification of sustainable development features and measurement of their importance in the supply chain management: case of mobile phones

Merja Halme, Information and Service Economy, Aalto School of Economics, Pl 11000, 00076, Aalto, Finland, merja.halme@aalto.fi, *Anu Bask*, *Markku Kallio*, *Markku Kuula*

Consumer values increasingly favor sustainable development in products and services. Sustainability can be seen as a source of competitive advantage, and even as the driving force of innovation. Thus far there is very little literature on what are the different sustainable features in a product and what are their importance. Even fewer studies exist viewing the sustainability features within a whole supply chain. In this study we identify the relevant product features related to sustainable development in the choice of mobile phone and measure their importance.

4 - Strategy,Investment and New Services Development Path in Retail Industry by using Dynamic Capabilities in Aspects of Path Dependency and Real Options: The Case of KOCTAS

Özcan Çavusoglu, Industrial Engineering Ph.D. Programme, Istanbul Technical University, Institute of Science and Technology, Faculty of Management, 34367, Istanbul, MAÇKA, Turkey, cavusogluo@itu.edu.tr, *Nevin Dönmez*

In this paper first of all detailed literature review has been done.First of all capability, core competencies, dynamic capabilities, path dependency and real options concepts are defined and relation between these concepts are stated. Then new definition about these concept and terminologies are defined. After that a new framework is proposed to define relationship between these concepts. Finally, to better understand framework, a case study is examined in the leader home improvement retailing company in Turkey.Findings, results and further implications for researcher and manager are stated.

■ WA-69

Wednesday, 8:30-10:00
R19-3

OR for Development and Developing Countries 3

Stream: OR for Development and Developing Countries
Invited session

Chair: *Elise del Rosario*, ORSP, 14A Cyber One, 11 Eastwood Ave., Bagumbayan, 1110, Quezon City, Philippines, elise@jgdelrosario.com
Chair: *Honora Smith*, Academic Unit of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, honora.smith@soton.ac.uk
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Closed-Loop Supply Chain Network Design Model For Remanufacturing in Turkey's Mobile Phone Market

Aslı Özmen, Business Administration, Abant Izzet Baysal University, Administrative Sciences Ofis no 318, Abant Izzet Baysal University, 14280, BOLU, Turkey, ozmen_a@ibu.edu.tr, *İsmail Erol*

Closed loop supply chain network has been designed for remanufacturing activities in mobile phone sector in Turkey. Due to the rapid consumption of mobile phones, the location of the old phones is a key

concern.We developed model analyzes whether the investment, which will provide unused cellular phone collection, inspection, sending of unused pieces to recycling facilities and remanufacturing, is profitable or not. Finally we discussed the opportunities of remanufacturing activities for mobile phone market in Turkey.

2 - Performance Efficiency of DMMMSU Colleges and Institutes: A Data Envelopment Analysis (DEA) Study
Milagros Baldemor, Mathematics, DMMMSU, Agoo, La Union, 2504, San Fernando, Philippines, milagrosbaldemor@yahoo.com

This study determined the performance efficiency of the 16 colleges and institutes of the Don Mariano Marcos Memorial State University along: Program Requirements, Instruction, Research, Extension and Others. It utilized the Data Envelopment Analysis and employed the Input Oriented Multi - Stage Constant Returns-to-Scale Model. The peers, weights and slacks were the basis in calculating the adjustments necessary for inefficient DMUs. No single college or institute in the university could serve as a model in efficiency in all the performance indicators.

3 - Mechanisms for resolving framework of conflict in the border area of transition from one state to another in the logistics and customs sphere
Irina Kazina, Telematika and Logistika, TTI, Lomonosova str.1, Riga, Latvia, irinakazina@yahoo.com

The paper discusses aspect of the introduction of new information technologies, identified areas to reduce transaction costs. The aim is to develop procedures for providing better performance of different phases in the systems Single windows. Was identified and developed the mechanisms that help resolve framework conflict. On the bases on these results we can conclude that the developed procedures to ensure enhanced efficiency allows you to reduce transaction costs, increase efficiency and improve the quality of information and information field in border area of transition

4 - Online Global Trading Marketplace as a Buyer-Seller Social Network: A Study of Implicit Social Interactions in Developed versus Emerging Markets
Yubo Chen, School of Economics and Management, Tsinghua University, School of Economics and Management, Tsinghua University, 100084, Beijing, China, chenyubo@sem.tsinghua.edu.cn, *Qi Wang*, *Jinhong Xie*, *Jurui Zhang*

The growing online global trading marketplaces provide unprecedented access and opportunities for firms to expand their business to global markets. This paper investigates the unique features of the online global trading marketplace from a network perspective. Specifically, based on a proprietary dataset from a leading Chinese online global trading marketplace, we study how implicit social interactions in this platform affect sellers' performance, how such impacts vary in developed versus emerging markets, and how they were affected by the global financial crisis.

■ WA-70

Wednesday, 8:30-10:00
R19-4

Ethics and OR I

Stream: OR and Ethics
Invited session

Chair: *Cristobal Miralles*, Depto. Organización de Empresas, Universidad Politecnica de Valencia, Cami de Vera s/n, 46022, Valencia, Spain, cmiralles@omp.upv.es
Chair: *Fred Wenstøp*, Strategy and Logistics, BI Norwegian School of Management, Nydalsveien 37, 0483, Oslo, Norway, fred.wenstop@bi.no

1 - The effect of the ethical leadership on perceived organizational justice and organizational identification of the employees: the case of tourism businesses
Şükran Öktem, Business Administration, Başkent University, Ankara, Turkey, gonga2311@gmail.com, *Hakan Turgut*, *Gözde Kubat*

In this study, the effect of the ethical leadership on perceived organizational justice and identification has been researched with a case study. The researches' views have been examined by performing a literature review. The study has been realized with the individuals working in the tourism businesses in Ankara(Turkey). The questionnaire has been applied with the face to face interviews. The hypothesis have been evaluated by looking at the interactions of the ethical leadership with the organizational justice and the organizational identification seperately from the data.

2 - Identifying a System of Bribery in Business Transactions
Sule Onsel Ekici, Industria Engineering Department, Dogus University, 34349, Istanbul, Turkey, sonsel@dogus.edu.tr, *Ahmet Ekici*

Corruption has been identified as one of the most important barriers to worldwide economic development and growth. Bribery, as the most common form of corruption, is the focus of this paper. Based on the Global Competitiveness Index and by the help of Bayesian networks; the objectives of this research are to identify factors that are related to bribery activities in a given country, to identify a structural model that delineate the relationships between bribery activities and other factors, and to specify the factors that have the greatest impact on the bribery activities.

3 - The contribution of corporate governance to bank stability
Aristotelis Boukouras, Business School, University of Edinburgh, 29 Buccluch Place, EH8 9JS, Edinburgh, United Kingdom, Aris.Boukouras@ed.ac.uk, *Davide Mare*

Since the last banking crisis there has been an increased pressure on banks to improve their corporate governance practises. But there is little empirical evidence to suggest that weak governance induced banks to take excessive risks before the crisis. We run a dynamic panel estimation in order to identify the impact of corporate governance on bank risk-taking by focusing on the recent banking crisis (2007-2009). We show that ineffective corporate governance practises increase bank risk. Our results contribute to the understanding of the main factors behind the latest bank failures.

4 - Study of awareness rate of patients from prism of patient rights.
Mohammad Reza Bateni, Group of Medical Library, Isfahan University and Medical Sciences, IRAN -Isfahan Hezar Jarib ST., IRAN Isfahan Mirdamad ST...No:115, 110110, Isfahan, Iran, Islamic Republic Of, bateni@mng.mui.ac.ir, *Shahla Shiranifard*

The purpose of this study is to determine the awareness rate patients hospitalized city from prism of patient's rights. This study has been done descriptively measured by using the contents of patients' rights prism and interviewing by questioner and completing relevant checklists for. The required sample was 385. Achieved results from analyzing the available information in completed checklists showed that more than 50 percent of patients don't have enough awareness of patient right. So, inform and awareness is very important.

■ WA-71

Wednesday, 8:30-10:00
R16-1

Health Care Management (Waiting Times & LOS)

Stream: Health Care Management
Invited session

Chair: *Stefan Nickel*, Institute for Operations Research (IOR), Karlsruhe Institute of Technology (KIT), Kaiserstrasse 12, 76131, Karlsruhe, Germany, stefan.nickel@kit.edu

1 - Modelling of length of stay and performance in neo natal care services
Reda Lebcir, Hertfordshire Business School, University of Hertfordshire, College Lane, AL10 9AB, Hatfield, United Kingdom, M.R.Lebcir@Herts.ac.uk, *Eren Demir*

Neo natal health care services are coming under increasing pressure due to high demand. The complexity of care in these services is making it difficult to deliver care effectively. We applied three modeling methodologies to represent length of stay and its impact on the performance of neo natal units in London (UK). The models' findings regarding the relationship between length of stay, patients' flows, and the performance of the units, can be very useful in guiding decision and policy making in these services.

2 - Reducing Wait Times and Improving Treatment Planning Process for Radiation Therapy
Mehmet Begen, Ivey School of Business, Western University, 1151 Richmond St. N., N6A3K7, London, ON, Canada, mbegen@ivey.uwo.ca, *Inge Aivas*, *Vusal Babashov*, *Michael Lock*, *Greg Zaric*

According to Cancer Care Ontario (CCO), the referral to consult and the ready to treat to treatment wait times targets must be fulfilled within 14 calendar days. Statistics showed that London Regional Cancer Program (LRCP) consults 65% and treats 70% of patients within the targets. We studied processes from patient referral to treatment at LRCP. We analyzed available data, interviewed stakeholders and observed processes. We prepared a process map of the radiation treatment planning and developed a discrete event simulation model to determine possible bottlenecks and reduce wait at LRCP.

3 - A multi-objective and multi-period approach for planning the delivery of long-term care services
Teresa Cardoso, Centre for Management Studies of Instituto Superior Técnico (CEG-IST), Instituto Superior Técnico, Technical University of Lisbon, Avenida Rovisco Pais, 1, 1049-001, Lisboa, Portugal, teresacardoso@ist.utl.pt, *Mónica Oliveira*, *Ana Paula Barbósa-Póvoa*, *Stefan Nickel*

A multi-objective and multi-period mathematical programming model is proposed to inform on how to organize institutional long-term care provision in the medium-term (in terms of capacity planning and location selection) when three equity objectives are pursued — access, socioeconomic equity and geographical equity. The multi-objective function is structured and uses weights built with the MACBETH approach, which assists in explaining on how to build the weight for each equity objective and to clarify its meaning. The applicability of the model is illustrated through a case study in Portugal.

4 - Indicators for Safe Medical Treatment
Tsutomu Mishina, Systems Science and Technology, Akita Perfectural Univeristy, 84-4 Tsuchia-Ebinokuchi, 015-0055, Akita, Japan, mishina@akita-pu.ac.jp, *Harumi Miyano*

Providing safe medical treatment is an important policy in hospitals, enforced by eliminating medical errors. Preventing accidents requires strict managerial measures, such as continuous monitoring of actions. However, it is difficult to establish a comprehensive set of safety guidelines. In this paper we show an organizational monitoring system where safety levels can be self-evaluated and later revised after determining the amount of risk of specific treatments. This system will help to indicate the necessary improvements to provide safe, high quality medical treatment.

■ WA-72

Wednesday, 8:30-10:00
R16-2

Simulation Studies in Healthcare

Stream: OR in Health & Life Sciences (contributed)
Contributed session

Chair: *Nilgun Fescioglu-Unver*, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Cad. No:43, Sogutozu, 06560, Ankara, Turkey, nfunver@etu.edu.tr

1 - Using Discrete-Event Simulation to analyze the process of cataract intervention at a university hospital outpatient department
Olav Goetz, School of Law and Economics, University of Greifswald, Germany, olav.goetz@uni-greifswald.de, *Claudia Bullmann*, *Maria Zach*, *Frank Tost*, *Steffen Fleßa*

Simulation supports economic analyses inside the hospital like patient flow, pathways or utilization rates.We constructed a stochastic discrete-event simulation model to represent the cataract intervention and to analyze scenario changes,e.g. appointment policy or new personnel.The results present insights to the underlying research questions.It was possible to reduce the utilization of the operation theatre by 22.72% by adding one additional physician.DES provides a powerful tool to monitor the questions inside the health care sector,helps analyzing processes and supports decision-making.

2 - Improving Value of Real Time Locating Systems in Healthcare
Nilgun Fescioglu-Unver, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Cad. No:43, Sogutozu, 06560, Ankara, Turkey, nfunver@etu.edu.tr, *Ece Arzu Demircan*

The number of healthcare facilities using real time locating systems (RTLS) for tracking patient, staff and mobile assets is increasing every day. Surveys show that the best way to use RTLS is asset tracking. When there is a need for a specific asset, RTLS system displays the available assets within the facility, and the demanding nurse frequently selects the closest one. This type of selection results in unbalanced utilization and early depreciation of assets. In this research we propose a model to balance the asset utilizations while still considering the distance nurses travel.

3 - Implementation of a simulation model of pre-hospital medical disaster response for a major road traffic accident
Christophe Ullrich, RMA, Belgium, christophe.ullrich@rma.ac.be, *Filip Van Utterbeeck*, *Michel Debacker*, *Erwin Dhondt*

A stochastic discrete event simulation model is constructed using Arena. This simulation model consists of 3 interacting components: the medical response model, the victim creation model and the victim pathway model. The medical response model focuses on the pre-hospital phase which includes triage procedures, evacuation processes and medical processes. We use realistic victim profiles for medical disaster simulations based on medical expertise. We show our result for a major road traffic accident for various levels of resources and with two politics of rescue: scoop and run or stay and play.

4 - Virtual rehabilitation systems
Orçin TelliÌ Atalay, physical therapy and rehabilitation, pamukkale university, pamukkale university school of physical therapy and rehabilitation, 20070, Denizli, Turkey, orcint@pau.edu.tr

Virtual Reality (VR) has been used in an increasingly wide range of applications. Virtual reality has potential for assisting recovery from illnesses.Active video game systems,a camera accessory, have also been used in studies of rehabilitation.Visual inputs are generally dominant among human sensory inputs for balance control as well as a general source of information, and virtual reality systems have evolved with an emphasis on visual displays. VR provides a relatively safe environment for training compared to many real-world environments.

■ WA-73

Wednesday, 8:30-10:00
R16-3

Financial Modelling and Commodity Pricing

Stream: OR in the Oil and Gas Sectors
Invited session

Chair: *Marcus Hildmann*, Information Technology and Electrical Engineering, ETH Zurich, ETL G 24.2, Physikstrasse 3, 8092, Zürich, Switzerland, hildmann@eeh.ee.ethz.ch

Chair: *Dejan Stokic*, tbd, 60386, Frankfurt, Germany, sdeyan@gmail.com

1 - Calculation of a Daily Forward Curve for Natural Gas
Marcus Hildmann, Information Technology and Electrical Engineering, ETH Zurich, ETL G 24.2, Physikstrasse 3, 8092, Zürich, Switzerland, hildmann@eeh.ee.ethz.ch

Gas is traded on the spot and the Future market over many hubs around the world. While the spot is traded on a daily frequency, Future contracts are available over longer periods. Since gas shows several different seasonal patterns, an arbitrage free daily prediction is necessary, analogous to the hourly price forward curve in electricity trading. We will show an analysis of the seasonality of natural gas as well as a set of factors as exogenous variables and propose a model to calculate an daily price forward curve arbitrage free to the market.

2 - The Impact of Alternative Performance Measures on Portfolio Procurement Strategy
Qi Fu, Department of Accounting and Information Management, University of Macau, Av. Padre Tomás Pereira, Taipa, Macau, gracefu@umac.mo

This paper studies a portfolio procurement problem, in which a buyer procures using a set of option contracts as well as a spot market with random price to meet the uncertain demand. The option contract consists of a fixed unit reservation price to buy the options upfront, and a dynamic unit execution price for the final order. We study the portfolio procurement strategies with both risk-neutral objective and an alternative performance measure of minimizing conditional value at risk (CVaR) to incorporate the risk concern of decision makers.

3 - Stochastic network pricing: a theme and three variations
Patrice Marcotte, DIRO, Université de Montréal, CP 6128 Succursale Centre Ville, H3C 3J7, Montréal, Québec, Canada, marcotte@iro.umontreal.ca, *Shahrouz Mirzaalizadeh*, *Gilles Savard*

Pursuing on the theme of two-stage bilevel stochastic pricing, where profit-maximizing tolls must be determined on a subset of arcs of a transportation network, we consider three variations. First, it is assumed that the disutility of commuters incorporates tardiness and reliability terms. Next, we consider chance constraints at the leader level. The third model embeds congestion associated with random capacities along the arcs of the transportation network. For each model, we provide a mathematical programming formulation, and illustrate their features through numerical examples.

4 - An approach to designing a mechanism for forming public-private partnerships
Alexander Belenky, Mathematics for Economics, National Research University Higher School of Economics and MIT, 20 Myasnitskaya Street, 101000, Moscow, Russian Federation, abelenky@mit.edu

When a state needs to implement a set of projects which it cannot fully or partially finance from public funds, it tries to find private partners to share expenses and risks associated with funding and operating the projects. This requires designing mechanisms for harmonizing public interests and those of the private sector to let the partnerships be formed. One such mechanism is based on the analysis of the solvability of three-person games on polyhedral sets of connected player strategies. Necessary and sufficient conditions for the equilibria in such games are proposed.

■ WA-74

Wednesday, 8:30-10:00
R16-4

OR in regular study programs

Stream: Initiatives for OR Education
Invited session

Chair: *Jo Smedley*, Centre for Excellence in Learning and Teaching, University of Wales, Newport, Lodge Road, Caerleon, NP18 3QT, Newport, Wales, United Kingdom, jo.smedley@newport.ac.uk
Chair: *Alexis Pasichny*, Students' Science Association, National Technical University of Ukraine, 37, Peremohy av., 03056, Kiev, Ukraine, alexis.pasichny@gmail.com

1 - OR dissemination activities for the Italian secondary school
Alberta Schettino, AIRO, Via Palmoriere n. 7, 18100, Imperia, Italy, Italy, albertaschettino@gmail.com, *Maria Celeste Bonetto*

We shall give an outlook of some of the dissemination activities of O.R. undertaken in Italy for secondary school. We shall describe two strictly related initiatives entered this year in the Istituto Tecnico "G. Galilei' in Imperia, Logistic & Transport curriculum: the introduction of O.R. in the syllabus of Mathematics in 3rd form (age 16), with a MINDSET Project type approach, and the project "What is O.R.", a zero-cost project aimed to our students aged 16-18, with the intent of introducing them to O.R. and re-inforcing their listening skills in English at the same time.

2 - Participatory Management in Higher Education for Organizational Sustainability: Istanbul Kemerburgaz University Case Study
Fikret Korhan Turan, Department of Industrial Engineering, Istanbul Kemerburgaz University, Mahmutbey Dilmenler Cad., No:26, Bagcilar, 34217, Istanbul, Istanbul, Turkey, korhan.turan@kemerburgaz.edu.tr, *Saadet Cetinkaya*, *Ceyda Ustun*

Istanbul Kemerburgaz University management considers implementing a set of investment projects that will improve the university's sustainability performance as a higher education institute. Using analytic hierarchy and network processes (AHP/ANP) as group decision support tools, we conduct a survey to determine a project portfolio that will satisfactorily respond to the needs of key stakeholders including students, faculty, staff, community and financial partners. Survey results show how stakeholder priorities for a private university change under low, medium and high financial constraints.

3 - Supporting learner achievement through OR approaches
Jo Smedley, Centre for Excellence in Learning and Teaching, University of Wales, Newport, Lodge Road, Caerleon, NP18 3QT, Newport, Wales, United Kingdom, jo.smedley@newport.ac.uk

Learners, while appropriately qualified for course entry, can encounter challenges with their learning skills, particularly during their first weeks of study. Co-curricular learning, accessible through a mix of traditional and modern technological delivery approaches, provides additional learning alongside the formal delivery. Using OR soft systems approaches, improved quality outcomes are evident with improved formal achievement and enhanced abilities to apply learning to real-life situations. Case study examples include academic and professional applications from the UK and Europe.

4 - An Analysis of the Effects of Distance Learning on the Productive Skills in Foreign Language Education
Merve Kayaci Çodur, Industrial Engineering, Ataturk University, Ataturk University Engineering Faculty, Industrial Engineering, 25200, Erzurum, Turkey, mkayaci@atauni.edu.tr, *Aysel Eyerci*

This study is aimed at revealing the findings of a quasi-experimental study. To obtain the results a questionnaire is used to analyze the effects of distance learning on the productive skills in foreign language education by using statistical evaluation methods. It is conducted with the students of Ataturk University, Turkey which began to conduct the course of Foreign Language I, an obligatory course for the all departments, through distance learning in the 2012-2013 academic years. The findings of the study are expected to contribute to this field and inspire further studies.

Wednesday, 10:30-12h00

■ WB-02

Wednesday, 10:30-12h00
O1-2

Modeling Sustainable Systems III

Stream: Sustainable Development Modeling with System Dynamics
Invited session

Chair: *Pierre Kunsch*, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, pkunsch@vub.ac.be

1 - Simulation based evaluation of e-waste disassembly layouts
Askiner Gungor, Industrial Engineering, Pamukkale University, 20100, Denizli, Turkey, askiner@pau.edu.tr, *Ozan Capraz*, *Olcay Polat*

The recovery of electronic waste plays a key role in environmental sustainability by minimizing the negative effects of hazardous materials and the use of world's limited resources. In this study, alternative e-waste disassembly layout plans for e-waste recovery facilities are proposed and analyzed using simulation in order to reduce the time spent for non-value added activities. Variability and uncertainty related to e-waste products are also taken into account.

2 - Determination of the optimal strategy of a quarry in Algeria using the Three Phase Discrete-Event Simulation: A case study
Latifa Ourbih - Baghdali, Department of Basic Infrastructures(DIB), National High school of Public Works (ENSTP), 1, rue SIDI GARIDI, VIEUX KOUBA, 16051, ALGER, Algeria, baghdalil@yahoo.fr, *Megdouda Ourbih-Tari*, *Abdelnasser Dahmani*

This paper focuses on a case study of Bejaia quarry in Algeria at the operational level, considering the random behavior, the resource characteristics and dynamic interactions during operations. A logical model for the quarry aggregates using an activity cycle diagram is built from which we have simulated the behavior of the quarry on a computer using the three phase discrete event simulation system. The purpose of the simulation is to improve the system being studied by determining the optimal strategy using the developed simulator with PSim language.

3 - Causal Dynamics of the Market for Rare Earth Elements
Patricia Rogetzer, Department of Information Systems and Operations, WU Wien - Vienna University of Economics and Business, Nordbergstrasse 15/3/A, 1090, Vienna, Vienna, Austria, patricia.rogetzer@wu.ac.at

Rare earth elements, strategic, non-renewable resources necessary for high-tech products, face the risk of shortages due to a deteriorated situation with respect to matching supply with demand. A systematic evaluation of raw material criticality is needed to meet the highly dynamic system. Based on causal-loop and stock and flow diagrams of selected modules a System Dynamics model, capable of representing interdependencies and feedback within a volatile market, is set up. Heterogeneity, uncertainty, and non-linearity of rare material markets are evaluated by scenarios and sensitivity analyses.

4 - Analysing causes of avoidable waste - A problem structuring approach
Duncan Shaw, Operational Research and Management Science, Warwick Business School, University of Warwick, CV4 7AL, Coventry, United Kingdom, duncan.shaw@wbs.ac.uk

We propose a new systems thinking approach (Waste And Source Analysis — WASAN) to analyse sources of waste that result from process, interdependency and human causes. WASAN supports stakeholders in exploring/negotiating solutions to optimally manage sources of waste. We also propose a framework to think through the human and technical reasons for why sources produce waste: behavioural, knowledge, material, processing and systemic (BKMPS) causes of waste. The framework is used to reflect on a study of applying WASAN to consider managing radioactive sources in the UK's nuclear industry.

■ WB-03

Wednesday, 10:30-12h00
O1-3

Generalized Semi-infinite Programming: Models, Extensions and Tractable Reformulations

Stream: Semi-Infinite and Semidefinite Optimization and Applications
Invited session

Chair: *Paul I. Barton*, Department of Chemical Engineering, MIT, Room 66-464, 02139, Cambridge, MA, United States, pib@mit.edu

1 - Control and Discovery of Information in Robust Optimization
Phebe Vayanos, MIT, United States, pvayanos@mit.edu, *Dimitris Bertsimas*, *Paul I. Barton*

We propose a powerful modeling paradigm for decision-making under uncertainty that captures the ability of the decision-maker to influence the set of possible realizations of the uncertain parameters and dynamically discover (or learn) information about them. We model these problems as multi-stage robust optimization problems in which both the uncertainty-set and the non-anticipativity constraints are decision-dependent. We highlight the modeling power of the approach in a variety of real-world application areas and propose efficient numerical solution procedures.

2 - Reformulation of nonsmooth generalized semi-infinite programs with application to design centering
Stuart Harwood, Chemical Engineering, MIT, 77 Massachusetts Ave, Room 66-319, 02139, Cambridge, MA, United States, harwood@mit.edu, *Paul I. Barton*

This work considers generalized semi-infinite programs (GSIP) with specific focus on their application to design centering. The goal is to reformulate the GSIP as a semi-infinite program when only convexity and continuity properties of the defining functions and sets hold. This contrasts with previous work, which typically requires that the functions defining the semi-infinite constraint set are at least smooth. We use a duality approach to achieve the reformulation, and this permits the use of nonsmooth convex relaxation techniques when formulating a robust design centering problem.

3 - On hybrid preconditioners for solving indefinite systems in interior point methods for linear optimization
Luciana Casacio, FEEC, Unicamp, Rua João da Silva Martins, 1192, 13274320, Valinhos, São Paulo, Brazil, luciana@densis.fee.unicamp.br, *Aurelio Oliveira*, *Christiano Lyra*

We are concerned with the KKT systems arising when an interior point method is applied to solve large-scale linear programming problems. We consider new approaches for splitting the variables into basic-nonbasic partitions to design novel preconditioners for iterative methods applied to these systems. This hybrid approach uses a generic preconditioner for the first iterations and a specially tailored one for the final iterations at the end. We provide a spectral analysis for the preconditioners and illustrate their practical behaviour on medium-scale problems.

■ WB-04

Wednesday, 10:30-12h00
O4-4

Computational Aspects of Interior Point Methods

Stream: Mathematical Programming
Invited session

Chair: *Jacek Gondzio*, School of Mathematics, University of Edinburgh, Edinburgh, United Kingdom, j.gondzio@ed.ac.uk
Chair: *Goran Lesaja*, Mathematical Sciences, Georgia Southern University, 203 Georgia Ave., 30460-8093, Statesboro, Georgia, United States, goran@georgiasouthern.edu

1 - Advances in interior point methods and column generation

Pablo Gonzalez-Brevis, School of Mathematics, University of Edinburgh, United Kingdom, P.Gonzalez-Brevis@sms.ed.ac.uk, *Jacek Gondzio*, *Pedro Munari*

The primal-dual column generation method which uses interior suboptimal master problem solutions to stabilize the column generation will be presented. Recent developments in how to reinitialize the method after new columns are added will be addressed. Theoretical and extensive computational experiments solving the root node of some combinatorial optimization problems show that the proposed method is sound in theory and competitive in practice. Extensions to solve multicommodity network flow, two-stage stochastic programming and support vector machine problems will be discussed.

2 - Iterative approaches for solving large-scale linear systems arising from interior point methods

Aurelio Oliveira, Computational & Applied Mathematics, State University Of Campinas, DMA IMECC Unicamp, C. P. 6065, 13081-970, Campinas, SP, Brazil, aurelio@ime.unicamp.br, *Carla Ghidini*, *Marilene Silva*

The preconditioned conjugate gradient and MINRES methods are applied to solve linear systems arising from interior point methods for linear programs. The conjugate gradient method requires more iterations to converge and fails more often in comparison with the MINRES. However, when the former achieves convergence, it is faster than the later. This observation leads to an approach that combines both methods. The MINRES is called upon whenever the conjugate gradient gives signs of fail. Numerical experiments reveal that such approach works better than standard ones on some large-scale problems.

3 - Sparsity preserving preconditioners for linear systems in interior point methods

Vera Kovacevic Vujcic, Laboratory for Operational Research, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Serbia, Serbia, verakov@fon.rs

Systems of normal equations arising in interior point methods for linear programming in the case of degenerate optimal face have highly ill-conditioned coefficient matrices. In 2004, Monteriro, O'Neal and Tsuchiya propose preconditioners which guarantee uniform well-conditionedness. However, the proposed preconditioners can lead to considerable loss of sparsity. Our approach is directed towards a generalization of the proposed preconditioners, which makes a balance between sparsity and well-conditionedness. Results of numerical experiments show the effects of the new approach.

4 - Matrix-free interior point method for difficult optimization problems

Jacek Gondzio, School of Mathematics, University of Edinburgh, Edinburgh, United Kingdom, j.gondzio@ed.ac.uk

The matrix-free interior point method allows for solving very large optimization problems without the need to have them explicitly formulated. The method uses problem matrices only as *operators* to deliver the results of matrix-vector multiplications. Recent advances including the new theoretical insights and the new computational results will be presented. Ref: J. Gondzio, Interior Point Methods 25 Years Later, EJOR 218 (2012) pp. 587-601. DOI: http://dx.doi.org/10.1016/j.ejor.2011.09.017

■ WB-05

Wednesday, 10:30-12h00
O4-1

Nonlinear Model Predictive Control

Stream: Optimal Control
Invited session

Chair: *Ekaterina Kostina*, Department of Mathematics and Computer Science, University of Marburg, Hans-Meerwein-Str., 35032, Marburg, Germany, kostina@mathematik.uni-marburg.de

1 - Using Nonlinear Model Predictive Control for Dynamic Decision Problems in Economics

Willi Semmler, Economics, New School for Social Research, 79 Fifth Ave, 10003, New York, New York, United States, SemmlerW@newschool.edu

For solving dynamic decision problems we propose a new procedure, called Nonlinear Model Predictive Control (NMPC), relies on the iterative solution of optimal control problems on finite time horizons. Like Dynamic Programming (DP), NMPC provides global solutions. But, unlike DP, NMPC only computes one optimal trajectory at a time, and thus avoids the curse of dimensions. NMPC is explained by means of numerical simulations for various economic examples, including stochastic problems, models with multiple equilibria and regime switches in the dynamics.

2 - An Efficient Condensing Technique Suited for MHE Arising in NMPC for instationary Partial Differential Equations

Gregor Kriwet, Mathematics and computer science, University of Marburg, Hans Meerweinstr. 6, 35032, Marburg, Germany, kriwet@mathematik.uni-marburg.de

We present an algorithm for moving horizon estimation arising in nonlinear model predictive control for processes described by in-stationary partial differential equations. The algorithm is based on a direct multiple shooting time domain decomposition strategy which ensures stability. The main part of the algorithm is an efficient condensing strategy, which eliminates the additional variables and constraints coming from the multiple shooting time domain decomposition. The method is real-time feasible for partial differential equations.

3 - Nonlinear Model Predictive Control (NMPC) of Non-Stationary Partial Differential Equations

Ekaterina Kostina, Department of Mathematics and Computer Science, University of Marburg, Hans-Meerwein-Str., 35032, Marburg, Germany, kostina@mathematik.uni-marburg.de

Many spatio-temporal processes in the natural sciences and engineering are described by non-stationary PDE models which are used for a process optimization. However in the presence of disturbances and model uncertainties the real process will never follow the off-line computed optimal solution. Thus the challenge is to compute feedback controls (e.g., NMPC) that take these perturbations into account. We present a new multi-level iterations strategy to make NMPC computations real-time feasible even for PDE optimal control problems. Based on joint work with H.G. Bock and G. Kriwet.

4 - Conditions for a weak minimality in optimal control problems with integral equations of Volterra type

Andrei Dmitruk, CEMI, Russian Academy of Sciences, Nakhimovskii prospekt, 47, CEMI, 117418, Moscow, Russian Federation, vraimax@mail.ru, *Nikolai Osmolovskii*

On a fixed time interval we consider an optimal control problem with a control system of Volterra type integral equations, with endpoint equality and inequality constraints, state inequality constraints, and mixed state-control equality and inequality constraints. The main assumption is that the gradients of mixed equality constraints and active mixed inequality constraints are linear-positive independent. For a weak minimum in this problem, we give first order necessary conditions in the form of Euler-Lagrange equation.

■ WB-07

Wednesday, 10:30-12h00
O4-3

Polynomial Optimization: Symmetry and Combinatorial Structures

Stream: Copositive and Polynomial Optimization
Invited session

Chair: *Daniel Plaumann*, Mathematics, University of Konstanz, Fachbereich Mathematik, Fach D203, 78457, Konstanz, Germany, Daniel.Plaumann@uni-konstanz.de

1 - Optimizing with symmetric polynomials and symmetric mean inequalities
Cordian Riener, Aalto Science Institute, Aalto University, Helsinki, Finland, cordian.riener@aalto.fi

A polynomial is called sums of squares (SOS) if it can be written as a sum of squares of polynomials. Clearly any such polynomial is non-negative and within recent years SOS decomposition has turned out to be a tool for polynomial optimization. In this talk we will be focusing on the situation of optimization with symmetric polynomials. In particular we will be interested in parametric problems, where the parameter n indicates the number of variables.

2 - Exploiting symmetry in polynomial optimization
João Gouveia, Universidade de Coimbra, Portugal, jgouveia@mat.uc.pt, *Greg Blekherman*, *James Pfeiffer*, *Rekha Thomas*

It is well known that the symmetry of a polynomial optimization problem can be used to reduce the complexity of optimizing over sums of squares relaxations for it. In this talk we will use this tool to provide a simple proof of lower bounds on relaxation steps needed to get optimal solutions of certain optimization problems on the cube, providing a generalization of a previous result of Laurent for the max cut problem. We also show the limitations of this approach to provide lower bounds for other problems, illustrating them with the matching problem.

3 - Extremal non-negative polynomials that are not sums of squares
Aaron Kunert, Universitaet Konstanz, Germany, aaron.kunert@uni-konstanz.de

We will present a construction of a family of non-negative polynomials that are not sums of squares. These polynomials arise in a very combinatorical way and can be parametrized by triples of points on a given elliptic curve. We will show that this construction can be used to obtain polynomials that are extremal in the cone of non-negative polynomials.

4 - Handelman's hierarchy for the maximum stable set problem
Zhao Sun, Tilburg University, Netherlands, sunzhao1987@gmail.com, *Monique Laurent*

The maximum stable set problem is a well-known NP-hard problem in combinatorial optimization, which can be formulated as the maximization of a quadratic square-free polynomial over the (Boolean) hypercube. We investigate a hierarchy of LP relaxations for this problem, based on a result of Handelman showing that a positive polynomial over a polytope can be represented as conic combination of products of the linear constraints defining the polytope. In particular, we relate the rank of Handelman's hierarchy with structural properties of graphs and study links to several other LP hierarchies.

■ WB-08

Wednesday, 10:30-12h00
O3-2

Keynote - J. Sokol

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Maria Antónia Carravilla*, INESC TEC, Faculty of Engineering, University of Porto, R. Dr. Roberto Frias s/n, 4200-465, Porto, Portugal, mac@fe.up.pt

1 - Industry Interaction and the Future of OR Education
Joel Sokol, Georgia Institute of Technology, Atlanta, GA, United States, jsokol@isye.gatech.edu

The rise of Analytics. The potential of MOOCs. The advent of Big Data. The promise of ubiquitous computing. Our students will face a very different world of OR possibilities; at the same time, the world of OR education is also changing in ways that are uncertain. How can we prepare our students for success, and retain our own educational relevance? There is no panacea, but in this talk I will argue that interaction with industry (broadly defined to include business, government, military, NGOs, etc.) and serious industry projects should be a key part of the OR education we give our students, both for our students' benefit and our own. Based on my experience with over 1500 students in industry project courses, as well as the experiences and best practices of others in academia and industry, guidelines for efficient implementation and for maximizing the benefit/resource-cost tradeoff will be discussed.

■ WB-09

Wednesday, 10:30-12h00
O3-3

Sponsor - AMPL

Stream: Sponsors
Sponsor session

Chair: *Maria Grazia Scutellà*, Informatica, Universita' di Pisa, Largo B. Pontecorvo 3, 56127, Pisa, Italy, scut@di.unipi.it

1 - AMPL Models for "Not-Linear" Optimization Using Linear Slvers
Robert Fourer, AMPL Optimization, 2521 Asbury Avenue, 60201-2308, Evanston, IL, United States, 4er@ampl.com

"How can I linearize this?" is perhaps the most common formulation question in optimization modeling. But popular solvers for mixed-integer linear programming can also be applied effectively to various extensions and generalizations of linearity. We describe features of the AMPL modeling language that encourage "not linear" modeling with discrete domains, logical restrictions, and a range of formulations equivalent to conic quadratic programs. We also present interfaces to alternative solvers that can handle logic in a natural and direct way not requiring the conventional transformations.

■ WB-10

Wednesday, 10:30-12h00
G5-1

Wireless sensor networks

Stream: Telecommunications and Network Optimization
Invited session

Chair: *Francesco Corman*, Transport Engineering and Logistics, Maritime and Transport Technology, Delft University of Technology, -, Delft, Netherlands, f.corman@tudelft.nl

1 - A new metric for partial observability solutions to sensor location problems
Marco Rinaldi, CIB, KU Leuven, Celestijnenlaan, 300A Box 2422, 3001, Leuven, Belgium, marco.rinaldi@cib.kuleuven.be, *Francesco Corman*, *Francesco Viti*

We study the problem of selecting where to get information in order to obtain a broad picture of the traffic patterns in a network, considering the practically relevant case of partial observability. We develop a new metric that, based solely on topological information and sound algebraic methods, captures the amount of information derived by some observed variables. A measure of the maximum error on the unobserved link flows can be estimated and used to identify the set of links that will minimize this error. We test the approach and the metric on toy and real-life sized networks.

2 - Maximizing Lifetime with Minimum Required Bandwidth in Wireless Sensor Networks
Ugur Yildiz, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Caddesi No:40 Sogutozu, 06560, Ankara, Turkey, uyildiz@etu.edu.tr, *Hakan Gultekin*, *Bulent Tavli*, *Kemal Bicakci*
A wireless sensor network consists of a base station and a number of sensors which can sense, receive, transmit, and process data with limited power supply. In this study, we develop an approach to determine the routes as well as the schedule of data flows which requires minimum bandwidth while maximizing the lifetime of the network. This approach first determines optimal data flows that maximizes the lifetime using linear programming and then schedules these flows with a heuristic that aims to minimize the required bandwidth. We test the performance of this method for small sized problems.

3 - Improving Wireless Sensor Network Reliability by Topology Control
Melek Şendil, Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Street No:43, Sogutozu, Ankara, 06560, Ankara, Turkey, msendil@etu.edu.tr, *Aysegul Altin Kayhan*
In this study, we aim to enhance the reliability of a WSN against possible attacks and failures by a new partial redundancy protocol while maximizing the network lifetime. We consider a network composed of a base station, many identical sensors, and a central sensor with higher energy. The proposed mixed IP model suggests that sensors who satisfy some conditions replicate their data and send it on two node disjoint paths. The performance of the model is evaluated according to some performance criteria. The tradeoff between network lifetime and reliability is examined.

4 - Lifetime maximization for Wireless Sensor Networks using video cameras
André Rossi, Lab-STICC - UMR 6285, Université de Bretagne-Sud, Centre de Recherche - BP 92116, 2 rue de Saint Maudé, 56321, Lorient, France, andre.rossi@univ-ubs.fr, *Alok Singh*, *Marc Sevaux*
We consider the problem of maximizing lifetime of a WSN where sensor nodes are equipped with video cameras for monitoring a set of targets. This problem is addressed using a column generation algorithm in which the subproblem is to generate groups. A group is a set of sensors that cover all the targets. Hence, designing a group is selecting a subset of sensors, setting the direction and focal distance for each video camera because a target is covered only if its picture is sharp. The master problem is to decide how long to use each group without violating the sensors battery limitations.

■ WB-11

Wednesday, 10:30-12h00
G5-3

New Directions in Location Analysis

Stream: Location Analysis
Invited session

Chair: *Dmitry Krass*, Rotman School of Mgmt, University of Toronto, 105 St. George st., M5S 3E6, Toronto, Ontario, Canada, krass@rotman.utoronto.ca

1 - Computational results for the p-median line problem with outlier detection
Robert Schieweck, Institute for Numerical and Applied Mathematics, University of Göttingen, Göttingen, Germany, r.schieweck@math.uni-goettingen.de, *Anita Schöbel*
The problem of locating a number of lines in the plane to approximate a finite point set is a well-known problem with applications in latent class regression. It is known to be NP-hard and can be solved by MIP-solvers only for small instances and special distance functions to measure point-line distance. We propose an algorithm based on a finite candidate set which is able to perform competitively and can deal with more general distance functions. It can also be adapted to incorporate the identification of potential outlier points while maintaining most of its performance.

2 - The Stochastically Capacitated Location Problem
Mozart Menezes, Haskayne School of Business, University of Calgary, 2500 University Drive NW, T2N1N4, Calgary, Alberta, Canada, mozart.menezes@ucalgary.ca, *Serigne Gueye*
In this work we present the Stochastically Capacitated Facility Location Problem (SCFLP). This is a generalization of the Median Problem with Unreliable Facility (MPUF); in that problem facilities' capacity are either zero or infinite while in this problem capacity is described by a well defined probability distribution. We show that an important property, namely sub-modularity, found in the Median and in the MPUF problems is inherited and may suggest that greedy-based heuristics can perform well with the UCFLP. This is a work in progress where encouraging first results will be discussed.

3 - Lagrangian heuristic for the two-stage facility location problem
Edith Lucero Ozuna Espinosa, Facultad de Ingeniería Mecánica y Eléctrica, Universidad Autónoma de Nuevo León, Av. Universidad s/n, Ciudad Universitaria, 66450, San Nicolás de los Garza, Nuevo León, Mexico, luceroozuna@gmail.com, *Igor Litvinchev*
In the two-stage facility location problem, a single product is produced at plants and then transported to depots, both having limited capacities. The product is transported to customers to satisfy their demands. The use of the plants/depots incurs a fixed cost, while transportation in both stages results in a variable cost. We need to identify what plants and depots to use, as well as the product flows such that the demands are met at a minimal cost. This work presents a simple decomposable relaxation and an algorithm to restore the feasibility of the corresponding Lagrangian solution.

4 - Competitive Location and Design Problem
Dmitry Krass, Rotman School of Mgmt, University of Toronto, 105 St. George st., M5S 3E6, Toronto, Ontario, Canada, krass@rotman.utoronto.ca, *Robert Aboolian*, *Oded Berman*
We present some new results on the problem of simultaneously determining the location and design of retail facilities in a competitive environment. Both theoretical and computational results will be discussed.

■ WB-12

Wednesday, 10:30-12h00
G5-4

System Dynamics Modelling and Simulation Session 2

Stream: System Dynamics Modeling and Simulation
Invited session

Chair: *Brian Dangerfield*, Centre for Operations Management, Management Science & Statistics, University of Salford, Salford Business School, Maxwell Building, The Crescent, M5 4WT, Manchester, United Kingdom, b.c.dangerfield@salford.ac.uk

1 - Tackling key strategic decisions of the chocolate-producing companies: A system dynamics approach
Tatiana Boyarskaya, University of St. Gallen, Switzerland, tatiana.boyarskaya@gmail.com, *Evgenia Ushakova*
International chocolate-processing companies have been increasing their market footprint through capacity expansion into cocoa producing countries where unstable economic and climatic situations lead to cocoa price fluctuations. These in turn affect the pricing and investment decisions of producers, who seek to avoid demand shortfalls and idle capacities. A system dynamics approach is applied to help chocolate companies manage capacity and price-risk hedging decisions. Based on simulation results we suggest an optimal range for annual capital expenditure and efficient risk-mitigation policies.

2 - Group Buying Schemes - A Sustainable Business Model?
Sebastian Koepp, Institute of Management, University of St. Gallen, 9000, St. Gallen, Schweiz, Switzerland, sebastian.koepp@student.unisg.ch, *Aliaksei Mukhachou*

Following a loss leader approach Groupon set up a global company in less than 3 years. Its coupon platform is connecting local customers to service suppliers offering discounted coupons. Groupon's unprecedented growth seemed a success story. Its business model was solely focused on short term growth. A systematic look at the dynamic structures Groupon's exploiting though made us raise concerns about the capability of generating long term profits; already before the IPO in 2011. This paper anticipated Groupon's downturn and provides strategic measures for Groupon's long term survival.

3 - Bootstrapping for Confidence Interval Estimation in the Taylor Rule Model for Monetary Policy in Brazil
Felix Neugebauer, System Dynamics Group, University of St.Gallen, Switzerland, felix.neugebauer@student.unisg.ch

We apply nonparametric residual based bootstrapping to estimate parameter confidence intervals in the Taylor rule system dynamics model for monetary policy in Brazil. The motivation behind this resampling approach is that very few assumptions on the data are required. The steps of data engineering between the system dynamics software and Excel are provided, offering a practical standard procedure for applied bootstrapping. The Taylor rule model coefficients are found to be highly significant. Moreover, we discuss the overall potential of bootstrapping for empirical system dynamics modeling.

4 - Modelling a Sovereign Debt Crisis: the case of Jamaica
Brian Dangerfield, Centre for Operations Management, Management Science & Statistics, University of Salford, Salford Business School, Maxwell Building, The Crescent, M5 4WT, Manchester, United Kingdom, b.c.dangerfield@salford.ac.uk, *Jide Lewis*

Using a system dynamics model the relationship between sovereign debt dynamics and the stability of financial institutions is examined. The model incorporates three main sectors: banks, central government and a rating agency. We identify the transmission mechanisms linking sovereign debt and financial sector crises when the above three agents interact over time. The model portrays an 'early warning system' for the vulnerability of banks to a default on public debt. Although informed by Jamaican data, the model provides a framework for the consideration of sovereign debt crises elsewhere.

■ WB-13

Wednesday, 10:30-12h00
G5-5

Public transport

Stream: Traffic
Invited session

Chair: *Cristián Cortés*, Civil Engineering Department, Universidad de Chile, Blanco Encalada 2002, 5th floor, Santiago, Chile, ccortes@ing.uchile.cl

1 - Effectiveness of holding strategies in a corridor with multiple bus operators and services
Ricardo Giesen, Transport Engineering and Logistics, Pontificia Universidad Catolica, Vicuna Mackenna 4860, Macul, 6904411, Santiago, RM, Italy, giesen@ing.puc.cl, *Daniel Hernandez*, *Juan Carlos Muñoz*, *Felipe Delgado*

Control strategies have been widely proposed in the literature to avoid bus bunching. However all of them consider a single line corridor, which is often not the case. We developed an optimization model to determine bus-holding strategies for a multi-line corridor. Simulations were performed to compare scenarios with central versus decentralized control. Our results show that the central control outperforms a decentralized one. Moreover, a decentralized control strategy in which each operator has information about the location of all buses in the system can be worse than the no control.

2 - Considering Travel Time and Demand Uncertainties While Setting Optimum Transit Line Frequencies
Ilayda Ulku, Department of Industrial Engineering, Istanbul Kültür University, Ataköy Campus, E-5 Karayolu Uzeri, Bakırköy, 34156, Istanbul, Turkey, ilaydakarabulut@gmail.com, *Orhan Feyzioglu*

The traditional objective to transit line frequency setting is the minimization of total travel time given forecasted mean values. This approach occasionally leads to excessive delays for the passengers due to the changing conditions. In this study, we obtain optimum line frequencies by considering stochastic travel times and demand, and use conditional-value-at-risk measure to control the possible large realizations of random outcomes. We characterize the random network parameters by a finite set of scenarios, propose a risk-averse mathematical model and solve it with a genetic algorithm.

3 - Application of path based line planning in public bus transport
Stefan Schneider, CLL, Salzburg Research, Jakob-Haringer-Strasse 5/III, 5020, Salzburg, Austria, stefan.schneider@salzburgresearch.at

We present a report of the implementation of a customer path based line planning tool for regional bus line planning in Upper Austria. The challenge was to identify an approach that was able to consider both collected demand data, composed of source and destination addresses from over 50 000 pupils and commuters, as well as a given minimal basic coverage. We give a comparison of a MIP-based formulation and a metaheuristic approach, regarding the computability and the practicality as judged by experts from the traffic association.

4 - Integrated timetabling and vehicle scheduling as an integer programming problem: the case of a feeder service from the Transantiago transit system
Cristián Cortés, Civil Engineering Department, Universidad de Chile, Blanco Encalada 2002, 5th floor, Santiago, Chile, ccortes@ing.uchile.cl, *Pablo A. Rey*, *Jaime Miranda*

This work describes an approach to solve in an integrated fashion the timetabling and vehicle scheduling stages for a bus feeder service provider of Transantiago. We formulate an integer programming model that deals with the commitment between quality of service and operational cost. It was designed to fulfil the operational conditions imposed by the authority, related to predefined aimed ranges of frequencies, capacities and headways, among other technical requirements. Results of optimal bus schedules help to support the day-to-day operation of the firm from a planning perspective.

■ WB-14

Wednesday, 10:30-12h00
G5-6

Location and routing Problems I

Stream: Hybridisation of Heuristic for Global Optimisation
Invited session

Chair: *Said Salhi*, Kent Business School, University of Kent, Centre for Logistics & Heuristic Optimisation,, Parkwood Road, University of Kent, CT2 7PE, Canterbury, Kent, United Kingdom, s.salhi@kent.ac.uk

1 - Approximating Dynamic Programing using metaheuristic for an energy problem
El-Ghazali Talbi, Laboratoire d'Informatique Fondamentale de Lille, Bâtiment M3 - Cité Scientifique, 59655, Villeneuve d'Ascq, France, France, talbi@lifl.fr, *Sophie Jacquin*, *Laetitia Jourdan*

We present a new approximate method for an energy production problem in hydroelectric networks. Our method is a hybrid metaheuristics involving genetic algorithm and dynamic programming. Based on the dynamic structure of the problem, we have proposed an encoding scheme of a solution associated with some specific operators. The

method is tested on a problem with a time horizon of one year divided into hourly intervals. The hydro system is head-sensitive and involves 7 cascaded reservoirs. Comparative results with other conventional methods are discussed.

2 - Solving Large p-Median Problems by a Multistage Hybrid Approach Using Aggregation, Variable Neighbourhood Search, and Exact Method
Chandra Irawan, Kent Business School, University of Kent, 5, Gore Mews, CT1 1JB, Canterbury, – Please Select (only U.S. / Can / Aus), United Kingdom, ca259@kent.ac.uk, *Said Salhi*, *Maria Paola Scaparra*

A hybridisation of VNS and exact method is designed to solve very large p-median problems. A multistage approach is used where learning previous stages is taken into account when tackling the next stage. Each stage is made up of several aggregated sub-problems that are solved with a fast procedure to produce good feasible solutions. These feasible locations are gathered to make up a new promising subset of potential facilities which is solved by VNS or CPLEX. Large data sets up to 89,600 points varying with various values of p are used to test the proposed approach with encouraging results.

3 - The Impact of Facility Disruption in Hub-and-Spoke Logistics Networks
Nader Azizi, Kent Business School, University of Kent, The Medway Building, ME4 4AG, Chatham, Kent, United Kingdom, n.azizi@kent.ac.uk

In a system of hub and spoke, hub facilities may become disrupted due to variety of reasons such as labor action and/or natural phenomena. This research attempts to ease the effects of hub failure by taking into account the probability of facility malfunction in design stage and providing contingency plans to respond to possible network disruptions. A special case i.e., postal service in which a single truck covers all the demand assigned to a particular hub facility is investigated. To this end, mathematical models are developed along with exact and heuristic solution to solve the models.

4 - The Split Delivery Vehicle Routing Problem: A Hybridisation of Heuristics and the Set Covering-Based Model
Nurul Huda Mohamed, Dept. of Mathematics, Universiti Pendidikan Sultan Idris, Faculty of Science & Mathematics, 35900, Tanjong Malim, Perak, Malaysia, nurul.h@gmail.com, *Said Salhi*, *Gábor Nagy*

The Split Delivery Vehicle Routing Problem which is a relaxation of the classical VRP where a customer can be served by more than one delivery is investigated. This study focuses on developing new MIP models based on the set covering problem (SCP) where a hybridisation of heuristics and the SCP are implemented. Initial routes are generated using simple modification of the saving and the sweep heuristics along with some refinement schemes. These generated routes are then used in the SCP. These models are tested on the SDVRP benchmark data sets. Interesting results are provided.

■ WB-15

Wednesday, 10:30-12h00
G5-2

Berth and Crane Operations I

Stream: Container Terminal Operations
Invited session

Chair: *Christian Bierwirth*, Martin-Luther-University Halle-Wittenberg, 06108, Halle, Germany, christian.bierwirth@wiwi.uni-halle.de

1 - A global point of view on some interrelated decision-making problems in container ports
Xavier Schepler, Université du Havre, France, xavier.schepler@gmail.com, *Stefan Balev*, *Sophie Michel*, *Eric Sanlaville*

This presentation offers a global point of view on some interrelated decision-making problems in container ports. Any subset of container terminals operating in a given port, and all the containers exchanged in those terminals over several weeks, may be taken into account. We include the possibility of container transfers between terminals. We focus on the management of quay spaces and of crane allocations, for transportation vehicles. Our goal is to minimize the weighted tardiness of vehicles. We present a mixed integer linear program and preliminary results.

2 - A solution procedure for the Direct ship-to-ship Container Transshipment Problem
M. Flavia Monaco, DIMES - Dipartimento di Ingegneria Informatica, Modellistica, Elettronica e Sistemistica, Università della Calabria, Via P. Bucci 41/c, 87036, Rende (CS), Italy, monaco@deis.unical.it, *Marcello Sammarra*

At a maritime container terminal, containers discharged from a vessel are usually stored in the yard, and then loaded on different vessels. Here we consider the case of two ships, simultaneously berthed at the quay, assuming that some of the containers discharged from each of them must be directly loaded into the other. Our aim is to schedule all the vessel operations and decide the stowage positions for the exchanged containers, so as to minimize their storage time and the overall service time. For this problem we present a heuristic procedure and discuss some computational results.

3 - Bi-objective Berth-Crane Allocation Problem
Deniz Ozdemir, Dept. of Industrial Engineering, Yasar University, Universite Caddesi, No:35-37,, Agacli Yol, Bornova, Izmir,, 35100, Izmir, Turkey, deniz.ozdemir@yasar.edu.tr, *Evrim Ursavas*

In this study, we propose a decision support tool for the simultaneous berth allocation and crane scheduling problem. We formulate the problem by bi-objective integer programming namely, the objectives of minimizing the total service time and cost of crane setups. To solve the problem we follow an epsilon-constraint method based solution algorithm to acquire the non-dominated berth-crane assignments and schedules as Pareto optimal frontier. With this multi-solution approach, decision maker is offered the flexibility of adjusting the balance within conflicting objectives.

4 - A Framework for Berth Allocation, Crane Assignment, and Crane Scheduling in Seaport Container Terminals
Christian Bierwirth, Martin-Luther-University Halle-Wittenberg, 06108, Halle, Germany, christian.bierwirth@wiwi.uni-halle.de, *Frank Meisel*

We present a framework that captures the decisions of berth allocation and crane operations planning in an integrative manner. The framework is laid down in three phases. Phase I estimates productivity rates for the cranes from the vessels' stowage plans. Phase II uses these rates for making berthing decisions and for assigning cranes to vessels. Phase III determines detailed crane schedules and aligns the decisions made. Computational tests reveal that the integrated planning is computationally tractable for problem scenarios of realistic size and that it enables significant cost savings.

■ WB-16

Wednesday, 10:30-12h00
G5-7

Exact algorithms and multi-objective models for vehicle routing problems

Stream: Routing Problems
Invited session

Chair: *Roberto Wolfler-Calvo*, LIPN, Université Paris Nord, 93430, Villetaneuse, France, roberto.wolfler@lipn.univ-paris13.fr

1 - Solving the Vehicle Routing problem with Intermediate Facilities
Roberto Wolfler-Calvo, LIPN, Université Paris Nord, 93430, Villetaneuse, France, roberto.wolfler@lipn.univ-paris13.fr, *Roberto Baldacci*, *Sandra Ulrich Ngueveu*

Given a depot, a set of clients and a set of intermediate facilities, the Vehicle Routing Problem with Intermediate Facilities (VRPIF) aims to design m feasible routes so that each customer is served by exactly one route, each intermediate facility is visited at most once and the sum of the routing and assignment costs is minimized. The VRPIF reduces to the capacitated m-Ring Star Problem if all demands are unitary. It differs from the multiechelon location routing and from the multivehicle traveling purchaser problems. An exact algorithm and extensive computational results will be presented.

2 - A Branch and Price and Cut approach to the Multi-Depot Vehicle Routing Problem with Private fleet and Common carriers.
Emanuele Tresoldi, Università Statale di Milano, 20100, Milano, Italy, emanuele.tresoldi@unimi.it, *Alberto Ceselli*, *Giovanni Righini*, *Daniele Vigo*

We consider a problem arising in the last mile delivery of small packages, which is an extension of the multi depot vehicle routing problem where customers can either be served by a private fleet, based at given depots, or through outsourcing to common carriers. Such a problem has been previously tackled in the literature by means of variable neighborhood search techniques. We experiment on adapting extended formulations and branch and cut and price algorithms, originally proposed for multi-depot profitable routing problems, presenting computational results on datasets from the literature.

3 - Hybridized exact-metaheuristic approach for time windows constrained vehicle routing problems
Jan Melechovský, Dept. of Econometrics, University of Economics, Prague, W. Churchill square 4, 13067, Praha 3, Czech Republic, jan.melechov@seznam.cz

Combination of exact and heuristic solution methods seems to be a promising stream in the discrete optimization research. Exact algorithms as column generation are often enhanced with some heuristic search to accelerate the most time consuming routines. Similarly, metaheuristics can generate a set of elite solutions whose parts might constitute near-optimal solutions. Exact solution framework can then be used as a post-optimization tool operating on the elite set. This note studies the perspectives of such hybridized approach. The research was funded by Czech Science Foundation (P402/12/P635).

4 - Developing and Solving an Integrated Multi-objective Model for Supporting Strategic and Tactical Decisions for One-Way Car Sharing Systems
Burak Boyacı, ENAC, EPFL, EPFL ENAC INTER LUTS, GC C2 406 (Bâtiment GC) Station 18, 1015, Lausanne, Vaud, Switzerland, burakboyaci@gmail.com, *Konstantinos G. Zografos*, *Nikolas Geroliminis*

Electric vehicle sharing has been proposed as an alternative for improving mobility and sustainability of the transportation system. One-way electric vehicle sharing problem arises when rented vehicles can be returned at any station. Although one-way systems offer significant flexibility and improve the level of service, they introduce additional fleet relocation costs to the operators. We introduce and solve an integrated multi-objective model for supporting strategic and tactical decisions for one-way electric vehicle car sharing systems and present results from a real case in Nice, France.

■ WB-17

Wednesday, 10:30-12h00
G5-8

Maritime transportation: Cases from the dry bulk and petroleum industry

Stream: Maritime Transportation
Invited session

Chair: *Harilaos N. Psaraftis*, Technical University of Denmark, Evrota 20, 15451, Neo Psychico, Greece, hnpsar@gmail.com

1 - Helicopter Routing Problem for Oil Platform Library
Ocotlan Diaz-Parra, DACI, Universidad Autónoma del Carmen, Col. Benito Juarez, 24180, Cd. del Carmen, Campeche, Mexico, ocotlan@diazparra.net, *Jorge A. Ruiz-Vanoye*, *María de los Ángeles Buenabad-Arias*

The Helicopter Routing Problem for Oil Platform consist of to minimize the cost of carry resources, goods or people from one location (airport/platform) to another location (airport/platform) by air with some restrictions as capacity and time windows. We present a set of test instances of the Helicopter Routing Problem for Oil Platform. The test instances were created using an algorithm called HRP-OPGen. The depository of instances can be downloaded for others researchers for experimentation.

2 - Routing and Scheduling of Platform Supply Vessels
Henrik Andersson, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Gløshaugen, Alfred Getz vei 3, NO-7491, Trondheim, Norway, Henrik.Andersson@iot.ntnu.no, *Daniel Friedberg*, *Vidar Uglane*

In this presentation we discuss a problem from offshore supply logistics in the oil production industry. Each day a vessel departs from a land base and delivers supplies to offshore platforms and transports waste back from the platforms to the base. The coordination of these tasks is complex and challenging. The problem involves decisions about allocating supplies and waste to different departures, vessel routing and scheduling, and refueling. We present a mathematical formulation of the problem and an algorithm for its solution.

3 - Agent Based Modelling of the global dry bulk shipping sector
Eoin O'Keeffe, The Bartlett, UCL Energy Institute, Central House, 14 Upper Woburn Place, WC1H 0NN, London, London, United Kingdom, eoin.okeeffe.09@ucl.ac.uk

The international dry bulk shipping sector is a complex system of interactions between multiple agents at varying timescales. This research investigates the sectors capacity to significantly reduce transport emissions through to 2050 by simulating its evolution using agent based modelling. It is proposed, supported by preliminary results, that the treatment of the dry bulk shipping sector as a system of heterogeneous agents, within a geospatial model of transport supply and demand, allows modelling of complex behaviour not captured with existing approaches.

4 - Agent Choices and Fluctuations in Oil Tanker Movements
Sophia Parker, UCL Energy Institute, University College London, 14 Upper Woburn Place, WC1H 0NN, London, United Kingdom, sophia.parker.09@ucl.ac.uk

This paper explores the nature of fluctuations in oil tanker movements in order to quantify the impact of higher oil prices. I present a novel way of modeling the shipping market using a matching model which is one way to compute a competitive equilibrium. The matching game allows for different beliefs about the future and ship types including energy efficiency and location. A dataset on VLCC transactions is used to estimate the model which confirms the hypothesis that shipowners are forward looking. The model can be used to test different carbon taxation levels and oil demand scenarios.

■ WB-18

Wednesday, 10:30-12h00
G5-9

Stochastic Modeling and Simulation IV

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Joris Walraevens*, Department of Telecommunications and Information Processing, Ghent University, B9000, Ghent, Belgium, jw@telin.ugent.be

1 - Stabilizing Policies for Probabilistic Matching Systems
Burak Buke, University of Edinburgh, United Kingdom, B.Buke@ed.ac.uk, *Hanyi Chen*, *Miklos Rasonyi*

The Internet portals, which match people who provide a specific service with the ones demanding the service, are becoming increasingly popular. Unlike the traditional queueing systems where the customers wait to access a resource, in these web portals the users wait in the system until they find a matching customer or supplier. In this work, we analyze the stability of such systems. We prove that these probabilistic matching systems are unstable and provide three control policies to stabilize these systems. We also provide a detailed analysis of performance measures for these policies.

2 - Generalized Processor Sharing vs. Priority Scheduling
Joris Walraevens, Department of Telecommunications and Information Processing, Ghent University, B9000, Ghent, Belgium, jw@telin.ugent.be, *Tom Maertens*, *Jasper Vanlerberghe*, *Stijn De Vuyst*, *Herwig Bruneel*

Generalized Processor Sharing (GPS) is a mechanism to share bandwidth in multi-class queueing networks. All backlogged classes get a weighted portion of the service capacity. The weights are set such that a certain objective function is minimized. However, a queueing system with GPS is notoriously hard to analyze. An alternative for GPS is priority scheduling: the classes are prioritized and the highest-priority class that is backlogged gets the complete service capacity. Queueing systems with priority are much easier to analyse. Therefore, we investigate the optimality of GPS vs. priority.

3 - The Assessment of Multi-dimensional Frequency by Monte-Carlo Markov Chain Approach
Ingrida Vaiciulyte, 1. Mathematics and Informatics Institute, Vilnius University; 2. Siauliai State College, 1. Akademijos st. 4, 2. Ausros al. 40, LT-76241, LT-08663, 1. Vilnius; 2. Siauliai, Lithuania, ingrida_vaiciulyte@yahoo.com

This work describes the empirical Bayesian approach applied in the estimation of multi — dimensional frequency. It also introduces the Monte-Carlo Markov Chain (MCMC) procedure, which is designed for Bayesian computation. Modeling of the discrete variable - the number of occurrences of rare, used statistical models: a normal distribution with unknown parameters - mean and variance, and Poisson distributions. The unknown parameters are estimated by the maximum likelihood method, using the adaptive Monte-Carlo Markov chain approach.

4 - Shadow economy: agent-based modeling
Oleg Nikonov, Business informatics, Ural Federal University, Mira 19, 620002, Ekaterinburg, Russian Federation, o.i.nikonov@ustu.ru, *Marina Medvedeva*, *Vitaly Tzoi*

The paper is devoted to the problem of evaluating the shadow economy level in a chosen region of the Russian Federation. We consider the psychological interaction of the agents in the agent network and use the agent-based model constructed in Anylogic modeling tool for the real statistic data analysis. The comparison of the simulation results with the official data of the economy of the region and the statements of officials is made. The paper is based on and develops the ideas of Bloomquist (2006) and Hokamp (2010).

■ WB-19

Wednesday, 10:30-12h00
G5-10

Hub Location 1

Stream: Hub Location
Invited session

Chair: *James Campbell*, College of Business Administration, University of Missouri-St. Louis, 63124, St. Louis, MO, United States, campbell@umsl.edu

1 - Consolidation of residual parcel volumes in a parcel service provider's long-haul transportation network
Martin Baumung, Deutsche Post Chair of Optimization of Distribution Networks, RWTH Aachen University, Kackertstrasse 7, 52072, Aachen, Germany, baumung@or.rwth-aachen.de, *Halil Ibrahim Guenduez*

We consider the direct long-haul transportation network of a parcel service provider where transports are carried out using swap bodies and several swap bodies are required on most relations due to large volumes. Our focus is on residual volumes, which are not enough to fill a swap body, and investigate how consolidation using hubs can lead to cost reduction through better utilization of swap body capacities. We developed a corresponding model minimizing total costs consisting of transportation costs for the swap bodies and costs for the additional sorting of parcels required in the hubs.

2 - Solving a hub location problem in German wagonload traffic with a local search heuristic
Julia Sender, Institute of Transport Logistics, TU Dortmund, Leonhard-Euler-Str. 2, 44227, Dortmund, NRW, Germany, julia.sender@tu-dortmund.de, *Uwe Clausen*

Wagonload traffic is a production form in railway freight traffic used for the transportation of single wagons. To decrease transportation costs the wagons are transported through a hub-and-spoke network. We consider a specific hub location model for the network design in German wagonload traffic. To solve real-sized instances we develop a heuristic solution approach based on local search. The neighborhoods are defined by different location and allocation moves. We present preliminary, promising results of testing the heuristic with test data provided from our project partner Deutsche Bahn AG.

3 - Optimization of hub locations in a postal service provider's distribution network with route planning and time restrictions
Halil Ibrahim Guenduez, Deutsche Post Chair of Optimization of Distribution Networks, RWTH Aachen University, Kackertstr. 7, 52072, Aachen, Germany, guenduez@or.rwth-aachen.de

Hub location and route planning are implemented independently in most distribution networks. Low-quality solutions are obtained if sequential methods, e.g. locate hubs first and plan routes second, are used. This work considers a hub-location-routing problem for a postal service provider, more precisely, a two stage distribution network taking into account route planning and time restrictions, which covers more realistic aspects of many real problems. We present a tabu search approach in order to solve large-scale instances and compare its performance with a sequential approach.

4 - Modeling Economies of Scale for Transportation Hub Location
James Campbell, College of Business Administration, University of Missouri-St. Louis, 63124, St. Louis, MO, United States, campbell@umsl.edu

A fundamental premise underlying the transportation cost in basic hub location models is that flows are concentrated on the inter-hub links, and therefore warrant a cost discount from the economies of scale. However, optimal flows in hub networks often violate this premise with some spoke flows exceeding hub arc flows. We provide results for a range of hub location problems and data sets that document this disconnect between the assumed model for transportation cost and the optimal flows. This raises an important question for hub location research using the basic model for economies of scale.

■ WB-20

Wednesday, 10:30-12h00
G5-11

Railway Timetabling

Stream: Optimization in Public Transport
Invited session

Chair: *Gabrio Curzio Caimi*, Netzentwicklung, BLS Netz AG, Genfergasse 11, 3001, Bern, Bern, Switzerland, gabrio.caimi@bls.ch

Chair: *Marco Laumanns*, IBM Research - Zurich, 8803, Rueschlikon, Switzerland, mlm@zurich.ibm.com

1 - A mesoscopic model for large-scale railway timetable planning
Giorgio Medeossi, Department of Engineering and Architecture, University of Trieste, Piazzale Europa 1, 34127, Trieste, Italy, giorgio.medeossi@units.it, *Raffaele Pesenti*, *Giovanni Longo*

This work presents a model for the automatic generation of timetables based on a mesoscopic infrastructure. The model considers all signals in lines and stations, while the layout of stations is simplified in the switch areas. The running times and time-losses are calculated as in simulation models and the headway times are automatically derived from the blocking times. The timetable is generated using a heuristic solution to solve a multicommodity flow model. In order to maximize the accuracy, various parameters can be defined, including the buffer times, the priority and the margins.

2 - Timetabling for Suburban Rail Services in India
Narayan Rangaraj, Industrial Engineering and Operations Research, Indian Institute of Technology, 400076, Mumbai, India, narayan.rangaraj@iitb.ac.in

We outline an integrated approach to timetabling for suburban rail services in India, consisting of (a) determining arrival and departure times at halts considering service patterns over common line resources, (b) platform allocation at stations, (c) rake linking at terminals and (d) introducing reliability in timings. (a) and (b) is done by an ILP with some parameters computed using a train traffic simulator, (c) is a network flow LP and (d) is done by providing slacks in traversal times and in headway using stochastic optimization. Mumbai suburban rail is presented as a detailed example.

3 - User Perspectives in Public Transport Timetable Optimization
Jens Parbo, DTU Transport, Bygningstorvet 116B, 2800, Kgs. Lyngby, Denmark, jepar@transport.dtu.dk, *Otto Anker Nielsen*, *Carlo Prato*

This study considers the timetable optimization problem in transit networks by integrating a transit assignment model and a heuristic optimization approach (Tabu search) that minimizes transfer waiting times. The heuristic tries to change bus lines' offset, thus affecting transfer waiting times experienced at bus transfer stops, and then the transit assignment runs after imposing the most promising offset changes. Coupling timetable optimization with transit assignment improves the reliability of the results because of the explicit consideration of passengers' route choice modifications.

4 - Periodic event scheduling (PESP) with route choice in railway timetabling
Jacint Szabo, Business Optimization, IBM Research Lab, Zurich, Säumerstrasse 4, 8803, Rüschlikon, Switzerland, jsz@zurich.ibm.com, *Sabrina Herrigel-Wiedersheim*, *Marco Laumanns*

One possible way for the automated design of long-term periodic railway timetables is to model it as a periodic event scheduling problem (PESP). One restriction in the PESP model is that the routes of the trains are fixed in advance, for example, for two trains in opposite direction the model cannot decide which sidings to take. In this talk we present an extension to PESP that allows route choice, and we also consider heuristics to speed up computations. We give experimental results on a real world medium-sized railway network.

■ WB-21

Wednesday, 10:30-12h00
G6-1

Machine Scheduling Problems 2

Stream: Scheduling
Invited session

Chair: *Jacques Teghem*, Mathro, Faculté Polytechnique/UMonss, 9, rue de Houdain, Rue de Houdain 9, 7000, Mons, Belgium, jacques.teghem@umons.ac.be

1 - Lexicographic optimization of a two-machine general flowshop with time-lags constraints
Jacques Teghem, Mathro, Faculté Polytechnique/UMonss, 9, rue de Houdain, Rue de Houdain 9, 7000, Mons, Belgium, jacques.teghem@umons.ac.be, *Emna Dhouib*

The model is a two-machine non-permutation flowshop with time-lags constraints for which two objectives are optimized lexicographically: the number of tardy jobs and the makespan. First a MILP formulation is proposed. Then the conditions to have interest to schedule two jobs in a different order on the two machines are analyzed.Based on this analysis, a heuristic is proposed. Numerical experimentations compare both approaches.

2 - Metaheuristics for scheduling on two identical machines with preparation times
Wafaa Labbi, Gestion, Algiers University 3, 02 Rue Ahmed Oueked, Dely Brahim, Algiers, Algeria, fawalab@yahoo.fr, *Mourad Boudhar*, *Ammar Oulamara*

We consider the problem of scheduling two identical machines with preparation times. Each job requires before its processing a non-negligible time and a set of resources (workers, tools, etc.). The objective is to minimize the makespan. This problem is NP-hard. We propose two mtaheuristics GA and TS to solve the general problem with empirical results.

3 - Multiprocessor task scheduling by sequence pair
Radoslaw Rudek, Institute of Business Informatics, Wroclaw Univeristy of Economics, Komandorska 118/120, 53-345, Wroclaw, Poland, radoslaw.rudek@ue.wroc.pl, *Andrzej Kozik*, *Agnieszka Rudek*

We propose a novel approach to solve multiprocessor task scheduling problems. It is based on sequence pair, originally developed for packing problems in VLSI physical design. In our approach, each schedule is represented as a pair of permutations, which encodes pairwise relations between tasks. We provide some properties for the proposed schedule representation. Furthermore, based on the insert neighbour of sequence pair, we extend the well known Ulam's metric to its two dimensional counterpart. We show its application to improve a tabu search method for the analysed problems.

4 - Development of two heuristics for the hybrid flexible flow shop scheduling problem with setup times dependent on the sequence minimizing the makespan.
Jimmy Carvajal, Industrial Engineering, Universidad Central, Cra 5 #21-38, 10011, Bogotá D.C., Bogotá D.C., Colombia, jcarvajalb@ucentral.edu.co, *John Cifuentes*

This research considers a Hybrid Flexible Flow Shop Scheduling with times dependent on the sequence. Like a realistic assumption, it is considered that some jobs can skip one stage and it continues the process. The research considers as optimization criterion the minimization of makespan. It presents two ways to solve the problem. The first one refers to a Memetic Algorithm (MA), in this method we conducted the calibration epoch. The second one heuristic is a dynamic dispatching rule based on linear programming techniques. The results are accorded like the performances in literature.

■ WB-22

Wednesday, 10:30-12h00
G6-2

Scheduling and Logistics

Stream: Scheduling II
Invited session

Chair: *Jenny Nossack*, Institute of Information Systems, University of Siegen, Hölderlinstraße 3, 57068, Siegen, North Rhine-Westphalia, Germany, jenny.nossack@uni-siegen.de

1 - Competitive Location and Pricing on Networks
Dominik Kress, Institute of Information Systems, University of Siegen, Universität Siegen, Hölderlinstraße 3, 57068, Siegen, Germany, dominik.kress@uni-siegen.de, *Erwin Pesch*

We analyze the effect of including price competition into a classical follower's location problem where the multinomial logit approach is applied to model the decision process of utility maximizing customers. We provide complexity results and apply well known numerical approaches that have previously been introduced in the literature to reliably and quickly determine local price equilibria for given sets of locations. We show that price competition may actually effect optimal facility locations and we provide first insights into the performance of heuristics for the location problem.

2 - A Branch-and-Bound Algorithm for the Acyclic Partitioning Problem
Erwin Pesch, FB 5, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, erwin.pesch@uni-siegen.de, *Jenny Nossack*

Partition the vertex set of a directed weighted graph into clusters. Clusters are to be determined such that the sum of the vertex weights within the clusters satisfies an upper bound and the sum of the arc weights within the clusters is maximized. Additionally, the graph is enforced to partition into a directed, acyclic graph where the clusters define the vertices. Applications arise at rail-rail transshipment yards. We propose an integer programming formulation and suggest an exact solution approach. Computational results are reported to confirm the strength of our proposal.

3 - Benders Decomposition on a Bipartite Traveling Salesman Problem
Jenny Nossack, Institute of Information Systems, University of Siegen, Hölderlinstraße 3, 57068, Siegen, North Rhine-Westphalia, Germany, jenny.nossack@uni-siegen.de, *Michel Gendreau*, *Erwin Pesch*

We address a generalization of the TSP where routes have to be constructed to satisfy customer requests, which either involve the pickup or delivery of a single commodity. A vehicle is to be routed such that the demand and the supply of the customers is satisfied under the objective to minimize the total distance traveled. We model this problem as an integrated model that simultaneously solves a routing and an assignment problem. Exact solution approaches based on the classical and the generalized Benders decomposition are presented and are analyzed in a computational study.

■ WB-23

Wednesday, 10:30-12h00
G6-3

Non-standard Optimization Methods and Applications 2

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Martin Gavalec*, Department of Information Technologies FIM, University of Hradec Kralove, Rokitanského 62, 50003, Hradec Kralove, Czech Republic, martin.gavalec@uhk.cz
Chair: *Jaroslav Ramik*, Dept. of Math. Methods in Economics, Silesian University, School of Business, University Sq. 1934/3, 73340, Karvina, Czech Republic, ramik@opf.slu.cz

1 - Solvability of Inverse Interval Equations in Fuzzy Algebra
Martin Bacovsky, Department of Information Technologies FIM, University of Hradec Kralove, Hradecká 1249/6, 50003, Hradec Kralove, Czech Republic, Czech Republic, martin.bacovsky@uhk.cz, *Martin Gavalec*, *Hana Tomaskova*

Discrete event systems in fuzzy algebra are described by fuzzy equations of the form Ax=b. In the inverse approach, the state vectors x, b are given and the transition matrix A is unknown. Most applications use vector and matrix inputs which are not exact numbers, but have interval values. In the contribution, the solvability and unique solvability of the inverse interval equation are described, as well as all matrix solutions, the maximal solution and all minimal solutions within a given matrix interval. The work has been supported by the Czech Science Foundation project 402/09/0405.

2 - Data flow optimization on Ethernet subnets
Agata Bodnarova, University of Hradec Kralove, Rokitanskeho 62, 50003, Hradec Králové, ?eská republika, Czech Republic, agata.bodnarova@gmail.com, *Martin Gavalec*

Redundancy in Ethernet networks eliminates single points of failure, when one failed device or design element brings down an intended service. Redundant design implies the occurrence of undesirable switching loops. The currently used Spanning Tree Protocol excludes the switching loops while preserving the redundant topology. As the algorithm creates a loop-free spanning tree by disconnecting some of active links, the solution is very inefficient. The optimization of the solution will be described in the presentation. The work was supported by the Czech Science Foundation project 402/09/0405.

3 - One-sided and two-sided linear optimization in fuzzy algebra
Martin Gavalec, Department of Information Technologies FIM, University of Hradec Kralove, Rokitanského 62, 50003, Hradec Kralove, Czech Republic, martin.gavalec@uhk.cz, *Karel Zimmermann*

The presentation shows a survey of recent results concerning optimization problems, where the feasible solutions are described by a finite system of (max, min)-linear equations and inequalities. The constraints are considered in one-sided as well as in two-sided version, and the objective function is defined as the maximum of a finite number of continuous unimodal real functions, each depending on one variable. The research has been motivated by specific problems considered in fuzzy area of operations research. The work has been supported by the Czech Science Foundation project 402/09/0405.

4 - Eigenspaces in max-t semirings - library of visualization programs
Richard Cimler, Department of Information Technologies FIM, University of Hradec Králove, Rokitanského 62, 500 02, Hradec Králové, Czech Republic, Czech Republic, richard.cimler@uhk.cz, *Martin Gavalec*, *Zuzana Nemcova*

A library of algorithms and visualization programs for computing the eigenspace of a given fuzzy matrix in various max-t semirings is presented. Eigenvectors of a fuzzy matrix correspond to stable states of a complex discrete-events system, characterized by the given transition matrix. Eigenspaces in max-t semirings for several fuzzy triangular norms t are described and visualized. The G?del and Lukasiewicz t-norms, as well as the product and drastic t-norms are considered. The work has been supported by the Czech Science Foundation project 402/09/0405 and project INDOP CZ.1.07/2.2.00/28.0327

■ WB-24

Wednesday, 10:30-12h00
G6-4

Shift Scheduling Approaches

Stream: Timetabling and Rostering
Invited session

Chair: *Gerhard Post*, Applied Mathematics, University of Twente, Netherlands, g.f.post@utwente.nl

1 - An assessment of using days off schedules for shift scheduling
Gerhard Post, Applied Mathematics, University of Twente, Netherlands, g.f.post@utwente.nl, *Sophie Van Veldhoven*, *Egbert van der Veen*, *Timothy Curtois*

This research investigates a days off decomposition to solve the shift scheduling problem. First, we assign days off, and secondly assign shifts to working days in the days off schedule. Both phases are solved using MILP. The method is applied to the Employee Scheduling Benchmark Data Sets. It turns out the instances roughly split in 3 groups. In the first group our method gives good results. If we single out night shifts, we get good results for the second group as well. In the third group cover requirements and shift sequences are too dominant for the days off decomposition to be successful.

2 - An implicit solution approach for multi-activity shift scheduling problems with breaks
Monia Rekik, Operations and decision systems, Laval University, 2325 rue de la terrasse, G1V 0A6, Quebec, Quebec, Canada, Monia.Rekik@cirrelt.ca

We consider an anonymous multi-activity shift scheduling problem. The objective is to construct multi-activity shifts from a set of predetermined shift types that minimize the workforce cost while respecting activity length restrictions and satisfying the demand for each activity over the planning horizon. We propose an implicit model and theoretically prove that it is valid. Our computational study shows that the implicit approach largely outperforms the equivalent explicit approach. It also shows that the proposed approach performs well for relatively large instances.

3 - Optimization-Based Heuristics and Lower Bound for the Shift Minimization Personnel Task Scheduling Problem
Oguz Solyali, Business Administration, Middle East Technical University, Northern Cyprus Campus, 99750, Kalkanli, Mersin 10, Turkey, solyali@metu.edu.tr

We consider the shift minimization personnel task scheduling problem in which a set of tasks with fixed start and finish times are assigned to a set of heterogeneous workforce such that the number of workers used is minimized. We propose optimization-based heuristics and lower bound. The lower bound relies on solving a new relaxed formulation of the problem. The heuristics decompose the problem into three stages and solve them sequentially. We present a detailed computational study which reveals that our lowering bounding procedure and heuristics outperform those noted in the literature.

4 - A flexible iterative improvement heuristic to support creation of feasible employee schedules in self-scheduling
Egbert van der Veen, University of Twente / ORTEC bv, Groningenweg 6k, 2803 PV, Gouda, Netherlands, Egbert.vanderVeen@ortec.com, *Johann Hurink*, *Marco Schutten*, *Suzanne Uijland*

In self-scheduling, employees propose their own schedules to match a staffing demand specified by the employer. Since these individually composed schedules often do not perfectly match with the specified demand, we have to adapt the schedules. Our approach aims to divide the burden of shift reassignments 'fair' among employees and the algorithm parameters allow to make a trade-off between transparency of the shift reassignments and the quality of the resulting schedule. We discuss computational results and indicate how various model parameters influence scheduling performance indicators.

■ WB-25

Wednesday, 10:30-12h00
G9-1

Decision Support Systems 2

Stream: Artificial Intelligence, Fuzzy systems (contributed)
Contributed session

Chair: *Vassilis Gerogiannis*, Project Management Department, Technological Education Institute of Larissa, Greece, 41110, Larissa, Greece, gerogian@teilar.gr

1 - A Multi-objective Mathematical Programming Problem with Fuzzy Relational Equation Constraints
Cheng-Feng Hu, Industrial Management, I-Shou university, Taiwan, chu1@isu.edu.tw

This work considers solving the fuzzy relational equation constrained multi-objective optimization problems. A set covering-based technique for order preference by similarity ideal solution is proposed for solving such problems. It is shown that a compromise solution of the sup-T equation constrained multi-objective optimization problem can be obtained by solving the associated set covering problem. A surrogate heuristic algorithm is then applied to solve the resulting optimization problem.

2 - Approaches to rectifying additive consistency of interval fuzzy preference relations
Kevin Li, Odette School of Business, University of Windsor, 401 Sunset Ave, N9G 2V9, Windsor, Ontario, Canada, kwli@uwindsor.ca, *Zhou-Jing Wang*

This research investigates how to rectify additive consistency of interval fuzzy preference relations (IFPRs). An approach is then proposed to derive an additive consistent IFPR from any given inconsistent IFPR. A consistency index is subsequently defined to measure the consistency level of IFPRs, followed by a formula to repair an inconsistent IFPR to generate an IFPR with acceptable consistency. A further algorithm is developed to rectify an inconsistent IFPR. Numerical examples are presented to illustrate how to apply the proposed approaches.

3 - Fuzzy Cognitive Maps for Software Requirements Prioritization: the SPRINT SMEs Approach
Vassilis Gerogiannis, Project Management Department, Technological Education Institute of Larissa, Greece, 41110, Larissa, Greece, gerogian@teilar.gr

In the context of the SPRINT SMEs project we follow an inductive approach for software requirements prioritization. In this paper, we describe this apporach by emphasizing on the identification of possible imprecise dependencies (i.e., cause-effect relationships) between any pair of prioritization criteria. The final result is a Fuzzy Cognitive Map that can be dynamically analyzed to automatically produce a ranking index for each individual atomized requirement. A case-study is also presented of applying the SPRINT SMEs approach in a Greek Small & Medium sized software development enterprise.

4 - New Possibilistic Aggregations for Optimal Valuation of Credit Risks of Investment Projects
Irina Khutsishvili, Department of Computer Sciences, Iv.Javakhishvili Tbilisi State University, 13, University st., 0186, Tbilisi, Georgia, irina.khutsishvili@tsu.ge, *Gia Sirbiladze*

The work proposes a decision support technology to minimize risks while choosing among competitive investment projects. The preliminary selection of projects with minor credit risks is made based on Kauffman's expertons method. Then ranking of the chosen projects is made using the new generalization of the Ordered Weighted Averaging (OWA) aggregation operator — AsPOWA presented in the environment of possibility uncertainty. Mathematical programming problem is constructed for numerical estimation of the vector of weights associated with the AsPOWA operator.

■ WB-26

Wednesday, 10:30-12h00
G9-7

Combinatorial Optimization Problems in Transportation 2

Stream: Combinatorial Optimization I
Invited session

Chair: *Valentina Cacchiani*, DEI, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, valentina.cacchiani@unibo.it
Chair: *Paolo Toth*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

1 - The bi-objective ring star problem: An evolutionary algorithm
Herminia I. Calvete, Métodos Estadísticos, Universidad de Zaragoza, F. de Ciencias, Edificio A, Pedro Cerbuna 12, 50009, Zaragoza, Spain, herminia@unizar.es, *Carmen Galé*, *Jose A. Iranzo*

The ring star problem aims to locate a cycle through a subset of nodes of a graph and assign each non-visited node to a visited one. The goal of the bi-objective ring star problem is to minimize both the cycle cost and the assignment cost. In this work we develop an evolutionary algorithm to approximate the set of Pareto optimal solutions. The distinctive aspect of the algorithm is that the chromosome contains information on the nodes in the cycle, but not on their position. The complete description of the cycle is obtained after solving a TSP.

2 - The Directed Profitable Rural Postman Problem
Renata Mansini, Department of Information Engineering, University of Brescia, 25123 , Brescia, Italy, rmansini@ing.unibs.it, *Marco Colombi*

In the Directed Profitable Rural Postman Problem only a subset of the required arcs can be selected provided that a penalty is paid for not served arcs. The problem looks for a tour serving the selected set of required arcs while minimizing both traversing and penalty costs. We analyze some properties of the problem and propose two heuristic solution algorithms and a branch and cut approach. Results on benchmark instances show that heuristic methods frequently outperform state of the art algorithms, whereas the exact method finds the optimal solution for all but three open instances.

3 - Some metaheuristics applied to the fixed charge transportation problem
Andreas Klose, Department of Mathematics, Aarhus University, Ny Munkegade 118, 8000, Aarhus, Denmark, aklose@imf.au.dk

The fixed charge transportation problem (FCTP) is to send a minimum-cost flow from a set of suppliers to a set of customers, where costs comprise a fixed-charge in addition to a linear term. In this paper, we apply and compare a few well-known metaheuristic search strategies to the FCTP. In particular, iterated local search, record-to-record travel, path relinking and and an "evolutionary" algorithm are combined to hybrid methods capable to improve best known results for some of the test problem instances usually considered in the literature.

4 - Implementation of a method for optimization of routing based on graph models optimization, clustering and savings heuristic
Maritza Acuña, Universidad Nacional de Ingenieria, 51, Lima, Lima, Peru, maritnet@gmail.com, *Mario Zumaran*

Currently companies engaged in the distribution have a number of clients to whom they must deliver the orders. These Clients fluctuate daily, in quantity and locations of their homes, so the deliverymen have to change the routes itinerary daily to meet its goal of delivering orders to all customers. We aim to propose a method of optimizing graph to solve this problem, Utilizing the graphs optimization method Floyd-Warshall, the method for clustering P-median and heuristics savings, to present the most appropriate path to follow, which in the most cases will be the optimum.

■ WB-27

Wednesday, 10:30-12h00
G9-8

Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks (COST TD1207)

Stream: Combinatorial Optimization II
Invited session

Chair: *Claudia D'Ambrosio*, LIX, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, dambrosio@lix.polytechnique.fr
Chair: *Andrea Lodi*, D.E.I.S., University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, andrea.lodi@unibo.it
Chair: *Martin Mevissen*, IBM Research Dublin, IBM Technology Campus, Damastown Industrial Park, Mulhuddart, 15, Dublin, Ireland, martmevi@ie.ibm.com

1 - Improving the Reliability of Smart Grids by Optimal Switchgear Investment and Operations
Jakub Marecek, IBM Research Dublin, F14 B3 Damastown, Technology Campus, Dublin 15, Ireland, jakub.marecek@ie.ibm.com, *Martin Mevissen*

Smart grids feature abundant switchgear, incl. reclosers and sectionalizers. Distribution system operators decide on the placement of switchgear, optimising a combination of customer disconnections and minutes lost in the subsequent operations. In practice, the multi-million dollar investment decisions are often made without any decision support. Starting from a two-stage stochastic program, we present a scenario reduction technique, a path-based reformulation, and a pattern-matching reformulation. Therein, we solve large-scale instances of mixed-integer semidefinite programming.

2 - Topology Optimization Methods in Electric Power Systems
Konstantin Vandyshev, Delft Institute of Applied Mathematics, Delft University of Technology, Netherlands, k.vandyshev@tudelft.nl, *Karen Aardal*, *Dion Gijswijt*

Network topology of electrical grid can be controlled for better system reliability, voltage profiles and transfer capacity. The UMBRELLA project emphasizes corrective switching as a promising technique, because it may be implemented in different time horizons, particularly as a short term remedial action; it utilizes existing grid so it doesn't need huge investments and it can substantially improve network flexibility and efficiency. In this talk we analyse and compare different problem formulation (AC/DC) and computational solution techniques, which are used in grid topology optimization.

3 - Solving Network Design Problems via Iterative Graph Aggregation
Maximilian Merkert, Department of Mathematics, FAU Erlangen-Nürnberg, Cauerstraße 11, 91058, Erlangen, Bayern, Germany, Maximilian.Merkert@math.uni-erlangen.de, *Andreas Bärmann*, *Frauke Liers*, *Alexander Martin*, *Christoph Thurner*, *Weninger Dieter*

We present an exact approach for solving network design problems (NDPs). Motivated by real world applications in transportation planning and energy optimization, the instances considered contain preexisting capacities such that a relatively high percentage of the demand can already be routed. Starting with an initial aggregation of the network, we solve a sequence of NDPs over increasingly fine-grained representations of the original network until an optimum solution is determined. Computational results on realistic networks show the effectiveness of our method.

4 - Ellipsoidal relaxations for 0-1 quadratic problems
Fabrizio Rossi, Dipartimento di Informatica, University of L'Aquila, Via Vetoio, 67010, L'Aquila, Italy, rossi@di.univaq.it, *Monia Giandomenico*, *Adam Letchford*, *Stefano Smriglio*

Ellipsoidal relaxations can be derived by exploiting a well known equivalence between semidefinite and lagrangian relaxations of non-convex quadratic problems. In this talk we present theoretical properties and discuss cases in which the ellipsoid can be calculated in an efficient way and the corresponding bound is significantly strong.

■ WB-28

Wednesday, 10:30-12h00
G9-2

Time consistency and risk averse dynamic decision models

Stream: Stochastic Programming
Invited session

Chair: *Davi Michel Valladão*, Natural Resources Optimization,

IBM Research Brazil, Av. Pasteur, 138/146 Botafogo, 22451-170, Rio de Janeiro, Brazil, davimv@br.ibm.com

1 - Computational Methods for Risk-Averse Undiscounted Transient Markov Models
Ozlem Cavus, Industrial Engineering, Bilkent University, Turkey, ozlem.cavus@bilkent.edu.tr, *Andrzej Ruszczynski*

We consider the total cost problem for discrete-time controlled transient Markov models. The objective functional of this problem is a Markov dynamic risk measure of the total cost. We propose two solution methods, value and policy iteration, and analyze their convergence. We illustrate the results on a credit limit control problem.

2 - Sequential Monte-Carlo approach to nonlinear bilevel stochastic programs
Leonidas Sakalauskas, Operational Research, Institute of Mathematics & Informatics, Akademijos 4, LT-08663, Vilnius, Lithuania, sakal@ktl.mii.lt

Bilevel stochastic programming analyses decision problems under uncertainty taking into account interdependencies of several actors. The sequential Monte-Carlo approach for solving the nonlinear stochastic bilevel problems is developed and discussed. The approach distinguishes by sequential simulation of random samples adjusting the sample size herewith ensuring convergence and numerical solution with admissible accuracy treated in a statistical manner. Application of the approach to management of interbank settlement system is discussed, too.

3 - Time consistency and risk averse dynamic decision models: Definition, interpretation and practical consequences
Davi Michel Valladão, Natural Resources Optimization, IBM Research Brazil, Av. Pasteur, 138/146 Botafogo, 22451-170, Rio de Janeiro, Brazil, davimv@br.ibm.com, *Birgit Rudloff*, *Alexandre Street*

In this paper, we develop an economic interpretation for the objective function of time consistent risk-averse dynamic stochastic programming models with a recursive formulation. Additionally, we argue that an inconsistent policy is suboptimal and propose a new way of measuring time inconsistency impact on the objective function. We illustrate the developed concepts using the portfolio selection problem with an widely-adopted risk measure, namely the Conditional Value-at-Risk, and show how to solve it for stage-wise independent returns.

■ WB-29

Wednesday, 10:30-12h00
G9-3

Queueing Systems II

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Fikri Karaesmen*, Dept. of Industrial Engineering, Koc University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, fkaraesmen@ku.edu.tr

1 - A Controlled Queueing System Model of Triage to Treatment in a Hospital Emergency Department
Mark Lewis, School of Operations Research and Information Engineering, Cornell University, 221 Rhodes Hall, 14853, Ithaca, NY, United States, mark.lewis@cornell.edu

In many healthcare systems, the care of patients consists of two phases of service: assessment and treatment. Often these are carried out by the same medical provider and so there is a question as to how to prioritize the work in order to balance initial delays for care with the need to discharge patients in a timely fashion. In this article, we model a hospital emergency room (ER) triage and treatment process as a tandem queue with a single server. We explore alternative service disciplines under various scenarios and identify optimal policies for each.

2 - Strategic Customer Behavior in a batch-service queueing system
Olga Boudali, Department of Mathematics, University of Athens, Panepistemioupolis, Zografou, 15784, Athens, Greece, olboudali@math.uoa.gr, *Antonis Economou*

We consider a queueing system where customers are served in batches of a fixed size. At his arrival epoch, a tagged customer is informed about the size of completed batches present in front of him and on his position in the uncompleted batch. We derive customers' equilibrium strategies, regarding the balking/joining dilemma. We also discuss the joint effect of the batch size and the service rate on customers' strategic behavior under various levels of information.

3 - Approximation of excessive backlog probabilities in queueing systems
Devin Sezer, Universite d'Evry, 91000, Evry, France, alidevin.sezer@univ-evry.fr

We study a stable queue with Poisson arrivals and exponentially distributed service rates. An excessive backlog happens when, starting from an empty system, the number of customers reach a high level without the queue ever becoming empty. The goal of the present research is to obtain asymptotic expansions of the probability of an excessive backlog for this system by analyzing a perturbation of an associated Hamilton Jacobi Bellman equation.

■ WB-30

Wednesday, 10:30-12h00
G9-10

Optimization problems on graphs

Stream: Graphs and Networks
Invited session

Chair: *Mirjana Cangalovic*, Laboratory for Operational Research, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, Belgrade, Serbia, Serbia, canga@fon.bg.ac.rs

1 - A variable neighborhood search for the dominating tree problem
Zorica Drazic, Department of Applied Mathematics, Faculty of Mathematics, University of Belgrade, Studenski trg 16, 11 000, Belgrade, Serbia, lolaz@sezampro.rs, *Mirjana Cangalovic*, *Vera Kovacevic-Vujcic*

Let G be an edge-weighted, simple, connected and undirected graph. The dominating tree problem on G is to find such a tree T in G with the minimal cost where each vertex which is not in T is adjacent to a vertex from T. For this NP-hard problem we develop a variable neighborhood search-based heuristic and investigate its numerical efficiency on a set of randomly generated instances.

2 - The metric dimension problem for hypercubes
Mirjana Cangalovic, Laboratory for Operational Research, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, Belgrade, Serbia, Serbia, canga@fon.bg.ac.rs, *Nebojsa Nikolic*, *Igor Grujicic*

The problem of finding the metric dimension MD(n) of the hypercube Qn is considered. We prove some special symmetry characteristics of resolving sets in Qn which can be used to reduce the feasible solution set of the problem and to increase the numerical efficiency of a searching for a metric basis. These characteristics are implemented within a new constructive heuristic for finding an upper bound of MD(n). The heuristic is applied to Qn for n up to 22, and some existing upper bounds are improved.

3 - New heuristics for minimum feedback vertex set problem
Milan Stanojevic, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Serbia, milans@fon.rs

The problem of finding a minimum feedback vertex set plays a prominent role in operating systems and VLSI chip design as well as in telecommunication. In this paper some constructive heuristics are presented. They were tested on randomly generated graphs which were varied in size and density. The results were compared to optimal values and in some cases to lower bounds. Comparison with some well known constructive heuristics were made, too.

4 - Analysis of Memetic Approaches for Graph Coloring Problem

Alexandre Gondran, ENAC, France, 7 avenue Edouard Belin, 31000, toulouse, France, alexandre.gondran@enac.fr, *Laurent Moalic*

Some real life problems can be modeled as a graph coloring problem. The main idea consists of partitioning all vertices into k independent sets. The best known approaches consist of hybridize genetic algorithm with a local search in a memetic way. One of the key feature is to find the best balance between intensification and diversification. In this work we present an analyze of the influence of the main parameters (population size, number of parents for crossover, number of local search iterations, ...) on the balance intensification/diversification.

■ WB-31

Wednesday, 10:30-12h00
G9-11

MSOM iFORM Special Interest Group Stream I

Stream: MSOM iFORM Special Interest Group Stream
Invited session

Chair: *Genaro Gutierrez*, IROM, U. Texas at Austin, 1 University Station, 78712-0803, Austin, TX, United States, genarojg@mail.utexas.edu

1 - Analysis and Enhancement of Practice-based Methods for the Real Option Management of Commodity Storage Assets

Nicola Secomandi, Tepper School of Business, Carnegie Mellon University, 5000 Forbes Avenue, 15213, Pittsburgh, PA, United States, ns7@andrew.cmu.edu

Practitioners approach the stochastic optimization model that arises in the real option management of commodity storage assets using the rolling intrinsic (RI) and rolling basket of spread options (RSO) heuristic policies, which rely on sequential reoptimization of a deterministic dynamic program and a linear program based on futures price spread options, respectively. This paper provides novel structural and numerical support for the use of the RI and RSO policies, and enhances them by developing a simple and effective dual upper bound to be used in conjunction with these policies.

2 - Commodity Processing and Financial Hedging Under Correlated Price and Demand in the Presence of Yield Uncertainty

Ankur Goel, Operations, Case Western Reserve University, 10900 Euclid Avenue, Peter B Lewis Building, 44106, Cleveland, OH, United States, ankur.goel2@case.edu

We consider a firm that procures an input commodity to produce an output commodity to sell to the end retailer. Retailer's demand for the output commodity is negatively correlated with the price of the output commodity. Input and output commodity prices are correlated and follow a joint stochastic price process. The objective of the firm is to maximize the value of its stakeholders. We show that partial hedging dominates both perfect hedging and no-hedging when input price, output price, and demand are correlated.

3 - Optimal and Approximate Procurement of Commodities when Due Dates are Asynchronous to the Market Contracts

Genaro Gutierrez, IROM, U. Texas at Austin, 1 University Station, 78712-0803, Austin, TX, United States, genarojg@mail.utexas.edu, *Ankur Goel*

We study optimal commodity procurement for a commodity processor through a model in which the state space consists of the strip of futures prices observed in an organized exchange. In this realistic modeling context we obtain optimal and approximate forward procurement policies for the general case in which the maturities of the traded futures contracts do not coincide with the procurement schedule of the commodity processor. In this case the forward prices at the time of the next procurement order are an important component of the economic cost of holding inventory and these prices are not

■ WB-32

Wednesday, 10:30-12h00
G8-1

Advances and applications in supply chain optimization

Stream: Supply Chain Optimization
Invited session

Chair: *Arianna Alfieri*, politecnico di torino, Italy, arianna.alfieri@polito.it
Chair: *Dolores Romero Morales*, Said Business School, University of Oxford, Park End Street, OX1 1HP, Oxford, United Kingdom, dolores.romero-morales@sbs.ox.ac.uk

1 - Optimizing Recycled Products Reverse Supply Chain

Abdelghani Elimam, Mechanical Engineering, Professor American University in Cairo, AUC Avenue., P.O. Box 74, 11835, New Cairo, Cairo, Egypt, aelimam@sfsu.edu, *Bajis Dodin*

Reverse Supply Chains (RSC) include activities for collecting and reprocessing used products. Sustainable development trends stress the need for RSC management. A RSC includes collecting recycled products in the top tier, processing the collected products in the intermediate tiers and the distribution of the recovered material in the bottom tier. The RSC is modeled as a Project Network that is formulated as a Mixed Integer Program for minimizing transportation, inventory and processing costs to yield the recycle time. The approach is illustrated using automotive parts and municipal waste.

2 - Green Innovation in Supply Chain Competition

Yu Xia, Supply Chain and Information Management, Northeastern University, 214 Hayden, 02115, Boston, MA, United States, y.xia@neu.edu, *Chialin Chen*, *Vaidy Jayaraman*

Green products are different in terms of their green quality levels, technologies and prices. We study a market with two competitive brands. We investigate two cases: in one case the brands belong to one firm, and in the other case the two brands belong to two competitive firms respectively. Consumer's preference between traditional quality and green quality are considered as a driving force for the firm/firms to determine their green strategy. Game Theory is used to find the optimal green quality level, equilibrium prices and market segmentation in the competitive supply chain.

3 - Optimising the e-grocery supply chain with a mobile service

Anna Corinna Cagliano, Department of Management and Production Engineering, Politecnico di Torino, corso Duca Degli Abruzzi 24, 10129, Torino, Italy, anna.cagliano@polito.it, *Alberto De Marco*, *Luca Gobbato*, *Guido Perboli*, *Roberto Tadei*

E-commerce solutions for grocery distribution are valid alternatives to traditional merchandising channels. However, they lack efficient approaches to connect all the partners with real-time information. The work presents an integrated smartphone-based service supporting supply chain management developed together with Telecom Italia. After describing the service architecture, including a time-dependent dynamic vehicle routing algorithm, its potential diffusion in a three-echelon supply chain is analysed through System Dynamics. Benefits and implications for stakeholders are discussed.

4 - Integrated Production Scheduling and Distribution Planning in Dairy Industry using Hybrid MILP and Simulation Approach
Bilge Bilgen, Industrial Engineering, Dokuz Eylul University, Tinaztepe Campus, Buca, 35160, Izmir, Turkey, bilge.bilgen@deu.edu.tr

In this paper we address the production scheduling and distribution planning problem in a yoghurt production line of the multi-product dairy plants. A MILP model is developed for the problem. The objective function aims to maximize the benefit by considering the shelf life dependent pricing and several cost components. Several key features of the industry are included. The hybrid modelling approach is adopted to explore the dynamic behaviour of the real world system. The efficiency of the proposed model is demonstrated in a case study for a leading dairy manufacturing company in Turkey.

■ WB-33

Wednesday, 10:30-12h00
G8-3

Lot-Sizing and Related Topics 3

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Franklina Toledo*, Applied Mathematics and Statistic, ICMC - USP, Av. Trabalhador Saocarlense, 400, CP 668, 13.560-970, Sao Carlos, Sao Paulo, Brazil, fran@icmc.usp.br

1 - Solving capacitated lot-sizing problems in practice: models, methods, and experiences
Stefan Droste, INFORM GmbH, Pascalstraße 23, 52076, Aachen, Germany, Stefan.Droste@inform-software.com

Research on models and algorithms for capacitated lot-sizing make practical applications very promising. After having extended the optimization module of our production planning system at INFORM GmbH accordingly and first applications with customers we give an overview of our approach and experiences in practice: extensions of the models made necessary by customers' requests, resulting adaptations of the solution methods, and experiences with our customers show what obstacles have to be overcome in practical applications of well-established research fields.

2 - Coffee aggregate production planning
Diana Yomali Ospina, Faculty of Engineering, University of Porto, Portugal, deg08015@fe.up.pt, *Maria Antónia Carravilla*, *José Fernando Oliveira*

The coffee supply chain has four main stages: harvesting, commercialization, production and distribution. The production process includes storage, roasting, grinding, blending and packaging. These processes are carried out in order to fulfil different requirements in terms of freshness, aroma, flavour, colour of coffee drinks. Our research aims to model the aggregate production planning of a Portuguese coffee company and simultaneously evaluate the influence of acquisition strategies of the green coffee beans on both the perecibility and on the total production cost and demand satisfaction.

3 - A MILP Model for Planning and Scheduling of Multi-product Multistage Semicontinuous Production Process: Dairy Industry Supply Chain
Çağrı Sel, Department of Industrial Engineering, Dokuz Eylul University, Dokuz Eylul University, Department of Industrial Engineering, Buca, 35160 Izmir, Turkey, 35160, Izmir, Turkey, cagri.sel@deu.edu.tr, *Bilge Bilgen*

In this study, we present a novel mixed integer linear programming model for planning and scheduling of dairy industry supply chain. The production is a multiproduct multistage semicontinuous process consisting of a single joint mixing unit and parallel packaging machines. The model aims at minimization of costs which account for production, procurement, transportation, cleaning and sequence dependent setups under consideration of perishability and shelf life restrictions. The numerical results demonstrate that optimal solutions are obtained within a reasonable computational time.

4 - Production planning problem in small foundries
Franklina Toledo, Applied Mathematics and Statistic, ICMC - USP, Av. Trabalhador Saocarlense, 400, CP 668, 13.560-970, Sao Carlos, Sao Paulo, Brazil, fran@icmc.usp.br, *Maria Gabriela Furtado*, *Victor Camargo*

The foundry industry produces a range of simple to sophisticated items used by various industries. As observed in the literature, production planning significantly influences productivity in this sector. In this work, we deal with this problem in small Brazilian foundries, whose major decisions are to determine which alloys to merge and which items to produce. In our approach, complete orders from clients must all be ready before they are delivered, rather than splitting them. Taking this into consideration, a mathematical model and a relax-and-fix heuristic are proposed.

■ WB-34

Wednesday, 10:30-12h00
G8-4

Supply chains: Queueing analysis / Operations management

Stream: Supply Chain Planning
Invited session

Chair: *Charles Corbett*, UCLA Anderson School of Management, 110 westwood plaza, box 951481, 90095-1481, Los Angeles, CA, United States, charles.corbett@anderson.ucla.edu

1 - Queueing Model Analysis on Supply Chain in Disruption Risk
Kuo-Hwa Chang, Department of Industrial and Systems Engineering, Chung Yuan Christian University, 200, Chung Pei Rd., 320, Chung-Li, Taiwan, kuohwa@cycu.edu.tw

There are two supply chain risks: operational risk and disruption risk. Operational risks are caused by uncertainties from factors such as supply and demand. Disruption risks are usually caused by disasters and companies will experience more devastating consequences from it than operational risk. One way to assess the consequence risk is to estimate how long the production in a supply chain will sustain when suffering the disruption. We model the supply chain system as an inventory-queueing system, based on which we estimate the sustaining time using phase-type distribution approximation.

2 - Balancing Stochastic Assembly Lines with Buffers using Queueing Networks
Mustafa Yuzukirmizi, Dep. of Industrial Eng., Kirikkale University, 71451, Kirikkale, Turkey, myuzukirmizi@kku.edu.tr

The assembly line balancing problem is basically assigning a set of tasks with precedence relations to stations. When the task times are stochastic and there are limited buffers between the stations, the problem becomes more challenging. By combining the advantages of both queueing theory and constraint programming, an optimal solution procedure is proposed. The ability to define precedence relations with constraint programming and then evaluating the performance of that assignment using queueing approach is the novelty of the research. Numerical experiments are also presented.

3 - Analysis of Transient Throughput rates of Transfer Lines with Multiple Machines in Pull Systems
Mahmut Ali Gokce, Industrial Systems Engineering, Izmir University of Economics, Sakarya Cad. No: 155, Balcova/ Izmir TURKEY, 35050, Izmir, Turkey, ali.gokce@ieu.edu.tr, *Mehmet Cemali Dincer*

Majority of research on the throughput of transfer lines, concentrate on the steady state results. Many transfer lines now have to changeover to different parts' production quickly, before enough time passes to reach steady state. Therefore, steady state may never be reached. For this reason, one would be more interested in transient behavior of the system. We show how to calculate mean and variance of and interval estimates for transient throughput for a pull type transfer line. Derivation of distributions of transient throughput with multiple machines and sample calculations are provided.

4 - Operations Management for Entrepreneurial Firms
Charles Corbett, UCLA Anderson School of Management, 110 westwood plaza, box 951481, 90095-1481, Los Angeles, CA, United States, charles.corbett@anderson.ucla.edu, *Guillaume Roels*, *Onesun Yoo*

We consider the setting of growth-oriented entrepreneurial firms where the entrepreneur's time is the chief bottleneck. We present insights into two classical problems in OM: process improvement and hiring. We examine the first via the current time-future time trade-off and the second via the time-money trade-off. Practical management insights are discussed.

■ WB-35

Wednesday, 10:30-12h00
G8-2

Balancing and Scheduling Assembly Lines

Stream: OR Applications in the Automotive Industry
Invited session

Chair: *Michael Manitz*, Technology and Operations Management, Chair of Production and Supply Chain Management, University of Duisburg/Essen, Mercator School of Management, Lotharstr. 65, 47057, Duisburg, Germany, michael.manitz@uni-due.de

1 - Dynamic Resequencing of Orders at Mixed-Model Assembly Lines in the Automotive Industry
Christian Franz, DS&OR Lab, University of Paderborn, Germany, chrfranz@web.de, *Leena Suhl*

The sustained growth of the product diversity in the automotive industry requests a detailed planning of the production sequence in order to avoid work overloads. As the originally planned production sequence often gets disturbed during the production process before the cars reach the final assembly line, a replanning becomes necessary. A new model of the resulting Mixed-Model-Resequencing Problem will be introduced that covers its dynamic nature. Furthermore heuristic solution methods that can be applied in real-time will be presented and applied to realistic test scenarios.

2 - Hybrid methods for solving the car sequencing and routing for the mixed assembly line
Raul Pulido, Operations, UPM, Ferraz 116 5b, 28005, Madrid, Madrid, Spain, raul.pulido@alumnos.upm.es, *Álvaro García-Sánchez*, *Adrian Aguirre*

This paper presents a hybrid approach for mid-sized problems in a mixed car assembly line. The proper car sequencing aims to assemble all the products minimizing the total production cost. However, this decision could be done jointly with other decisions in the assembly line. The problem comprises sequencing rules and inventory vehicle routing constraints. The main contribution of this work consists in the development of hybrid MIP-CP approach to obtain good quality solution for large scale problems that cannot be solved to optimality using only exact methods.

3 - Constraint programming based solution procedure for assembly line balancing problem with task assignment restrictions
Mehmet PinarbaŞi, Industrial Engineering, Hitit University, Muhendislik Fakultesi, Cevre Yolu Bulvari No:8, 19030, CORUM, Merkez, Turkey, mehmetpinarbasi71@hotmail.com, *Hacı Mehmet Alağaş*, *Mustafa Yuzukirmizi*, *Bilal Toklu*

Assembly lines are production systems which is very common in several manufacturing areas. To improve process productivity line balancing has become crucial. Besides the precedence constraints, assignment restrictions effect the number of possible task-station combinations. In this study a new constraint programming based solution procedure is proposed with task related restrictions. A set of test problems from literature are solved. Computational results show that the effectiveness of the proposed procedure.

■ WB-36

Wednesday, 10:30-12h00
G7-1

Cutting and Packing 4

Stream: Cutting and Packing
Invited session

Chair: *Pierpaolo Caricato*, University of Salento, Via Monteroni, Ecotekne Corpo O, 73100, Lecce, LE, Italy, pierpaolo.caricato@unisalento.it

1 - Integrating customer-order requirements and manufacturing-related cutting decisions
Pierpaolo Caricato, University of Salento, Via Monteroni, Ecotekne Corpo O, 73100, Lecce, LE, Italy, pierpaolo.caricato@unisalento.it, *Doriana Gianfreda*, *Antonio Grieco*

Make-to-order firms often face conflicting objectives when they combine customer-related requirements with manufacturing issues. We address the case of textile industries, where rolls of fabric are produced by weaving textile fibers. Such rolls are then cut into rectangles in order to fulfill customers' orders. The problem is modeled as a variant of the rectangular CSP (Cutting Stock Problem). A pattern generation based algorithm is presented, which takes into account both manufacturing effectiveness (trim loss minimization) and customer satisfaction (lateness minimization).

2 - Modeling of cutting stock problem for a company of metalworking sector
Juan Pablo Orejuela Cabrera, Ing. Industrial., Universidad del Valle, 76001000, Cali, Valle del cauca, Colombia, juan.orejuela@correounivalle.edu.co, *Diana Peña*, *Cristiam Gil*

This research proposal was developed a mathematical model that allows planning and scheduling the steel rolls cut process, answering the following question: How to configure the rolls cut so as to meet the requirements of demand and in turn minimize waste and inventory levels in a metalworking company? To address this problem in a metalworking company, it was made a methodology that consists of 5 steps. One of the most important results of the work performed is the reduction of 4% of the cost of waste weekly compared with the actual process of the company.

3 - New Lower Bounds for the Variable Sized Bin-Packing Problem with Conflicts
Mohamed Maiza, Laboratoire de Mathématiques Appliquées, Ecole Militaire Polytechnique, EMP (Ex-ENITA), BP 17, Bordj El Bahri, 16111, Algiers, Algeria, m_maiza77@yahoo.fr, *Sais Lakhdar*, *Mohammed Said Radjef*

We address a variant of the classical 1D-BPP, where the objective is to minimize the total cost of heterogeneous bins needed to store given set of items. In this version, some of the items are incompatible with each other, and cannot be packed together. The conflicts are represented by a graph whose nodes are the items. This problem generalizes both the Variable Sized BPP without conflicts and the Vertex Coloring Problem. We propose two lower bounds for this problem based on both the relaxation of the integrity constraints and the computation of the large clique in the conflicts graph.

4 - Controlling Usable Leftover in the One-dimensional Cutting Stock Problem
Mitja Štiglic, Academic Unit for Business Informatics and Logistics, Faculty of Economics, University of Ljubljana, Kardeljeva ploščad 17, 1000, Ljubljana, Slovenia, mitja.stiglic@ef.uni-lj.si, *Miro Gradisar*, *Luka Tomat*

Various methods for solving the one-dimensional cutting stock problem with usable leftover (CSPUL) can be found in the literature, but none of them deals with the excessive accumulation of usable leftover (UL) on stock after multiple periods of cutting. UL is scrap that is longer than or equal to some threshold t and is put on stock to be used in future cutting periods. The paper deals with the problem of how to set t. To fill the above-mentioned gap we proposed a new method that determines an optimal t and prevents the excessive accumulation of UL in stock.

■ WB-37

Wednesday, 10:30-12h00
G7-4

Multicriteria Decision Making and Its Applications IX

Stream: Multicriteria Decision Making II
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Shunsuke Hayashi*, Graduate School of Information Sciences, Tohoku University, 6-3-09 Aramaki-Aoba, Aoba-Ku, 980-8579, Sendai, Japan, s_hayashi@plan.civil.tohoku.ac.jp

1 - Pseudo-Polynomial Time Algorithms for the Resource Dependent Assignment Problem

George Steiner, Operations Management, McMaster University, 1280 Main W. MGD 415, L8S 4M4, Hamilton, Ontario, Canada, steiner@mcmaster.ca, *Dvir Shabtay*, *Liron Yedidsion*

In the resource dependent assignment problem (RDAP) the cost of assigning agent j to task i is a product of task i's cost and the linear cost function of the amount of resource allocated to the agent. A solution is defined by the assignment of agents to tasks and by a resource allocation to each agent. Two criteria measure the quality of a solution: the total assignment cost and the total weighted resource consumption. Yedidsion et al. showed that the bicriteria versions of the problem are NP-hard. We give pseudo-polynomial time algorithms, proving that the problems are weakly NP-hard.

2 - An Exact Method for the Multi-objective Independent Set Problem

Mohamed El-Amine Chergui, Operationnel Research, University of Sciences and Technology Houari Boumediene, PO. 32, Bab Ezzouar, 16111, Algiers, Algeria, mohamedelaminec@yahoo.com, *Mohamed El-Amine Badjara*

We describe a branch and bound method to generate the efficient set for the Multi-objective Independent Set problem (MOIS). Depending on the depth length and given the constraint propagation on fixed vertices along a branch of the tree, each leaves is reduced to a MOIS problem with a significantly decreased size and any method to solve a MOILP problem can be used to determine the subset of efficient solutions associated with the current leaves. Randomly generated graphs having until 50 vertices, a density ranging from 0.1 to 0.7 and more than two criteria are successfully solved.

3 - A unified algorithm for solving multiobjective non linear programming problems without convexity assumption

Sana'a Zarea, Mathematical Sciences Department,Faculty of Sciences, Princess Nora Bint Abdulrahman University, P.O.Box 92000, Riyad, Saudi Arabia, s_zarea@yahoo.com, *Abou-Zaid EL- Banna*

A unified algorithm for solving multiobjective nonlinear programming (MNP) problems even so under a duality gap exists is proposed. The Weighted-Norm (WN) Approach is efficient in handling multiobjective convex programs, since it can generate the complete set of efficient solutions, while the method of constraints can generate the complete set of efficient solutions even so in the non-convex case, but it needs a feasibility test. For this reasons, the proposed unified algorithm treats general (MNP) by combining the (WN) and the method of constraints. An illustrative example is given.

4 - Consolidation of Delphi methods and autonomous aggregation-disaggregation algorithms for group multi-criteria decision analysis

Andrej Bregar, Informatika, Vetrinjska ulica 2, 2000, Maribor, Slovenia, andrej.bregar@informatika.si

Although the aggregation-disaggregation analysis and the Delphi method are based on different core principles, they can be, to some extent, combined to lead to synergistic effects. Hence, an iterative hybrid procedure for quantitative group MCDA is introduced that consolidates an autonomous aggregation-disaggregation algorithm with a moderated Delphi process. The procedure is evaluated according to a universal framework for the assessment of group MCDA methods and systems. It is compared with a pure automated aggregation-disaggregation approach and the standard Delphi method.

■ WB-39

Wednesday, 10:30-12h00
G7-3

Current Issues in Multiobjective Linear Programming

Stream: Vector- and Setvalued Optimization and Applications
Invited session

Chair: *Matthias Ehrgott*, Engineering Science, University of Auckland, Private Bag 92019, 1001, Auckland, New Zealand, m.ehrgott@auckland.ac.nz

1 - Solving polyhedral convex vector and set optimization problems

Andreas Löhne, Institut für Mathematik, MLU Halle-Wittenberg, Theodor-Lieser-Straße 5, 06099, Halle (Saale), Germany, andreas.loehne@mathematik.uni-halle.de

An introduction as well as recent advances on Benson's algorithm are presented. We point out that the algorithm is closely related to a set-valued approach to vector optimization, and to set optimization as well. Recent improvements of the algorithm include the case of arbitrary polyhedral ordering cones and allow to treat also unbounded problems. Combined with another algorithm, Benson's algorithm will be used to solve convex polyhedral set optimization problems. Numerical examples for are given.

2 - Data Envelopment Analysis without Linear Programming

Maryam Hasannasab, Mathematics & computer Sciences, Kharazmi University of Tehran, No. 599, Taleghani Ave., , Taleghani Ave., 15618, Tehran, Iran, Islamic Republic Of, hasannasab.tmu84@gmail.com, *Matthias Ehrgott*, *Andrea Raith*

Data envelopment analysis is a linear programming based method for performance measurement. We use a multi-objective linear programming (MOLP) formulation of DEA and apply primal and dual variants of Benson's outer approximation algorithm to solve this MOLP model. The theory behind these algorithms allows us to identify all efficient DMUs and all hyperplanes defining the efficient frontier of the production possibility set without solving any linear programmes. We provide numerical results to illustrate the advantages of the new DEA/LP algorithm.

3 - Finite Representation of Non-dominated Sets in Multi-objective Linear Programming

Lizhen Shao, Automation, University of Science and Technology Beijing, 100083, Beijing, China, lshao@ustb.edu.cn, *Matthias Ehrgott*

We address the problem of representing the set of nondominated points of an MOLP by a finite subset of such points. We illustrate the drawbacks of the known global shooting (GS), normal boundary intersection (NBI), and normal constraint methods concerning the coverage and uniformity of the representation. Then we propose an algorithm which combines the positive elements of both the GS and NBI methods but overcomes their limitations. We prove that the new algorithm computes a set of evenly distributed nondominated points and finally we show some numerical results.

4 - An interior point-based method to solve multiobjective linear programs
Víctor Blanco, Quant. Methods for Economics & Bussines, Universidad de Granada, Facultad de Ciencias Economicas y Empresariales, Campus Cartuja, 18011, Granada, Spain, vblanco@ugr.es, *Justo Puerto*, *Safae EL Haj Ben Ali*

Several algorithms are available for finding the entire set of Pareto-optimal solutions of Multiobjective Linear Programmes. However, all of them are based on active-set methods. We present a method, based on a transformation of any MOLP into a unique lifted Semidefinite Program, the solutions of which encode the entire set of Pareto-optimal extreme point solutions of any MOLP. This SDP problem can be solved by interior point methods; thus unlike an active set-method, our method provides a new approach to find the set of Pareto-optimal solutions of MOLP.

■ WB-40

Wednesday, 10:30-12h00
Y12-1

DEA Applications II

Stream: DEA and Performance Measurement
Invited session
Chair: *Manuela Maria Oliveira*, IPMA, Portugal, moliveira@ipma.pt

1 - DEA models for the analysis of efficiency of agricultural farms
Iryna Deineko, WBS, The University of Warwick, CV4 7AL, Coventry, United Kingdom, Iryna.Deineko@wbs.ac.uk, *Robert Dyson*, *Victor Podinovski*

In this talk we generalise recent developments in the methodology of DEA aimed at the analysis of efficiency of agricultural farms. We also discuss our practical experience with the application of new DEA models. The focus of this presentation is on the use of additional information in the form of production trade-offs that reflect the relative difficulty (in terms of resources) of different agricultural crops. We discuss the meaning of production trade-offs in the agricultural context, give examples of their assessment and demonstrate the difference their use has on the results of efficiency

2 - Panel Data Analysis and Two-Stage DEA Regression: Assessing the Effect of Contextual Variables in Agricultural Research Performance in Brazil
Geraldo Souza, Statistics, University of Brasilia, SHIN QI 10 Conj. 01 Casa 13, Lago Norte, 71525-010, Brasilia, DF, Brazil, geraldo.souza@embrapa.br, *Eliane Gomes*

We fit a panel data model for DEA-VRS performance data generated by each of the Brazilian Agricultural Research Corporation research centers. We investigate the effects on performance of a set of contextual variables: process improvements, impact of technologies, intensity of partnerships, revenue generation. An instrumental variable estimation procedure is suggested to handle the endogeneity of the independent variables and to function as a test of exogeneity. The estimation process allows for estimation under heteroskedasticity, cross-sectional correlations and serial correlation.

3 - Comparing the efficiency of Spanish conventional and organic citrus farmers
Ernest Reig, Applied Economics II, University of Valencia, Facultat d'Economia, Avda.dels Tarongers s/n, 46022, Valencia, Spain, ernest.reig@uv.es, *Mercedes Beltran*

We compare the efficiency of two groups of organic and conventional Spanish citrus farmers, using Data Envelopment Analysis and directional distance functions, and drawing a distinction between group technologies and an enveloping meta-technology. We measure the relative potential to scale down the cost of farm operations in specific tasks, like tillage or pruning, valued in monetary terms, instead of dealing with conventional inputs. The conventional farming system displays higher efficiency in broad terms, but its superiority differs according to specific cultivation tasks.

4 - The influence of catch quotas on the productivity of the Portuguese bivalve dredge fleet
Manuela Maria Oliveira, IPMA, Portugal, moliveira@ipma.pt, *Ana Camanho*, *Miguel B. Gaspar*

The impact of management changes on the productivity of the fleet, operating in northwest and southwest areas, is assessed using Malmquist indices and the directional distance function models.The results showed that the implementation of a weekly quota improved the productivity of both fleets due to the decrease in fishing days and fuel consumption. The simulation of weekly quotas in the south area showed that this management policy would lead to a reduction of about 12% in the same resources revealing the importance of applying this type of management measure in similar fisheries worldwide.

■ WB-41

Wednesday, 10:30-12h00
Y12-5

Energy Meteorology

Stream: Decision Making under Uncertainty and Environmental Applications
Invited session
Chair: *John Boland*, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd., 5095, Mawson Lakes, South Australia, Australia, john.boland@unisa.edu.au

1 - Characterising solar radiation variability in space and time
John Boland, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd., 5095, Mawson Lakes, South Australia, Australia, john.boland@unisa.edu.au

Much research has gone into forecasting solar radiation for a single site, including characterising the distributional qualities. For multi-site installations, there has been some work on understanding the variability, for example the work of Hoff et al. on the output variability of clusters of photovoltaic receivers. We will report on work entailing probabilistic forecasting of solar radiation at multiple locations using classical time series methods coupled with approaches from dynamical systems. This is an extension of the work of Huang et al 2013, developed for a single site.

2 - Neurofuzzy Inference in a Solar Radiation Time Series
Carlo Lucheroni, School of Science and Technologies, University of Camerino, via M. delle Carceri 9, 62032, Camerino (MC), Italy, carlo.lucheroni@unicam.it, *John Boland*

A hourly scalar time series of Australian solar radiation data, two years long, is studied using a Fuzzy Inference System (FIS) model. A static FIS model is proposed to model each year of data in terms of a short-term intra-year Sugeno type autoregression of two lags. The FIS machine is trained on the first year of data, and forecasting is computed for each of the hours of the next year. Forecasting results are compared to the second year time series. The quality of results, pretty good, is discussed by means of error plots and metrics like MeAPE, MBE and NRMSE.

3 - Maximum entropy methods for environmental applications
Julia Piantadosi, Centre for Industrial and Applied Mathematics, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, Mawson Lakes Boulevard, Mawson Lakes, 5095, Adelaide, South Australia, Australia, julia.piantadosi@unisa.edu.au

We will adapt recent work on modelling and simulation of rainfall using a copula of maximum entropy that allows us to incorporate the observed correlation to applications in energy such as solar and wind.

4 - Territorial Design Approach for Decentralized Green Energy Planning
Seda Ugurlu, Industrial Engineering, Istanbul Technical University, 34367, Istanbul, Turkey, sedayanik@itu.edu.tr, *Basar Oztaysi*

We present a territorial design approach to integrate the green and decentralized energy strategies to achieve effective energy planning. We use ordinary kriging method and GIS to obtain spatially distributed energy demand and green energy supply predictions in the whole territory. We develop a linear transportation model to group small geographical areas into larger clusters. We find the optimum solution for the model and then apply AssignMAX rule. We present a case study for Turkey and obtain autonomous territories satisfying energy need using green energy potential in each territory.

■ WB-42

Wednesday, 10:30-12h00
Y12-3

Policy Analytics 1

Stream: Policy Analytics
Invited session

Chair: *Alexis Tsoukiàs*, CNRS - LAMSADE, Université Paris Dauphine, 75775, Paris Cedex 16, France, tsoukias@lamsade.dauphine.fr

1 - From Evidence Based Policy Making to Policy Analytics
Alexis Tsoukiàs, CNRS - LAMSADE, Université Paris Dauphine, 75775, Paris Cedex 16, France, tsoukias@lamsade.dauphine.fr, *Giulia Lucertini*

We present a critical review of the policy making literature with particular emphasis to evidence based policy making. We claim that EBPM, while reflects a need for supporting the policy cycle and the decision process within it, failed to become a real standard both in theory and practice. We introduce the concept of policy analytics and explain what we should expect from it (as decision analysts).

2 - Justified decisions are better than simple ones: explaining preferences using even swap sequences
Wassila Ouerdane, LGI- Ecole Centrale Paris, Ecole Centrale de Paris, Grande Voie des Vignes, 92290, Châtenay-Malabry, France, wassila.ouerdane@ecp.fr, *Christophe Labreuche*, *Nicolas Maudet*, *Vincent Mousseau*

The even swap method is an interesting approach for identifying the best alternative among several options. This constructive method is intuitively attracting: only two attributes are involved in even swaps, and utilities are never explicitly mentioned to the Decision Maker (DM). The aim of this paper is to investigate whether this approach can be generalized to robust preference relations and used to generate convincing explanations.

3 - Argumentation theory for public policies
Gabriella Pigozzi, LAMSADE, Université Paris Dauphine, 75775, Paris Cedex 16, France, gabriella.pigozzi@dauphine.fr, *Nicolas Paget*

A decision process in public policy has to be accountable and legitimate, both for the stakeholders participating in the process and the citizens who will be affected by the policy. The development of formal models allows to investigate properties, thus helping to ensure transparency of the deliberation and the decision-making processes. We propose a two-steps model. First, we extend argumentation theory to characterize the deliberation process among a group of individuals. Second, we define ways to aggregate individual positions into a collective one, using social choice theory concepts.

4 - Assessing the diversity in an organization with respect to its context
Marc Pirlot, Mathematics and Operational Research, Université de Mons UMONS, Faculté Polytechnique, Rue de Houdain 9, B-7000, Mons, Belgium, marc.pirlot@fpms.ac.be, *Denis Bouyssou*, *Thierry Marchant*, *Thierry Marchant*

The attention to diversity management has much grown in the last two decades. This concept is generally related to equal employment opportunity or affirmative action. Some indices have been proposed to measure diversity in an organization. Not only, these indices have not been characterized, but furthermore, they do not take into account the distribution in categories in the surroundings of the organization. We define several indices which measure the similarity between the diversity inside an organization and in its surroundings and we characterize them.

■ WB-43

Wednesday, 10:30-12h00
Y12-2

Knowledge Management & Decision Making

Stream: Decision Support Systems
Invited session

Chair: *Isabelle Linden*, Departement of Business Administration, University of Namur, 8 rue Rempart de la Vierge, 5000, Namur, Belgium, isabelle.linden@fundp.ac.be
Chair: *Pascale Zaraté*, Institut de Recherche en Informatique de Toulouse, Toulouse University, 118 route de NarBonne, 31062, Toulouse, France, zarate@irit.fr

1 - An integrated approach to budget allocation in partnership construction projects based on multiple criteria decision making
Hamidreza Koosha, Industrial Engineering Faculty, Ferdowsi University of Mashhad, Mashhad, Khorasan, Iran, Islamic Republic Of, koosha@um.ac.ir, *Samira Samizade*

In recent years, the construction business in Iran has experienced a considerable growth and investment in this area needs applicable models to budget allocation. In this research, we aim to develop a model to cope with the complexity of budget allocation in partnership construction projects in Iran. We first use Analytical Hierarchy Process (AHP) to determine the importance weights of each objective. Then, we use goal programming to model the problem based on weights. The applicability of this capital budgeting problem is showed by a real world case.

2 - Knowledge Sharing to Support Decision Making Processes in Multinational Corporations
K. Nadia Papamichail, Manchester Business School, University of Manchester, Booth Street East, M15 6PB, Manchester, United Kingdom, nadia.papamichail@mbs.ac.uk, *Mahmoud Abdelrahman*

Knowledge Management Systems (KMS) help decision makers and users leverage and share their knowledge. In the current fluid environment, the challenge for Multinational Corporations (MNC) is to accumulate knowledge that stems from various sources to support Decision Making (DM) processes. Based on semi-structured interviews with 42 subjects, this paper identifies factors that affect knowledge sharing through the use of KMS to support DM processes in MNC. The study extends the existing literature by proposing a new theoretical framework.

3 - A multicriteria model for characterizing potential crucial knowledge
Sahar Ghrab, Computer Science, High Institute of Computer Science and Multimedia, Road of Gremda, 3062, Sfax, Tunisia, Tunisia, ghrab.sahar@gmail.com, *Inès Saad*, *Gilles Kassel*, *Faiez Gargouri*

The paper treats the issue of evaluating and characterization potential crucial knowledge requiring a capitalization operation. Due to the innovative and scarcity aspects of innovative projects, most of knowledge is in the course of validation which can be guaranteed in the short or medium terms. This article proposes a method to construct a preference model which allows characterizing a new decision's class for potential crucial knowledge. We rely on the DRSA approach for defining preference model of decision makers. The new class had been experimented in a medical society (ASHMS).

4 - Machine learning integrated optimization for decision making
Atiyeh Vaezipour, Department of Computer and Electrical Engineering, Jonkoping University, Sweden, atiehvaezipour@gmail.com, *Amir Mosavi*, *Ulf Seigerroth*

Due to the dynamic nature of stored big data in today's political and behavioral decision-making, inter-temporal choice and marketing, enterprise decision management, etc., the traditional approaches of statistical analysis, analytics, information processing and business intelligence have become less useful in making the informed decisions. Here, the novel methodology of integration of data mining, modeling, and interactive decision-making is studied as an effective approach where numerous what-if scenarios are evaluated and optimization-based decision processes are used.

■ WB-45

Wednesday, 10:30-12h00
Y10-3

Fair division and cooperative game theory

Stream: Cooperative Game Theory
Invited session

Chair: *Marco Dall'Aglio*, Dept of Economics and Business, LUISS University, Viale Romania 32, Rome, Italy, mdallaglio@luiss.it

1 - New Quantifiable Definitions of Fairness
Le Hoang, Magi, Polytechnique, CP 6079, Succ. Centre-ville, H3C 3A7, Montéal, Québec, Canada, le-nguyen.hoang@polymtl.ca, *Francois Soumis*, *Georges Zaccour*

Defining fairness is a difficult problem of mathematical modeling. Main results come from the cake-cutting literature, although they apply to a specific setting. In this talk, we generalize these ideas by focusing on the idea of trades. We argue that fairness is defined by the comparison of each person's allocation with how he perceives others. Based on this principle, we propose different quantifications of fairness called fairness gaps, which are essential for optimization. In particular, we provide a specific definition for the particular setting of multi-attribute utility functions.

2 - Bounds for alpha-optimal partitioning of a measurable space based on several efficient partitions
Camilla Di Luca, Economics and Finance, LUISS Guido Carli, 32, Viale Romania, 00197, Roma, Italy, cdiluca@luiss.it, *Marco Dall'Aglio*

We provide a two-sided inequality for the alpha-optimal partition value of a measurable space according to n nonatomic finite measures. The result improves on that of Legut (1988) since the bounds are obtained considering several partitions maximizing the weighted sum of the partition values with varying weights. This result can be used in the context of fair division cooperative games.

3 - Collusion games in Knaster's procedure for coalitions with and without structure
Marco Dall'Aglio, Dept of Economics and Business, LUISS University, Viale Romania 32, Rome, Italy, mdallaglio@luiss.it, *Federica Briata*, *Vito Fragnelli*

We study the collusion in Knaster's procedure, starting from the paper of Fragnelli and Marina (2009). First, we introduce a suitable dynamic mechanism, so that the coalition enlargement is always non-disadvantageous. Then, we define a new class of TU-games in order to evaluate the collusion power of the agent and we analyze the same games in the context of coalition structures.

■ WB-46

Wednesday, 10:30-12h00
Y10-1

Matching and Other Games

Stream: Game Theory and Combinatorial Optimization
Invited session

Chair: *David Ramsey*, School of Mathematics and Statistics, University of Limerick, Plassey, —-, Limerick, Ireland, david.ramsey@ul.ie

1 - Strategic Mating Games with Age-Dependent Prefences
Steve Alpern, ORMS, Warwick Business School, University of Warwick, Coventry, CV4 7AL, London, United Kingdom, s.alpern@lse.ac.uk

We consider a steady state model of mutual mate choice in which an individual's mate preferences depend on his/her age, and the preferences are over the ages of prospective mates of the opposite sex. Unmated members of the two sexes are randomly matched, and a matched couple become a mated couple if both agree to it. We concentrate on the biologically motivated preference system in which both partners desire a maximum period of mutual fertility. Both discrete and continuous time models are considered.

2 - Partnership Formation with Multiple Traits
David Ramsey, Department of Computer Science and Management, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370, Wroclaw, Poland, david.ramsey@pwr.wroc.pl

I present a model of partnership formation based on two traits. Searchers prefer partners of high beauty and similar character. Beauty is observed instantly, but a date is required to observe character. On observing the beauty of a prospective partner, a searcher decides whether to date. The participants then observe each other's character and decide whether to pair. Beauty has a continuous distribution, while character forms a circle and has a uniform distribution. When dating costs are high, the equilibrium is block separating. In general, the form of the equilibrium is different.

3 - The betters' best bet
John Howard, Management, London School of Economics, Houghton Street,, London, WC2A 2AE, United Kingdom, j.v.howard@lse.ac.uk, *Steve Alpern*

Two gamblers argue about who can do better from making fair bets, starting from the same unit stake. They play a game in which each chooses a distribution over the non-negative reals with unit mean. A number is drawn independently from each distribution, and the gambler whose distribution produced the higher number wins. We show that there is a unique simple optimal distribution which wins half the time, and then extend the analysis to look at cases with more restricted sets of distributions.

4 - Patrolling Games: The line and other results
Katerina Papadaki, Operational Research, London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, United Kingdom, k.p.papadaki@lse.ac.uk, *Alec Morton*, *Steve Alpern*

Motivated by the problem of optimizing randomized, and thus unpredictable, patrols for vulnerable facilities, we present a class of patrolling games. The facility to be patrolled can be thought of as a network or graph Q of interconnected nodes, and the Attacker can choose to attack any node of Q within a given time T. He requires m consecutive periods there, uninterrupted by the Patroller, to commit his nefarious act (and win). The Patroller can follow any path on the graph. We present analytical results for various classes of graphs and specifically for the line graph.

■ WB-47

Wednesday, 10:30-12h00
Y10-2

Topics in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Snjezana Pivac*, Faculty of Economics, University of Split, Department of Quantitative Methods in Economics, Matice hrvatske 31, 21000, Split, Croatia, spivac@efst.hr

1 - Assortment Planning of a Configurable Product
Ratna Babu Chinnam, Industrial & Systems Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, r_chinnam@wayne.edu, *Edward Umpfenbach*

Producers of configurable products such as automobiles often struggle to balance supply chain complexity with sufficient customer choice. We present a model based on mutinomial logit demand designed for an automotive manufacturer to tackle this problem. Our model scales with their complex product, considers the effect of packaging, and considers sustainability aspects of the product.

2 - Revenue Management Models with Financial Hedging
Gülce Sarı, Industrial Engineering, Koc University, Turkey, gsari@ku.edu.tr, *Fikri Karaesmen*, *Suleyman Ozekici*

In recent years, hedging practices has gained substantial importance due to the various channels of uncertainties that the businesses face. In this study, we first present an analysis of revenue management (RM) models with related hedging strategies. Unlike most of the literature, we incorporate risk sensitivity into the model by taking a mean-variance approach to establish a trade-off between the return and the risk of the cash flow. Furthermore, we show that by employing the right financial hedging strategies the risk associated with the RM cash flow can be reduced.

3 - Companies' Financial Success using Electronic Managerial Tools
Snjezana Pivac, Faculty of Economics, University of Split, Department of Quantitative Methods in Economics, Matice hrvatske 31, 21000, Split, Croatia, spivac@efst.hr, *Ivana Tadic*

The main aim of this paper is to research whether Croatian companies applying human resource information system (HRIS) and electronic recruitment as electronic managerial tools, provide better business results. After providing primary and secondary research, the comparative analysis of companies' classification and ranking are done using multivariate cluster and multicriteria PROMETHEE methods. Finally, binary logistic regressions are estimated. Significant odds ratio shows if company with developed HRIS has higher probability of financial success.

4 - Advances In Profit-Driven Order Promising For Make-To-Stock Environments — A Case Study With A Canadian Softwood Lumber Manufacturer
Rodrigo Cambiaghi Azevedo, Mechanical Engineering Dept, Université Laval, FORAC, Pavillon Adrien-Pouliot - 1065, av. de la Médecine, Université Laval, G1V 0A6, Quebec, Quebec, Canada, rodrigo.cambiaghi@ey.com, *Sophie Damours*, *Mikael Rönnqvist*

A new approach for profit-driven order promising for make-to-stock environments is proposed. It consists of two main steps. First, products are allocated to customer segments over a planning horizon. Then, nested booking limits are computed based on customer segments' willingness to pay as well as on different configurations of value chain costs. Second, available allocations are consumed from the most profitable sourcing location as orders arrive at the producer. Simulations supported by real data show considerable increase of the profitability of the producer.

■ WB-48

Wednesday, 10:30-12h00
Y11-1

Financial Decision Analysis

Stream: Financial Mathematics and OR
Invited session

Chair: *Norio Hibiki*, Administration Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, 223-8522, Yokohama, Japan, hibiki@ae.keio.ac.jp

1 - Optimal Symmetric No-trade Ranges in Asset Rebalancing Strategy with Transaction Costs
Norio Hibiki, Administration Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, 223-8522, Yokohama, Japan, hibiki@ae.keio.ac.jp, *Rei Yamamoto*

We discuss an optimal asset allocation problem with transaction costs to determine the symmetric no-trade ranges using the DFO (Derivative Free Optimization) approach. Specifically, we solve the five-asset problem with boundary constraints for cash for Government Pension Investment Fund in Japan in a discrete-time and finite-period setting. We conduct the sensitivity analysis for the various proportional transaction cost rates, the tracking error aversions, and so on. We show the possibilities of applying the model to the practical problem determining the symmetric no-trade ranges.

2 - A Cutting Plane Algorithm for Mean-CVaR Portfolio Optimization under Nonconvex Transaction Costs
Yuichi Takano, Graduate School of Decision Science and Technology, Tokyo Institute of Technology, 2-12-1-W9-77 Ookayama, 152-8552, Meguro-ku, Tokyo, Japan, takano.y.ad@m.titech.ac.jp, *Keisuke Nanjo*, *Noriyoshi Sukegawa*, *Shinji Mizuno*

We minimize the conditional value-at-risk (CVaR) to construct a portfolio under nonconvex transaction costs. Although this problem is formulated as a mixed integer linear programming (MILP) problem with special ordered set (SOS) type 2 constraints, large-scale problems are intractable even for state-of-the-art MILP solvers. Thus, we utilize a Kelley's convex cutting plane algorithm that is specialized for the problem. Numerical experiments demonstrate that our algorithm is able to attain a near-optimal solution to large-scale problems within a reasonable time.

3 - Rebalance Schedule Optimization of a Large Scale Portfolio under Transaction Cost
Rei Yamamoto, Mitsubishi UFJ Trust Investment Technology Institute Co., Ltd., 2-6, Akasaka 4-Chome, Minatoku, 107-0052, Tokyo, Japan, yamamoto@mtec-institute.co.jp, *Hiroshi Konno*

This paper is concerned with an optimization problem associated with a rebalancing schedule of a large scale fund subject to nonconvex transaction cost. We will formulate this problem as a 0-1 mixed integer programming problem. This problem can be solved by an integer programming software if the size of the universe is small. However, it is still beyond the reach of the state-of-the-art technology to solve a large scale rebalancing problem. We will show that we can now solve these problems almost exactly within a practical amount of time by using an elaborate heuristic approach.

4 - Equilibrium relationship between the profit of the market and its transaction cost by financial institution
Shingo Nakanishi, Osaka Institute of Technology, 5-16-1, Omiya, Asahi-ku, 5358585, Osaka, Osaka, Japan, nakanisi.suita@gmail.com, *Masamitsu Ohnishi*

In this study, when the financial institution has introduced the transaction cost, we investigate how the relationship among all winners, all losers and its financial institution of the market to continue a fair bet based on the normal distribution is shown. Since it is too difficult for every winner to continue to win, we clarify that the maximum value of sum of the profit of winners is drawn as the parabolic curve based on its trial number. Moreover, we confirm that the maximum value of sum of the profit of the market is also equilibrium to the transaction cost.

■ WB-49

Wednesday, 10:30-12h00
Y11-2

Risk Analysis and Data Mining

Stream: Data Mining in the Financial Sector
Invited session

Chair: *Marcus Hildmann*, Information Technology and Electrical Engineering, ETH Zurich, ETL G 24.2, Physikstrasse 3, 8092, Zürich, Switzerland, hildmann@eeh.ee.ethz.ch
Chair: *Dejan Stokic*, tbd, 60386, Frankfurt, Germany, sdeyan@gmail.com

1 - Optimal Invoice Factoring Strategy for Cash-constrained Manufacturers
Chaocheng Gu, Dept. of Logistics and Operations Management, Huazhong University of Science and Technology, School of Management 309, Luoyu Road 1037, 430074, Wuhan, Hubei, China, ccgu.hust@gmail.com, *Shiming Deng*

This study develops an optimal strategy for the manufacturer who uses factoring to finance. We investigate two factoring strategies respectively called 'fixed maturity strategy' and 'just in time strategy'. We examine the two-side effects of factoring and find an optimal timing exist in the fixed maturity strategy. A comparison of the two strategies indicates that the just in time strategy could perform worse than the fixed maturity strategy. An interesting observation of our numerical study shows that the factor can actually improve his profits by charging lower fee rates.

2 - Optimal dynamic default risk management with budget constraint
Martin Erausquin, UPV/EHU University of the Basque Country, Spain, martin.erausquin@ehu.es

We consider a resource allocation problem, where a rational agent has to decide how to share a limited amount of resources among different companies that are facing finantial difficulties. The objective is to minimize the total long term cost incurred by the economy due to default events. We formulate the problem in the framework of Multi Armed Restless Bandit problem and, assuming a two-state Markovian evolution of the default risk, the optimal policy, given by a priority index function, is obtained analytically. We study the structure of this policy, and discuss some extensions of the model.

3 - Robust Strategies for Equity Portfolio Optimisation
Ifelere Baale, Kent Business School, University of Kent, The University of Kent, Canterbury, Kent, United Kingdom, iob5@kent.ac.uk, *Said Salhi*

This research primarily investigates optimisation problems in the management of equity portfolios. It considers the principal objectives of maximising portfolio return and minimising portfolio risk within the framework of Modern Portfolio Theory. As these objectives are divergent, there is an emergent need to produce solutions that cater for various scenarios and are robust. Momentum strategies are investigated by embedding an optimisation model that evaluates portfolio returns systematically for future periods using robust optimisation techniques. A case-study using the FTSE-350 is presented.

4 - Perturbation propagation based outlier detection in multivariate financial time series
Dejan Stokic, tbd, 60386, Frankfurt, Germany, sdeyan@gmail.com

Outlier detection and later false positive testing for multivariate time series is usually based on different correlation analysis. Major drawback of the approach is that the existing outlier dramatically change the correlation structure, on which the outlier testing is actually based. We propose a novel perturbation propagation approach, by measuring the impact of unusually large price deviations on the whole system. In doing so, We use the fact that price outliers have single and isolated occurrences.

■ WB-50

Wednesday, 10:30-12h00
Y11-3

Environmental and renewable markets

Stream: Financial and Commodities Modeling
Invited session

Chair: *Silvana Stefani*, Quantitative Methods for Economics and Business Sciences, Università Milano Bicocca, Piazza Ateneo Nuovo 1 U7-4023, I-20126, Milano, Italy, silvana.stefani@unimib.it

1 - A software tool for the optimal planning and the economic evaluation of trigeneration districts
Stefano Zigrino, Department of Information Technology and Mathematical Methods, University of Bergamo, 24044, Dalmine (BG), Italy, stefano.zigrino@unibg.it, *Maria Teresa Vespucci*, *Alberto Gelmini*, *Francesca Bazzocchi*

We present a mixed integer model for planning distributed trigeneration systems. The profitability of the investment depends on the energy consumption, on the configuration of the system and technical features of generators and on electricity and fuels prices. The model determines the annual optimal dispatch given configuration of the system, load profiles and prices. The optimal dispatch is used for the economic evaluation with a cash flow analysis. The procedure allows to compare alternative plant configurations and to assess system sensitivity to model parameter values.

2 - Stochastic Programming and Optimal Regulation of EU-ETS
Paolo Falbo, Department of Economics and Management, University of Brescia, Contrada Santa Chiara, 50, 25122, BRESCIA BS, Italy, falbo@eco.unibs.it, *Cristian Pelizzari*, *Luca Taschini*

Environmental and energy targets for 2030 are the top priority in the EU community for the next years. Research that helps policy makers in their task of designing 2030 targets will be timely and well received by a wide range of stakeholders. A stochastic programming problem is developed where environmental and energy targets are jointly set subject to economic and physical constraints. A social welfare function is maximized and the policy interactions are investigated by simulating possible future price scenarios (gas, coal, and electricity) and choosing different target levels.

3 - Setting the fair price for heating renewables
Silvana Stefani, Quantitative Methods for Economics and Business Sciences, Università Milano Bicocca, Piazza Ateneo Nuovo 1 U7-4023, I-20126, Milano, Italy, silvana.stefani@unimib.it, *Fausto Bonacina*

All EU member states have introduced policies to support the market introduction of RES-E. The existing support instruments encompass essentially feed-in tariffs, quota-based tradable green certificates, feed.in premia. The support scheme caused the European electricity users an enormous cost. After an international comparison, we focus on Italy, where the incentive system is strongly in favour of electricity production. In this paper we show how the incentive policy should be shifted to heat renewable production and find a fair price for heat renewable.

■ WB-51

Wednesday, 10:30-12h00
Y11-4

Mathematical Behavior Finance and Related Topics

Stream: Financial Optimization
Invited session

Chair: *Hanqing Jin*, Mathematical Institute, Oxford University, OX1 3LB, Oxford, United Kingdom, jinh@maths.ox.ac.uk
Chair: *Ronald Hochreiter*, Finance, Accounting and Statistics, WU Vienna University of Economics and Business, Augasse 2-6, 1090, Vienna, Austria, ronald.hochreiter@wu.ac.at

1 - Consumption-based Behavioural Portfolio Selection in Continuous Time

Hanqing Jin, Mathematical Institute, Oxford University, OX1 3LB, Oxford, United Kingdom, jinh@maths.ox.ac.uk

We study the optimal consumption-investment problem in a continuous-time financial market with behavioural criteria featured by S-shaped utility function and probability distortions. Different formulations of the problem are studied. When optimal solution exists, we get explicit solutions based on some algebraic equations

2 - Discrete-time behavioral portfolio selection under prospect theory

Duan Li, Systems Engineering & Engineering Management Dept., The Chinese University of Hong Kong, Shatin, NT, Hong Kong, dli@se.cuhk.edu.hk

We formulate and study a general multi-period behavioral portfolio selection model under Kahneman and Tversky's prospect theory, featuring an S-shaped value function. We first discuss the ill-posedness issue and identify the conditions for the well-posedness under a multi-period framework. Under these conditions, we derive a semi-analytical optimal policy. In particular, the optimal behavioral portfolio policy takes a piecewise linear feedback form for i) cases with one risky asset and ii) cases with multiple risky assets whose joint distribution is within the elliptical distribution family.

3 - General Linear Formulations of Stochastic Dominance Criteria

Milos Kopa, Department of Probability and Mathematical Statistics, Charles University in Prague, Faculty of Mathematics and Physics, Sokolovská 83, CZ 186 75, Prague, Czech Republic, kopa@karlin.mff.cuni.cz, *Thierry Post*

We develop and implement linear formulations of general N-th order Stochastic Dominance criteria for discrete probability distributions. Our approach is based on a piece-wise polynomial representation of utility and its derivatives and can be implemented by solving a relatively small system of linear inequalities. This approach allows for comparing a given prospect with a discrete set of alternative prospects as well as for comparison with a polyhedral set of linear combinations of prospects. We also derive a linear dual formulation in terms of lower and co-lower partial moments.

4 - Financial Optimization Modeling using R

Ronald Hochreiter, Finance, Accounting and Statistics, WU Vienna University of Economics and Business, Augasse 2-6, 1090, Vienna, Austria, ronald.hochreiter@wu.ac.at

Simplifying the task of modeling optimization problems is important. Many commercial products have been created to support the optimization modeling process, but none of these products has been adopted by a significantly large number of users. As soon as real-world decision problems under uncertainty have to be modeled, flexible and quick changes to the underlying model are necessary. Simplifications are crucial to implement such optimization models into business processes successfully. Examples from portfolio optimization will be shown to substantiate the proposed modeling environment.

■ WB-52

Wednesday, 10:30-12h00
B13-1

Forecasting II

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Gian Luigi Mazzi*, key indicators for european policies, european commission - eurostat, JMO building bech a2-44, 2920, luxembourg, Luxembourg, gianluigi.mazzi@ec.europa.eu

1 - Judgmental Forecasting and Biases in a Company: Personality Traits, Departments, and Incentives

Clint Pennings, Rotterdam School of Management, Erasmus University, Netherlands, cpennings@rsm.nl, *Jan van Dalen*, *Stefanie Protzner*, *Laurens Rook*

Judgmental forecasting is central to the forecasting process at many companies, but is subject to many biases. An experiment was conducted in which respondents forecast demand and provide input to a meeting to examine these biases. Psychological traits and attitudes are examined to analyze differences in unintentional biases; different departmental roles and incentives (asymmetrical cost functions) are used to influence intentional biases. Insights gained are based on various measures of operational performance and forecast accuracy, and learning is explicitly taken into account.

2 - Resampling towards the future

Clara Cordeiro, CEAUL, University of Algarve, Campus Gambelas,, FCT, DM, 8005-139, Faro, Portugal, ccordei@ualg.pt, *Manuela Neves*

In previous studies from the authors, an extensive work involving exponential smoothing methods and the bootstrap methodology revealed as being a prosperous and promising association. Based on this 2-in-1 recipe, an algorithm (Boot.EXPOS) was built for forecasting time series with one seasonal pattern. In case of more than one seasonal pattern the procedure is not suitable, so a new challenge arose. A combination of an appropriate forecasting method that considers such seasonal components, with the same resampling scheme, was derived. The performance of the algorithm will be illustrated.

3 - EuroMIND : a monthly indicator of Euro area economic activity

Rosa Ruggeri Cannata, Key indicator for European policies, European Commission - Eurostat, Luxembourg, rosa.ruggeri-cannata@ec.europa.eu, *Cecilia Frale*, *Massimiliano Marcellino*, *Gian Luigi Mazzi*, *Tommaso Proietti*

Timely monitoring the economic situation at least monthly is one of the main goals of analysts; unfortunately official statistics present significant gaps at monthly frequency. We present a euro area monthly indicator of economic activity based mostly on official statistics and derived by mean of a robust procedure combining single factor models with temporal disaggregation. We also present a back calculation strategy aimed to extend the indicator coverage to the 70s. Finally we show in details the usefulness of this indicator for business cycle analysis and short term forecasting.

4 - A system for euro area and member states turning point detection

Gian Luigi Mazzi, key indicators for european policies, european commission - eurostat, JMO building bech a2-44, 2920, luxembourg, Luxembourg, gianluigi.mazzi@ec.europa.eu, *Monica Billio*, *Laurent Ferrara*

Availability of a timely and reliable system for detecting turning points is essential for running business cycle analysis and is a key tool for policy and decisions makers. Usually turning points detection targets either the classical or the growth cycle. Here a multivariate model is presented, detecting simultaneously both cycles' turning points within the so called ABCD framework. The model, originally developed for the euro area, has been extended to its largest countries. Finally a direct vs. indirect euroarea real-time detection comparison is presented and discussed.

■ WB-53

Wednesday, 10:30-12h00
B13-2

Energy Market Models

Stream: Energy systems and markets
Invited session

Chair: *Steven Gabriel*, Civil & Env. Engin./ Applied Math and Scientific Computation Program, University of Maryland, 1143 Martin Hall, 20742, College Park, MD, United States, sgabriel@umd.edu

1 - Market power across the Channel, continental gas markets isolated?

Olivier Massol, Center for Economics and Management, IFP School, 228-232 Avenue Napoléon Bonaparte, 92852, Rueil-Malmaison, France, olivier.massol@ifpen.fr

Existing empirical analyses of spatial market relationships focused only on price co-movements. These approaches do not tell us much about the arbitragers' competitive behavior, and the validity of the market equilibrium conditions. We propose an alternative approach incorporating price, transfer cost, and trade flow data. A case study focusing on the UK-Belgium Interconnector demonstrates that: both markets have achieved a high degree of spatial integration, and that the assumption of perfectly competitive arbitrages is firmly rejected by the data suggesting the presence of market power.

2 - Optimal long-term contracts in gas markets. A risk-sharing approach.

Ibrahim Abada, GDF SUEZ, 02 place S de Champlain, Faubourg de l'Arche, 92930 , Paris la Défense Cedex, France, ibrahim.abada@gdfsuez.com, *Andreas Ehrenmann*, *Yves Smeers*

We present a simple stochastic gas market model to capture the optimal long-term contracts signed between a producer and a midstreamer. The problem is based on an equilibrium approach where each player strives to optimize his long-term risk-adjusted payoff. The risk measure we use is coherent and time-consistent. We assume the existence of a spot market where gas can be exchanged in the short run and the possibility to sign market-indexed or oil-indexed contracts. We discuss some ways to solve the model as well as our first results.

3 - Energy Price Forecasting models with spikes

Baptiste Salasc, R&D, Air Liquide, Centre de recherche Claude & Delorme, 1, chemin de la porte des Loges B.P 126, 78354, Jouy-en-Josas, France, baptiste.salasc@airliquide.com, *Kim Levy*, *Jean André*, *Alexana Cranmer*, *Steven Gabriel*

Fitting forecasting models to highly volatile electricity prices presents a number of challenges and a wide variety of methods. The work examines time series, regression modeling and a hybrid of the two applied to Alberta's market to predict prices and understand the characteristics influencing prices. The time series models include seasonality and exogenous factors while the regression model uses a combination of linear and logit modeling based on work by Cassano and Sick (2011). Errors stem largely from inaccuracy in predicting the extent of a spike in price or the time of a spike in price

4 - Valuation of hydro reservoir storage systems in competitive electricity markets

Christoph Weber, Universität Essen, Universitätsstr. 11, 45117, Essen, Germany, Christoph_Weber@uni-duisburg-essen.de, *Bastian Felix*

In competitive markets the valuation of hydro storage investment projects needs to take into account the market information and therefore the uncertainty of electricity prices. The correct valuation of reservoir storage systems within an uncertain market is a valuation problem with high dimensionality. We propose an approach that applies numerically constructed multinomial recombining price trees to reduce the problem dimension. We present results for a representative case study. In doing so, we apply a spot price model accounting for the price fundamentals as well as for the price stochastic.

■ WB-54

Wednesday, 10:30-12h00
B14-1

Markets and Auctions in Power Systems I

Stream: Energy, Environment and Climate
Invited session

Chair: *Leonardo Nepomuceno*, Electrical Engineering, UNESP - Univ Estadual Paulista, Av. Eng. Luiz Edmundo C. Coube 14-01, Bairro: Vargem Limpa, 17033-360, Bauru, SP, Brazil, leo@feb.unesp.br

1 - Commodity pricing in markets with non-convexities: Lessons from a duopoly

Panagiotis Andrianesis, Mechanical Engineering, University of Thessaly, Pedion Areos, 38334, Volos, Greece, pandrianesis@hotmail.com, *George Liberopoulos*

Commodity pricing in markets with non-convexities has attracted renewed attention in the context of electricity market deregulation. Such markets, under marginal pricing, may lead to outcomes where truthful bidding results in losses for some participants. To deal with this issue, some designs modify the uniform market-clearing prices to ensure that no participant incurs losses, while others keep marginal pricing and employ mechanisms that provide make-whole payments to participants that incur losses. We discuss both approaches and explore their implications for a stylized duopoly.

2 - Auction Problem in Turkish Day Ahead Electricity Market

Kürşad Derinkuyu, Logistics Management, University of Turkish Aeronautical Association, Turk Hava Kurumu Universitesi, Turkkusu Campus / Etimesgut, 06790, Ankara, Turkey, kursad@utexas.edu

Auctions in Turkish Day Ahead Market (DAM) are hourly based blind-sided uniformly priced models and Market Operator clears the market by solving an optimization problem in an hour. We discuss the formulation of optimization problem in Turkish DAM and provide aggregation techniques, variable elimination algorithms, and upper bound calculations to solve this problem within the required time. Empirical evidences coming from the Turkish DAM real data indicate the upper bound has a substantial solution quality and the overall suggestions deliver remarkable solution time improvements.

3 - Optimized capacity allocation with cross-matching in intraday electricity markets

Matin Bagherpour, IT Development, Nord Pool Spot, Vollsveien 17 B, 1366, Lysaker, Norway, matin.bagherpour@npspot.com

The majority of traded electricity in power markets is in day-ahead market. However, stochastic nature of power production, especially wind power, has made a requisite for trading electricity close to real time to bring the market back in balance. Traders in the intraday market can sale and purchase electricity using different hourly and block bids. In this paper, a mixed integer programming model is proposed for cross-matching between different types of orders in order to maximize electricity flow, while network constraints such as available transmission capacity and ramping limits are met.

4 - Incorporating Transmission System Representation into a Multi-Period Auction Model for Hydrothermal Systems

Leonardo Nepomuceno, Electrical Engineering, UNESP - Univ Estadual Paulista, Av. Eng. Luiz Edmundo C. Coube 14-01, Bairro: Vargem Limpa, 17033-360, Bauru, SP, Brazil, leo@feb.unesp.br, *Julio Cesar Breda*, *Edmea Cássia Baptista*, *Antonio Balbo*

Single-period auction models generally cause economic inefficiencies and cross-subsidies, resulting in poor energy market operation. This paper proposes a multi-period auction model for hydro-dominated systems that incorporates the representation of hydropower constraints such as: limits on reservoirs, discharges, energy targets, as well as the representation of the transmission capacity. The model proposed avoids ex post corrections and as a result, mitigates economic inefficiencies and cross-subsidies, enhancing market efficiency.

■ WB-55

Wednesday, 10:30-12h00
B14-2

Decision Making in Wild Nature and Environment

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Isabel Pedro*, CEG-IST, Avenida Rovisco Pais, 1049-001, Lisboa, Portugal, ipedro@ist.utl.pt
Chair: *Nikita Ivkin*, Faculty of Management and Applied Mathematics, Moscow Institute of Physics and Technology (State University), Institutskiy Pereulok, 9, 141700, Dolgoprudny, Moscow Region, Russian Federation, ivkinnikita@gmail.com

1 - Modeling consumer preferences about alternative vehicles: survey-based experiments

Gabriela Oliveira, University of Coimbra, Portugal, gdoliveira.ses@gmail.com, *Luis C. Dias*, *Paula Sarabando*

This study concerns the choice of a vehicle focusing on its powertrain technology: gasoline, diesel, hybrid, plug-in hybrid or fully electric. The study aims at finding out to what extent consumer preferences can be approximated by a multi-attribute additive model (additive value function). Surveys were conducted by interviewers/analysts trained in this type of models. Subjects were also asked to answer a conjoint analysis type of questionnaire before and after performing a Multi-Criteria Decision Analysis. This presentation reports on some initial conclusions derived from these experiments.

2 - Brazilian State owned water utilities

Isabel Pedro, CEG-IST, Avenida Rovisco Pais, 1049-001, Lisboa, Portugal, ipedro@ist.utl.pt, *Pedro Carvalho*, *Rui Marques*

Using DEA, we analyse the efficiency of the State water companies in the Brazil. We applied several models including robust methods based on partial frontiers. We also investigate the influence of exogenous variables on the Brazilian water utilities performance by applying conditional efficiency measures based on the order-m method and its probabilistic formulation. Our research suggests that inefficiency of Brazilian water utilities is relevant and in fact, operation environment does matter, since several exogenous variables might influence the performance considerably.

3 - Interior point methods applied to predispatch with simultaneous bar and lines maneuvers

Silvia Maria Simões Carvalho, DFQM, UFSCar, Rodovia João Leme dos Santos, Km 110, SP-264, 18052-780, Sorocaba, São Paulo, Brazil, silviamsc@ufscar.br, *Christiano Lyra*, *Aurelio Oliveira*

The primal-dual interior point method is used to minimize the predipatch generation costs and transmission losses on short term operation planning if hydroelectric power systems with previously scheduled maneuvers. A matrix structure study is performed to consider the changes that occur in the system along the planning period. This information is used to develop specialized methods for the studied problem class. Numerical experiments with IEEE and real Brazilian power systems show that the proposed approach is fast and robust obtaining convergence in all performed tests.

4 - Clustering Healthcare Processes with a Robust Approach

Pavlos Delias, Accountancy, Kavala Institute of Technology, Kavala, Greece, pdelias@teikav.edu.gr, *Michael Doumpos*, *Panagiotis Manolitzas*, *Nikolaos Matsatsinis*

Process Mining has been proved to be an effective approach to discover process models from event logs. However, when a highly diversified behavior is allowed (like in a healthcare environment) mining a single model could yield pointless results. One way to tackle this diversity is clustering the log into coherent groups. In this work we propose a robust spectral clustering approach. The spectral approach let one with greater flexibility in representing data (a similarity measure is enough) while the proposed robust technique can handle outliers, a common occurrence in healthcare processes.

■ WB-56

Wednesday, 10:30-12h00
B15-3

Applied Mathematics Desk: Industrial Experiences and Success Cases in Italy - Session II

Stream: OR Applications in Industry
Invited session

Chair: *Antonino Sgalambro*, Istituto per le Applicazioni del Calcolo "Mauro Picone", National Research Council (CNR), Via dei Taurini 19, 00185, Roma, Italy, a.sgalambro@iac.cnr.it

1 - Optimal deployment of a cruise fleet

Gianni Di Pillo, Dept. of Computer Control and Management Engineering, University of Rome, via Ariosto 25, Sapienza Universita' di Roma, 00185, Rome, RM, Italy, dipillo@dis.uniroma1.it, *Marcello Fabiano*, *Stefano Lucidi*, *Massimo Roma*

The optimal deployment of a cruise fleet is the problem of a company which manages a cruise fleet, and aims to optimizing the cruises itineraries of the fleet in a given maritime area in order to minimize costs due to fuel and port costs. The problem can be modelled either as a MINLP problem or as a MILP problem of dimension much larger than the first one. As far as we are aware, this problem appears to be tackled for the first time. We present the optimization model and some computational results, obtained using the real data provided by a major cruise company.

2 - Transport planning and vehicle scheduling on multi-tier distribution network

Carlo Caligaris, ACT Operations Research, Italy, carlo.caligaris@act-OperationsResearch.com, *Marcello Fabiano*, *Graziano Galiano*, *Silvia Colasante*

This work builds on a real-world experience and approaches a complex distribution problem. From a set of shipping points, our model drives the shipments towards either a drop or transit point with the best-performing truck. The order's delivery follows specific sequences, dates and time. The model draws on 1,500 orders and 1,000 shipments daily, 30 transit points, 10 shipping points (DC and store), and 150 trucks.

3 - Optimal fleet cargo scheduling

Marcello Fabiano, ACT Operations Research, 00198, Rome, Italy, marcello.fabiano@act-operationsresearch.com, *Graziano Galiano*, *Sara Melone*

In this work we present a vessels scheduling problem: to decide which vessel assign to different cargoes with the possibility to buy the voyage on the freight market. Fleet cargo scheduling is critical due to multiple factors: the large shipment costs and the unpredictable circumstances that can affect the voyages. Several influencers affect the total cost including consumptions, port restrictions, time windows, freight market. We built an optimization model to schedule a fleet of vessels. The work is related to the oil transportation domain and it is based on real experiences.

4 - Warehouse optimization in a semi-automatic context

Massimo Roma, Dipartimento di Ingegneria Informatica, Automatica e Gestionale, Universita' di Roma, via Ariosto 25, 00185, ROMA, Italy, roma@dis.uniroma1.it, *Paolo De Luca*, *Aida Huerta*, *Raffaele Maccioni*

This study draws on a retailer's fifteen-thousand-SKU warehouse serving multi-hundred stores. Before being conveyed to shipping, items are picked, sorted and loaded onto pallets via a semi-automated or manual-assisted process. We optimized the handling process upstream to expedite sorting and shelving operations at the store. Our model outputs the palletized loads of mixed items amid a time-windowed order preparation. If harmonized, multi-level optimization could benefit even more heavily to daily performance and return on automation investment.

■ WB-57

Wednesday, 10:30-12h00
B15-4

Business Analytics and Intelligent Optimization Applications

Stream: Business Analytics and Intelligent Optimization
Invited session

Chair: *Sanja Petrovic*, Division of Operations Management and Information Systems, Nottingham University Business School, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, Sanja.Petrovic@nottingham.ac.uk

1 - Learning and Intelligent Optimization (LION) for Multiobjective Problems
Roberto Battiti, DISI - Dipartimento di Informatica e Telecomunicazioni, Universita' di Trento, Via Sommarive, 14, 38123, Trento, Italy, battiti@disi.unitn.it, *Mauro Brunato*

Multiobjective Optimization Problems lack information about the best way to combine the different objectives into a single utility function. We use objective decomposition to diversify a team of intelligent local searchers scouting for portions of the Pareto front. Simple Reactive Search Optimization (RSO) schemes are studied to quickly adapt by exploiting the global knowledge obtained during the collective search. After the most promising mechanisms are selected by offline analysis, the balance among the interaction and adaptation mechanisms is adjusted while running on a specific task.

2 - Social Network Analysis for detecting Spider Constructions in Social Security Fraud: New insights and challenges
Véronique Van Vlasselaer, Decision Sciences and Information Management, KU Leuven, Naamsestraat 69, 3000, Leuven, Belgium, Veronique.VanVlasselaer@kuleuven.be, *Dries Van Dromme*, *Bart Baesens*

Although fraud is highly discussed in literature, there is no silver bullet solution that can tackle all problems concerning fraud. As it is difficult to generalize, — e.g. bank fraud has a different structure than social security fraud — each problem has its own domain-specific characteristics and requires a tailored solution. This paper is devoted to social security fraud. Analyzing the interrelations between companies in terms of shared resources, this analysis succeeds to combine local information and social network variables to perceive good results for detecting spider constructions.

3 - A Case-Based Reasoning Approach to Radiotherapy Treatment Planning for Brain Tumour
Sanja Petrovic, Division of Operations Management and Information Systems, Nottingham University Business School, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, Sanja.Petrovic@nottingham.ac.uk, *Gulmira Khussainova*, *Rupa Jagannathan*

A Case-based reasoning (CBR) approach to radiotherapy treatment planning for brain tumour will be presented. The case base consists of description of patients and radiotherapy plans for their treatments. The similarity measure has to be designed in such a way so that a case useful for the treatment for the new patient is retrieved from the case base. We propose new similarity measures that aggregate appropriately similarity values between case features. Possible approaches to adaptation to take into account the differences between the retrieved case and the new patient will be discussed.

■ WB-58

Wednesday, 10:30-12h00
B15-6

Real Implementation Optimization 3

Stream: OR and Real Implementations
Invited session

Chair: *Ben Lev*, Decision Sciences, Drexel University, LeBow College of Business, 101 N. 33rd st., 19104, Philadelphia, Pa, United States, blev@drexel.edu

1 - A fuzzy decision making approach for post-disaster multi-criteria facility location-assignment problem
Ceyda Sol, Faculty of Engineering and Natural Sciences, Industrial Engineering, Sabanci University, Sabanci Universitesi Orta Mahalle, Universite Caddesi No 27, Orhanlı, 34956, Istanbul, Turkey, ceydasol@sabanciuniv.edu, *Kemal Kilic*

The recent experiences on logistical challenges of accessing to emergency distribution centers at the disaster affected areas have increased the attention and importance on relief network design decisions. In this study, we address post-disaster multi-criteria facility location-assignment problem and propose a fuzzy decision making approach quantitatively modeling the significant performance metrics of the relief chains (equity, accessibility, mobility, reliability and cost) based on utility functions. We also give a real-life example of the proposed method for Van earthquake (2011).

2 - A Design of Experiments Approach for the Automated Parameter Tuning Problem
Aldy Gunawan, School of IIT, Temasek Polytechnic, Singapore, Singapore, aldygunawan@lycos.com, *Hoong Chuin Lau*

Many configurators proposed to define the algorithms'parameter values are classified into model-free and model-based approaches. We introduce an approach based on the hybridization of the DOE and RSM. DOE is for determining the importance of parameters. FO-RSM is then proposed to define the promising initial range for the important parameters. A SO-RSM is then built to approximate the center point. Our approach can be embedded with existing configurators, ParamILS and Randomized Convex Search, to tune algorithms and demonstrate that our approach leads to improvements against the earlier work.

3 - A hierarchical approach to improve railway timetables
David Canca, School of Engineers, University of Seville., Av. de los Descubrimientos s/n, Isla de la Cartuja, 41092, Seville, Spain, dco@us.es, *Alejandro Zarzo*, *Eva Barrena*, *Encarnación Algaba*

The problem of designing the best railway timetable to attend the demand described by an unbalanced, two-direction, O-D matrix can be decomposed in two different decision problems. Considering certain number of available train units, the first decision is the selection of most convenient services, reinforcing some segments and relaxing some others. The second part is the design of a new timetable, modifying adequately the original one. Both problems are formulated with similar objectives: move as many passengers as quickly as possible. Computational results for a real case study are provided.

4 - Xpress-Mosel: Implementing decomposition approaches for concurrent and distributed solving
Susanne Heipcke, Xpress team, FICO, 54 rue Balthazar de Montron, 13004, Marseille, France, susanneheipcke@fico.com

The Xpress-Mosel environment includes a language that is both a modeling and a programming language, libraries for embedding and remote launching, and tools such as a debugger and profiler. We discuss examples of hybrid decomposition algorithms implemented with Mosel using a combination of different solvers and heuristics in a distributed computing setting. We show how to use the various entry points for user interaction with the solver modules (eg callbacks invoked during branch-and-bound search or loading user solutions) for implementing coarse or tightly integrated hybridization schemes.

■ WB-59

Wednesday, 10:30-12h00
B15-5

Soft OR and Multimethodology I

Stream: Soft OR / Systems and Multimethodology
Invited session

Chair: *Leroy White*, Management Department, University of Bristol, Social Science, 8 Woodland RD, BS8 1TN, Bristol, United Kingdom, leroy.white@bris.ac.uk

1 - Developing a framework for measuring the impact of voluntary and community organisations
Leroy White, Management Department, University of Bristol, Social Science, 8 Woodland RD, BS8 1TN, Bristol, United Kingdom, leroy.white@bris.ac.uk

There are a number of challenges associated with demonstrating the impact of the social actions of voluntary and community organisations. To work towards drawing out the principles and values associated with measuring impact a variety of different problem structuring approaches was used in an iterative way. This paper will focus upon the framework to support the development an impact appraisal approach for voluntary and community organisations.

2 - Axiomatic Formulation of Problem Structuring? Methods to Principles
Mike Yearworth, Faculty of Engineering, University of Bristol, Queens Building, University Walk, BS8 1TR, Bristol, United Kingdom, mike.yearworth@bristol.ac.uk, *Leroy White*

From reviewing engineering practice there appears evidence of possible widespread use of non-codified problem structuring. We review these practices with the view to assimilate the learning back into the problem structuring community and of benefit to both engineering and PSM/management communities. We attempt to re-interpret PSMs into an axiomatic formulation, thus presenting a set of problem structuring principles, which would fit well with engineering pragmatics and possibly encourage wider use of problem structuring. We explore the opportunities and apprehensions that this might present.

3 - The value of mixing SD and DES: reflections from a healthcare project
Jennifer Morgan, Management Science, University of Strathclyde, Graham Hills Building, 40 George St, G1 1QE, Glasgow, United Kingdom, jennifer.s.morgan@strath.ac.uk, *Susan Howick*, *Valerie Belton*

Mixed System Dynamics (SD) and Discrete Event Simulation (DES) modelling has increased in popularity yet questions remain as to how the methods might be used together and the value offered. This paper reflects on a healthcare mixed methods project. It considers why the methods were required, how the methods were used together and how this changed throughout the modelling process. Mixing SD and DES enabled a rich system representation of the system and exploration at several levels of detail to inform understanding. The potential and realised value of a mixed methods project design is explored.

4 - Evaluating the Effectiveness and Sustainability of an Improvement Intervention Utilising Lean Systems Methodology
Gavin Betts, Hull University Business School, University of Hull, Cottingham Road, HU6 7RX, Hull, East Yorkshire, United Kingdom, g.betts@hull.ac.uk

The Vanguard Method, also known as Lean Systems Methodology (LSM), is an established approach for the redesign of operational service systems. This paper outlines proposed research to evaluate the effectiveness of LSM, with a particular emphasis on the sustainability of change over time. The research is based on the historical analysis of an individual case study some two years post-intervention. Research methods include quantitative metrics for effectiveness drawn from the Check phase of LSM, together with semi-structured interviews.

■ WB-60

Wednesday, 10:30-12h00
B15-7

Learning: Methods and Algorithms I

Stream: Information and Intelligent Systems
Invited session

Chair: *Youssef Masmoudi*, University of Sfax, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef.masmoudi@gmail.com
Chair: *Metin Turkay*, Department of Industrial Engineering, Koc University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, mturkay@ku.edu.tr

1 - A Binarization Strategy for Mixed Data Classification
Youssef Masmoudi, University of Sfax, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef.masmoudi@gmail.com, *Metin Turkay*, *Habib Chabchoub*

This work presents a binarization pre-processing strategy. We propose that the use of binary attributes for representing nominal and integer data is beneficial for classification accuracy. We also describe a procedure to convert integer and nominal data into binary attributes. An expectation—Maximization clustering algorithm was applied to classify the values of the attributes with a wide range to use a small number of binary attributes. Then we use SVM for classification. The proposed method demonstrates better accuracy with the tested datasets.

2 - Observing Customer Segment Stability Using Soft Computing Techniques and Markov Chains
Abdulkadir Hiziroglu, Management Information Systems, Yildirim Beyazit University, Cinnah Street, Cankaya, 06100, Ankara, Turkey, hiziroglu@ybusm.info

This study proposes a model that utilizes soft computing and markov chains within data mining framework to observe stability of customer segments. The model was applied on real-world data that were procured from a UK retail chain covering four periods of shopping transactions of around 300,000 customers. Internal validity was measured by two different clustering validity indices and a classification accuracy test. The model helps extracting meaningful information regarding segment stability by providing practitioners useful managerial implications and better understanding of segment stability.

3 - The Development of an Instrument to Assess Organizational Learning Activities
Shihping Huang, National Chiao Tung University, Taiwan, kevin1003@gmail.com, *Yu-Lin Wang*

This paper describes the development and validation of a measure of organizational learning that is based on Huber's (1991) conceptualization. The scale development process was carried out over three stages (item generation, scale purification, scale validation), that comprised two separate data collections phases involving a total of 435 working adults from multiple and diverse workplace settings. The data provide evidence for the face, content, discriminant, convergent and nomological validity, dimensionality and reliability of the organizational learning scale.

4 - Observational Learning for Adaptive Scheduling
Ana Madureira, DEI, ISEP, Portugal, amd@isep.ipp.pt, *Ivo Pereira*

From nature we can conclude that species that can learn from observation can develop a social culture.Observing a task being performed by someone else often accelerates human learning. In this work we attempt to imitate the species behavior and incorporate Observational Learning into scheduling support system in order to improve the overall scheduling performance.We consider that human and artificial intelligence must be combined to effectively solve the design of scheduling support systems for manufacturing environments where dynamic adaptation and optimization become increasingly important.

■ WB-62

Wednesday, 10:30-12h00
R18-1

Mixed-Integer Non-Linear Programming 3

Stream: Mixed-Integer Non-Linear Programming
Invited session

Chair: *Javier Diaz*, Sistemas e Informatica, Universidad Nacional de Colombia, Cra 80 65-223, Facultad de Minas Bloque m8A oficina 212, 1, Medellin, Antioquia, Colombia, javidiaz@unal.edu.co

1 - On the efficiency of an algorithm for two-stage mixed nonlinear problems
Eugenio Mijangos, Applied Mathematics and Statistics and Operations Research, UPV/EHU, P.O. Box 644 – Dept. Matematica Aplicada y E.I.O. (UPV/EHU), 48080, Bilbao, Spain, eugenio.mijangos@ehu.es

We consider two-stage mixed 0-1 nonlinear problems with nonlinear objective function and nonlinear convex constraints. These problems have continuous and binary variables in the first stage and only continuous variables in the second stage. To solve this problem an algorithm based on the Twin Node Family concept of the Branch-and-Fix Coordination method is put forward. Each nonlinear subproblem generated in the nodes of the trees associated with this method is solved by solving sequences of quadratic subproblems. Its efficiency is compared with that of codes that solve general MINLP problems.

2 - Resolution of the maximum loadability problem with discrete control variables
Edilaine Soler, Departamento de Matemática, Faculdade de Ciências, UNESP - Univ Estadual Paulista, Av. Eng. Luiz Edmundo Carrijo Coube, 14-01, 17033-360, Bauru, SP, Brazil, edilaine@fc.unesp.br, *Edmea Cássia Baptista*, *Geraldo R. M. da Costa*, *Vanusa Sousa*

The problem of finding the maximum loading of a power system can be formulated as a mixed integer nonlinear programming problem. In most techniques existing in the literature based on determining of the maximum loadability via optimization techniques, the discrete controls are modeled as continuous variables. These formulations are unrealistic because some controls can be only adjusted by discrete steps. This work presents an efficient handling of discrete variables by penalty function becoming the problem continuous and differentiable. Simulations with the IEEE test systems are presented.

3 - A Scheduling Problem for Rebuidling Bridges
Shungo Koichi, Information Systems and Mathematical Sciences, Nanzan University, Seireicho 27, 4890863, Seto, Japan, shungo@nanzan-u.ac.jp

It is said that the expected lifetime of bridges is 50 years. In Japan, over 50 years old bridges have increased in number since many bridges were built around 1960. Hence, the demand for rebuilding those bridges is growing. However, the closure of bridges to be rebuilt has a significant influence on traffic. Therefore, it is necessary to make a fair schedule for rebuilding those bridges. To resolve this problem, we propose a nonlinear IP model whose objective is the minimization of the time to detour due to the closure. We also show that the objective function is supermodular.

4 - A MINLP model to the Hydro Scheduling Problem with price uncertainty and risk management: The case of a head-dependent cascaded reservoir system in Spain
Javier Diaz, Sistemas e Informatica, Universidad Nacional de Colombia, Cra 80 65-223, Facultad de Minas Bloque m8A oficina 212, 1, Medellin, Antioquia, Colombia, javidiaz@unal.edu.co, *Luis Moreno*

A large-scale mixed-integer non-linear programming (MINLP) model for short-term hydro-scheduling (STHS) problem of a hydroelectric generation company (H-GENCO) is presented. The model could serve for decision making about three questions associated with three classical problems in a pool-based electricity market: when to generate?, the Unit Commitment Problem; how much to generate?, the Economic Dispatch Problem; how to offer?, the Bidding Design Problem. Price scenarios and trade-off between profit and risk as an efficient frontier are considered. Results of a case study are discussed.

■ WB-63

Wednesday, 10:30-12h00
R18-2

Logistics and Maritime II

Stream: OR and Maritime Studies
Invited session

Chair: *Panagiotis Angeloudis*, Civil & Environmental Engineering Dept, Imperial College London, Centre for Transport Studies, Skempton Building, Rm 205, SW7 2BU, London, United Kingdom, pa01@ic.ac.uk

1 - Empty container sharing and mechanism design in a two-port system
Liming Liu, Faculty of Business, Lingnan University, Tuen Mun, Hong Kong, China, limingliu@ln.edu.hk

We study a two-carrier collaboration problem with sharing of empty containers in a two-port system, where the carrier can use the idle empty container of another carrier in some port. The problem is modeled into a time-space network. We show the conditions for carriers share idle empty containers and the quantity of containers to be shared. We have also designed mechanisms for carriers to share the cost savings. From the analysis, several useful managerial insights have been obtained for carriers' collaboration in sharing of empty containers.

2 - Proactive Transshipment Does More than Stock Balancing
Rachel Zhang, IELM, Hong Kong UST, Clear Water Bay, 00000, Kowloon, Hong Kong, rzhang@ust.hk, *Li Jiang*, *Li Li*

We explore the strategic effects of transshipment early in the season in a setting of two retailers each facing a demand that depends on the prices at both retailers and ordering before demand realization. With responsive pricing by the retailers, transshipment at the end of the season can be completely avoided. Yet, if the retailers can transship early, they will do so even in the absence of demand uncertainties. This is also true even if the retailers have to set prices before demand realization and stock imbalance may be unavoidable.

3 - Minimization of energy consumption within a container terminal
Thalis Zis, Civil and Environmental Engineering, Imperial College London, Room 610, Skempton Building, Imperial College London, SW7 2BU, London, United Kingdom, tz909@ic.ac.uk, *Robin North*, *Panagiotis Angeloudis*, *Michael Bell*

Container terminals require large amounts of energy due to the intensity of their operations. The limited area available for storing containers as well as the ever-increasing need for time efficiency has interesting implications in the energy demands of the port as a system. This work examines the energy demands of in-port container movements for several common terminal layouts and equipment types with a particular focus on minimising energy requirements for horizontal transportation of containers in the yard subject to meeting volume handling requirements.

4 - Strategic Network Design in Maritime Container Industry
Panagiotis Angeloudis, Civil & Environmental Engineering Dept, Imperial College London, Centre for Transport Studies, Skempton Building, Rm 205, SW7 2BU, London, United Kingdom, pa01@ic.ac.uk, *Luciano Greco*, *Eleni Hadjiconstantinou*, *Michael Bell*

We consider an essential model in which two symmetric and profit-maximizing firms compete in a shipping industry characterized by a given map of ports, technology, and demand functions of container flows. The model is designed as a 4-stage information game: in the

first stage, firms simultaneously invest in their supply capacity, while the second stage deals with the design of firms' transport network. Network structure is addressed in the 3rd stage, while the ultimate stage deals with demand allocation based on the cost of links between ports. The game is solved by backward induction.

■ WB-64

Wednesday, 10:30-12h00
R18-3

Computation and Computational Design

Stream: Algorithm and Computational Design
Invited session

Chair: *Haldun Sural*, Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, sural@ie.metu.edu.tr
Chair: *Basak Akteke-Ozturk*, Department of Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, bozturk@metu.edu.tr

1 - Heuristic algorithms for the Critical Node Problem

Pierre Hosteins, Information Science, University of Torino, Corso Svizzera, 185, 10149, Torino, Italy, hosteins@di.unito.it, *Andrea Grosso*, *Roberto Aringhieri*, *Bernardetta Addis*

We consider the problem of deleting K>0 nodes, called "critical", from an undirected graph. The aim is to minimize the number of node pairs that are still connected by at least one path in the remaining graph. The problem belongs to the family of so-called interdiction problems and it has received significant attention in recent literature, together with other graph fragmentation problems. We present a computational study on the performances of several heuristic algorithms for the selection of critical nodes, and we discuss the effectiveness of intensification and diversification techniques.

2 - A Linear Formulation with Distance Variables for the Quadratic Assignment Problem

Serigne Gueye, UNIVERSITE D'AVIGNON CERI-LIA, France, serigne.gueye@univ-avignon.fr, *Philippe Michelon*

We present a formulation exploiting distance variables to solve the quadratic Assignment Problem (QAP). It involves a quadratic number of variables. It has been stengthened by some facets and valid inequalities, and numerically tested with QAPLIB instances whose distance matrices are given by the shortest paths in some grid graphs. For all instances the formulation provides competitive lower bound, in a fewer computational time, in comparison to other litterature techniques.

3 - Robust Optimization of Generalized Desirability Functions

Basak Akteke-Ozturk, Department of Industrial Engineering, Middle East Technical University, 06531, Ankara, Turkey, bozturk@metu.edu.tr, *Gerhard-Wilhelm Weber*, *Gulser Koksal*

We adjust the formulation of desirability functions and consider the generalized case having a piecewise max-type structure for solving their optimization problem by nonsmooth optimization approaches. This optimization problem is needed to be robustified because the regression may be done under lack of knowledge about the underlying model and scenarios or there can be noise in the data, and hence, the responses would be uncertain. We show on two examples how generalized semi-infinite programming and disjunctive optimization can be used for this purpose.

4 - Counting Inequivalent Monotone Boolean Functions

Tamon Stephen, Department of Mathematics, Simon Fraser University, 250-13450 102nd Ave., V3T 0A3, Surrey, British Columbia, Canada, tamon@sfu.ca, *Timothy Yusun*

The nth Dedekind number is the numbers of Boolean functions on n variables that are monotone in the sense that when x<=y, then f(x)<=f(y); values are only known only up to n=8. We consider the probelm of counting these functions up to equivalence via permutations of the variables, where values were known only up to n=6. We propose a strategy to count inequivalent MBF's by breaking the calculation into parts based on the profiles of these functions. As a result we are able to compute the number of inequivalent MBFs in 7 variables. The number obtained is 490013148.

■ WB-65

Wednesday, 10:30-12h00
R18-5

Quality Improvement

Stream: OR in Quality Management
Invited session

Chair: *Ipek Deveci Kocakoç*, Econometrics, Dokuz Eylul University Faculty of Economics and Administrative Sciences, Dokuz Eylul Universitesi Ikt.Id.Bil.Fak., Buca, 35160, Izmir, Turkey, ipek.deveci@deu.edu.tr

1 - Lean is "in" for financial service companies, but not really "within"

Michael Leyer, Frankfurt School of Finance & Management, Germany, m.leyer@fs.de

Lean thinking is important for a successful implementation of process-driven changes. Results from a questionnaire with 3.624 employees from financial service institutions not only reveal that there is a moderate lean thinking in these companies. We rather observe a "lean fata morgana'. Employees in general believe they are leaner than their actual behaviour discloses. Managers perceive their work environment leaner than subordinates do. At the same time, managers do not behave lean as they spend almost a third of their working time with operational work instead of guiding the employees.

2 - An opportunistic maintenance policy for components in complex systems under condition monitoring

Hao Peng, Eindhoven University of Technology, 5600 MB, Eindhoven, Netherlands, h.peng@tue.nl, *Qiushi Zhu*, *Geert-Jan van Houtum*

Due to the advanced sensor technologies nowadays, we can continuously monitor the degradation of critical components in complex systems to prevent the unexpected failures by employing condition-based maintenance (CBM) policies. How to coordinate different maintenance actions in the system becomes a challenging problem. In this research, we propose a new optimization model to determine the control limits of opportunistic maintenance for monitored components. Moreover, a case study on lithography machines in semiconductor industry is provided.

3 - An application of the DEA methodology to Bordeaux wine classifications

Tatiana Bouzdine Chameeva, OM and IS, BEM Bordeaux Management School, 680 Cours de la Liberation, 33405, Talence, France, tatiana.chameeva@bem.edu

The desire to give a hierarchy to wine properties in Bordeaux wine region goes back to centuries. Classifications were created to provide information on wine quality. Soils, technical processes used, aging period, differ. The goal is to evaluate the performance of five famous Bordeaux Grand Cru Classifications using the DEA methodology. The study reveals relative inefficiencies of certain classifications. On the basis of these results it will be possible to determine whether or not wine classifications are portrayed as a useful source of information for consumers and producers.

4 - ROC Analysis on Selection Problem of Solder Paste Inspection Machines

Ipek Deveci Kocakoç, Econometrics, Dokuz Eylul University Faculty of Economics and Administrative Sciences, Dokuz Eylul Universitesi Ikt.Id.Bil.Fak., Buca, 35160, Izmir, Turkey, ipek.deveci@deu.edu.tr, *Gokce Baysal*

Receiver operating characteristics (ROC) curves are useful for comparing classifiers performance. Solder paste inspection (SPI) machines for printed circuit boards (PCB) evaluate PCBs as "accept' or "reject'. Since false decisions in this process have a cost for the company, sensitivity is an important factor in the selection process of SPI machines. This paper aims to compare three SPI machines in terms of false decision which are false positive and false negative. After this evaluation, the most appropriate one will be recommended for buying.

■ WB-66

Wednesday, 10:30-12h00
R18-4

Sustainable Management for Resources, Conservation and Recycling III

Stream: Optimization for Sustainable Development
Invited session

Chair: *Sadia Samar Ali*, Operations Management, Fortune Institute of International Business , New Delhi - 110057, India, Plot No.5 Rao Tula Ram Marg, Opp Army R&R Hospital, Vasant Vihar, New Delhi - 110057, 201009, New Delhi, India, sadiasamarali@gmail.com

1 - Closed loop supply chain networks design in Presence of Distributed Generation(DG): Benders decomposition approach

Salman Khodayifar, school of mathematical, Institute for Advanced Studies in Basic Sciences(IASBS) Ghavazang, Zanjan, Iran, Islamic Republic Of, s.khodayifar@gmail.com, *Hassan Salehi Fathabadi*, *Mohammad Ali Raayatpanah*, *Hamed Rahimian*

Distributed Generation (DG) is an interesting topic that has drawn attention of distributed/production networks to itself in recent years.DG systems installed near customer zones.Such distributed generators are increased under effect of various policies like distribution loss reduction, distribution cost reduction,increase system reliability and reduction of energy buying from transmission line.In this paper, an approach based on Benders decomposition method is indicated for determining optimal locations,sizing and the service areas of DGs in closed loop supply chain networks.

2 - Are carbon footprint become a barrier trade for developing countries?

Mahmoud Nawar, Past deputy of Cotton Research Institute, 9 Gamma St,., Giza, Giza, Egypt, dr_nawar90@yahoo.com

Actually, Developing countries may be put a carbon footprint eco-label system as a barrier trade for these countries , because the cost of these system , the weak of environment systems and the level of technology, high cost of certification, measure and tests, training of workers, consumer press etc.. These systems needs the funds, training, etc., from the developed countries. Now ISO put standard of ISO 14067 which determine the guide for using carbon footprint system. The result is products has eco-label of carbon footprint prefer for import, export or consumed between developed countries

3 - Green vehicle routing problem with time windows

Asli Aksoy, Industrial Engineering, Uludag University, Muhendislik Mimarlik Fakultesi, Gorukle Kampusu, 16059, Bursa, Turkey, asliaksoy@uludag.edu.tr, *Seval Ene*, *Ilker Küçükoğlu*, *Nursel Ozturk*

In recent years, with the growing environmental concerns, industrial organizations must have to consider environmental factors to enhance the competitive aspect. Thus, efficient vehicle routing, which can lower fuel consumptions, has received considerable attention. The scope of this study is, developing a model which minimizes the fuel consumption for green vehicle routing problem with time windows (G-VRPWTW) and presenting results of computational applications to assess the performance of a model. Achieved results show that proposed model provides considerable reductions in fuel consumption.

4 - Distribution centers to improve the supply chain efficiency and sustainability of the system.

Elisabeth Freitas Rodrigues, CEFET/RJ, zzzzz, rio de janeiro, Brazil, efreitasr@uol.com.br, *Nelio D Pizzolato*

The retail chains have introduced distribution center (DC). The primary objective was to replace the role of the traditional distributor. However, beyond a certain scale of operation another objectives have been achieved, such as the improvement in the efficiency of the organization and the compliance with the increasing traffic problems which restrict the access of large trucks to urban retailers. This study seeks to measure the economic benefits brought by the DCs and its importance related to the overall sustainability of the system containing this support element.

■ WB-69

Wednesday, 10:30-12h00
R19-3

Humanitarian Logistics and Disaster Response

Stream: Stream of INFORMS Society for Public Programs, Service and Needs
Invited session

Chair: *Burcu Balcik*, Ozyegin University, X, X, Turkey, burcu.balcik@ozyegin.edu.tr

1 - Dynamic Team Deployment in Urban Search and Rescue

Elise Miller-Hooks, University of Maryland, Civil and Environmental Engineering Dept., Parkville, 20742, College Park, MD, United States, elisemh@umd.edu

An effective urban search and rescue response in post-disaster situations is crucial to saving lives and minimizing injuries. This talk will describe the development of optimization-based strategies for real-time deployment of international, federal, state and/or local USAR teams and will exploit a priori information (e.g., building inventories, building materials and use, fragility functions) and real-time remotely sensed pre- and post-disaster images of the impacted area, data from structural health monitoring systems, and rapid inspection results. Practical considerations will be addressed.

2 - Stochastic Optimization Models for the Last Mile Distribution Network Design Problem in Humanitarian Relief

Nilay Noyan, Manufacturing Systems/Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, nnoyan@sabanciuniv.edu, *Burcu Balcik*, *Semih Atakan*

We study a distribution network design problem, which determines the locations and capacities of points of distributions in the last mile network, while considering the uncertainties inherent in the chaotic post-disaster environment. Additionally, we consider equity and accessibility issues which are critical in designing last mile distribution networks. We develop two-stage stochastic programming models and conduct numerical analysis to evaluate the proposed alternative models. We discuss the practical implications of our results on a case study based on the 2011 Van earthquake in Turkey.

3 - The Post-Disaster Debris Clearance Problem with Incomplete Information

Melih Çelik, Industrial Engineering Department, METU, ODTU Endustri Muhendisligi, Bolumu Oda: 326 ODTU, 06531, Ankara, Turkey, celik@ie.metu.edu.tr, *Ozlem Ergun*, *Pinar Keskinocak*

Debris management is one of the most complicated activities among post-disaster operations. The debris clearance problem finds a clearance schedule for the roads so that benefit accrued by connecting relief supply and demand is maximized. We define a stochastic debris clearance problem with limited information. Information is updated as clearance activities proceed. We formulate a partially observable Markov decision process and propose heuristic approaches for solving the problem. We present the results of computational experiments regarding solution quality and computational time.

4 - A Continuous Approximation Approach for Assessment Routing in Disaster Relief
Burcu Balcik, Ozyegin University, X, X, Turkey, burcu.balcik@ozyegin.edu.tr, *Karen Smilowitz*, *Michael Huang*

In this paper, we focus on the assessment routing problem which routes teams to different communities to assess damage and relief needs following a disaster. We propose a continuous approximation approach which uses aggregated instance data to develop routing policies and cost approximations. Numerical tests are performed that demonstrate the effectiveness of the cost approximations at predicting the true implementation costs of the policies and compare the policies against more complex solution approaches.

■ WB-70

Wednesday, 10:30-12h00
R19-4

Ethics and OR II

Stream: OR and Ethics
Invited session

Chair: *Cristobal Miralles*, Depto. Organización de Empresas, Universidad Politecnica de Valencia, Cami de Vera s/n, 46022, Valencia, Spain, cmiralles@omp.upv.es
Chair: *Fred Wenstøp*, Strategy and Logistics, BI Norwegian School of Management, Nydalsveien 37, 0483, Oslo, Norway, fred.wenstop@bi.no

1 - Fairness in Modeling
Sven Diekmann, Philosophy & Ethics of Technology, Eindhoven University of Technology, P.O. Box 513, IPO 1.14, 5600 MB, Eindhoven, Netherlands, s.diekmann@tue.nl

In this paper I propose the overlapping design consensus. It is a mutual agreement among all stakeholders, based on fairness, for making decisions on the construction of models and the involved value choices. While it is commonly accepted that values do influence models, the discussion on which values should influence them is still going on. Furthermore, when building models, it is unclear who has legitimate authority to decide whether a model sufficiently addresses all problematic aspects: modelers, problem-owners, stakeholders? The overlapping design consensus settles these questions.

2 - The Role of System Thinking in Understanding and Fighting Terrorism
Giorgio Gallo, Informatica, University of Pisa, Largo B. Pontecovo, 2, 56127, Pisa, Italy, gallo@di.unipi.it, *Valentina Bartolucci*

Peace is one of today's most relevant ethical challenges, and OR can give a relevant contribution. Here, we claim that System Thinking, integrated by discourse analysis methodologies, is fundamental in analysing terrorism and in conceiving counter-terrorism interventions. In fact, terrorism cannot be understood outside a context, language and culture, and only within a systems perspective it can be fully grasped as a dynamic phenomenon. Without such a perspective, as it has happened in several cases which will be discussed, the risk of back-firing in counter-terrorism intervention may be high.

3 - Climate change: Righteous believers — righteous deniers
Fred Wenstøp, Strategy and Logistics, BI Norwegian School of Management, Nydalsveien 37, 0483, Oslo, Norway, fred.wenstop@bi.no

Science says that threatening climate change requires action now, but meaningful actions emerge only slowly. Deniers eschew actions, and believers in climate change sometimes support detrimental policies. The reason is that climate change is a new kind of challenge; a future threat we cannot see with consequences we cannot easily predict. Meaningful action requires a way of thinking, which can deal with models. But our righteous affective brain intervenes, which bases actions on "what you see is all there is'. This poses a fundamental challenge for operations research.

4 - Critical review of GRI and other indicators on people with disabilities
Cristobal Miralles, Depto. Organización de Empresas, Universidad Politecnica de Valencia, Cami de Vera s/n, 46022, Valencia, Spain, cmiralles@omp.upv.es, *Lourdes Canos*

The actual progress considering people with disabilities as stakeholder within the CSR paradigm seems to be conditioned not only by national regulations, but also by the local cultural and moral principles. Thus, to include heterogeneity in the manager's mindset when making decisions on the workforce, the business process, or the product design requires wider approaches and indicators. This additional complexity is analyzed starting by a critical review of the (scarce) related indicators of the Global Reporting Initiative (GRI), one of the most used frameworks for measuring sustainability.

■ WB-71

Wednesday, 10:30-12h00
R16-1

Health Care Management (Operating Rooms)

Stream: Health Care Management
Invited session

Chair: *Elena Tanfani*, Department of Economics and Business Studies, University of Genova, Via Vivaldi 5, 16126, Genova, Italy, etanfani@economia.unige.it

1 - A Simple Bicriteria Heuristic Approach for an Elective Surgery Scheduling Problem
Margarida Pato, CIO, University of Lisbon and ISEG, Technical University of Lisbon, Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, mpato@iseg.utl.pt, *Maria Eugénia Captivo*, *Inês Marques*

The healthcare sector in Portugal requires an efficient use of resources and the simultaneous reduction of waiting lists. This becomes of even higher relevance to the operating theatre unit of a hospital. A bicriteria surgery scheduling problem arising in a Lisbon hospital is presented. Two conflicting objectives are considered: maximize surgical suite occupation and maximize the number of surgeries scheduled. A constructive and improving heuristic specially designed to address both objectives of the problem was developed. Results obtained with real data from the hospital are presented.

2 - A cardinality-constrained robust approach for the Stochastic Surgical Case Assignment Problem
Giuliana Carello, Elettronica, Informazione e Bioingegneria, Politecnico di Milano, via Ponzio 347%, 20133, Milano, Italy, giuliana.carello@polimi.it, *Bernardetta Addis*, *Elena Tanfani*

We propose a cardinality-constrained robust optimization approach to tackle the Surgical Case Assignment Problem with uncertain surgery times, in which a penalty associated with waiting time and tardiness of patients must be minimized. The models have been tested on real life based instances. The impact of requiring different levels of robustness is analyzed. Further, we consider randomly generated realistic scenarios assuming lognormal distributions for surgery: the obtained robust solutions prove to behave well w.r.t. operating room utilization rate and number of rescheduled patients.

3 - The Dynamic Patient Admission Scheduling with Operating Room Constraints, Flexible Horizon, and Patient Delays
Andrea Schaerf, Dept. of Electrical, Mechanical and Management Engineering, University of Udine, Via delle scienze 206, 33100, Udine, UD, Italy, schaerf@uniud.it, *Sara Ceschia*

We propose and solve by local search a new variant of the Patient Admission Scheduling problem. The novelty consists in considering the dynamic version of the problem, which includes the stochastic arrival and discharge of patients (including urgent ones). In addition, we integrate constraints about the utilisation of operating rooms for patients

undergoing a surgery. This new problem has to include the complex management of delay of the patient admission, a flexible planning horizon, and new components of the objective function which take into account the utilisation of hospital resources.

4 - Multiobjective Optimization Models for Tactical and Operational Management of Operating Rooms
Rosita Guido, Department of Mechanical, Energy and Management Engineering, University of Calabria, Ponte Pietro Bucci, Arcavacata di Rende (CS), 87036, Rende, Italy, rosita.guido@unical.it, *Domenico Conforti*

Surgical planning and scheduling problems have a structural complexity, mainly due to the presence of several stakeholders, typically acting with conflicting interests. In this work, we propose a new approach for enhancing Operating Rooms efficiency and effectiveness by developing multi-objective optimization models and determine approximated Pareto frontiers by exploiting metaheuristics approaches based on genetic algorithms.The experimental validation of the proposed approach demonstrate that it could be a reliable and accurate base for the development of a manager decision support system.

■ WB-72

Wednesday, 10:30-12h00
R16-2

Health Care Scheduling

Stream: OR in Health & Life Sciences (contributed)
Contributed session

Chair: *Felipe Baesler*, Facultad Ingeniería, Universidad del Desarrollo, Av Sanhueza 1750, Concepcion, Chile, fbaesler@ingenieros.udd.cl

1 - Integrated Ambulance Scheduling and Rostering using a Flexible Job Shop Scheduling Problem Formulation
Claire Reeves, Mathematical Sciences School, Queensland University of Technology, 0617 Gardens Point Campus, GPO Box 2434, 4001, Brisbane, QLD, Australia, claire.reeves@student.qut.edu.au

Ambulance services operate in a resource constrained environment but must still provide responses to patients within time limits. We formulate a dynamic model for optimising integrated scheduling and rostering of ambulance crews. The primary objective minimises the number of ambulance crews while complying with fluctuating demand and crew rostering constraints. Secondary objectives minimise tardy responses and ambulance crew overtime. A flexible job shop scheduling technique is used to create the model. The validity of the model has been tested with a real life scenario.

2 - Fairness and cooperation in nurse rostering
Djamila Ouelhadj, Maths, University of Portsmouth, Lion Gate Building, PO1 3HF, Portsmouth, United Kingdom, djamila.ouelhadj@port.ac.uk, *Simon Martin*, *Pieter Smet*, *Ender Özcan*, *Greet Vanden Berghe*

Nurse rostering is a real-world timetabling problem where there is interest in building fair nurse rosters rather than focusing on reducing the overall number of constraint violations. We propose a cooperative agent-based approach to tackle this problem. A series of computational experiments were conducted on a set of benchmark instances from Belgian hospitals with different choices of objective functions guiding the search towards an even distribution of constraint violations amongst nurses. The results show that this approach is indeed capable of generating high quality fair nurse rosters.

3 - Mobile Blood Collection Scheduling
Felipe Baesler, Facultad Ingeniería, Universidad del Desarrollo, Av Sanhueza 1750, Concepcion, Chile, fbaesler@ingenieros.udd.cl, *Cristian Palma*, *Macarena Lopez*

The mobile blood collection is an activity that has to be performed almost every day in some blood centres. This paper presents an integer programming model developed to help the decision makers of a regional blood centre in Chile in the mobile blood collection scheduling process. The model is composed of 16.000 binary variables and 30.000 constraints. The results showed that it is possible create an annual schedule that satisfies all the problem constraints increasing the number of blood donations up to 50%.

4 - Evaluation of the Smaller Variance First Rule in an Appointment System with Equally Spaced Appointment Times
Ahmad Reza Pourghaderi, Industrial & Systems Engineering, National University of Singapore, NUS, #09-37, Blk 14, 39 Prince George's Park, 118431, Singapore, Singapore, pourghaderi@nus.edu.sg, *Boray Huang*

We study the sequencing problem of patients with different exponential service rates to minimize the expected waiting time. Wang 1999 claimed that the optimal sequence is the descending order of the patient service rates. This result is consistent with the optimality of the Smaller Variance First Rule which is conjectured widely in the literature. We have provided counter examples to show SVFR may not be optimal and a reasonable explanation to support why we should not put the least uncertain patient first. A sufficient condition to ensure SVFR is not optimal for 4-patient problem is derived.

■ WB-73

Wednesday, 10:30-12h00
R16-3

Optimization and Planning for Natural Resources

Stream: OR in the Oil and Gas Sectors
Invited session

Chair: *Vadim Strijov*, Russian Academy of Sciences, Computing Center, Vavilova 42-268, 119333, Moscow, Russia, Russian Federation, strijov@ccas.ru

1 - Long-term planning for an underground mine
Michel Gamache, Mathematics and Industrial Engineering, École Polytechnique de Montréal, P.O. Box 6079, Station Centre-Ville, H3C 3A7, Montréal, Quebec, Canada, michel.gamache@polymtl.ca, *Jean Collard*

In this presentation, we will present a model for long-term planning for Raglan Mine, a large nickel mining complex in the Nunavik region at the extreme limit of Northern Quebec, Canada. We will discuss the mixed integer linear programming model and the constraints that are related to the various operating characteristics of this mine. Results of solutions and strategies to reduce computation time will be presented.

2 - Optimisation of water systems with the use of or models and techniques
Ioannis Kaldellis, MECHANICAL ENGINEERING, TECHNOLOGICAL EDUCATIONAL INSTITUTE OF PIRAEUS, 250 P. Ralli and Thivon Av., 12244, Athens, Greece, jkald@teipir.gr, *Emilia Kondili*

In the present work an optimisation model is developed for the water systems planning that takes into account different water supplies and assigns priorities in the various water uses in order to be able to distribute the water in the most valuable way. The optimisation model is applied in the selected cases of the Aegean island region, results in an evaluation of the various water supply systems and also identifies the most efficient water distribution. The added value of the work is the exploitation of OR models for the solution of water systems optimisation problems.

3 - Optimal Power Flow DC with Overload Relaxation by Modified Logarithmic Barrier
Mayk Coelho, Science and Technology Institute, Federal University of Alfenas, Rua João Bueno Brandão, 155 - apto 31, 37701339, Poços de Caldas, Minas Gerais, Brazil, mayk.coelho@unifal-mg.edu.br, *Aurelio Oliveira*, *Anesio Santos*, *Anesio Santos*

The primal dual interior point methods when applied to optimal power flow problem with overloaded systems, may not achieve convergence. In order to eliminate these difficulties it is proposed a new barrier function, replacing the classical logarithmic barrier by a modified logarithmic barrier function. The new function expands the problem feasible region, allowing no interior and operationally acceptable solution to be obtained, enabling an optimal dispatch and avoiding blackouts. Computational tests are performed on the IEEE30 system and in Brazilian systems.

4 - Open-Pit Mine Optimisation

Amin Mousavi, School of Mathematical Sciences, Queensland University of Technology, Brisbane, QLD, Australia, a.mousavinogholi@qut.edu.au, *Erhan Kozan*, *Shi Qiang Liu*

In most open-pit mining stockpiles are designed to blend materials and to compensate for mill deficit. This paper develops a new block sequencing model for open-pit mines with machines, stockpile, precedence relationship and processing constraints. The size of industrial scale block sequencing problems is intractable for standard integer programming solvers. Therefore, a constraint programming technique is applied to solve the real-case applications. Computational results demonstrate that high quality solutions to large size problems can be obtained in a reasonable time.

■ WB-74

Wednesday, 10:30-12h00
R16-4

Additional educational activities for OR

Stream: Initiatives for OR Education
Invited session

Chair: *Olga Nazarenko*, National Technical University of Ukraine "Kyiv Polytechnic Institute", Mayakovskogo avenue 17v, apt.72, 02225, Kyiv, Ukraine, onazzzaro@gmail.com
Chair: *Kateryna Pereverza*, Students Science Association, National Technical University of Ukraine, Kyiv, Scherbakova str., 42/44, app. 54, Kyiv, Ukraine, pereverza.kate@gmail.com

1 - Teaching OR to a blind student

Laura Plazola Zamora, Metodos Cuantitativos, Universidad de Guadalajara, Periferico Norte 799 Modulo M 2do. nivel, 45100, Zapopan, Jalisco, Mexico, azucenadelrey@yahoo.com.mx, *Jose Luis Chavez - Hurtado*, *Sara Marín*

We studied the case of a blind student of human resources Career at the University of Guadalajara. The aim was to explore a teaching scheme through which the blind student can learn OR. We developed tactile material specially designed for the student to understand basic concepts of linear programming. Using Excel-Solver the student was able to model, solve the problem and interpret the results. Blind students form a small minority and as such their needs may not be so well known. Thus they require modified school practices in order to develop to their maximum capacity.

2 - Summer School as instrument for the OR-courses approbation

Kateryna Pereverza, Students Science Association, National Technical University of Ukraine, Kyiv, Scherbakova str., 42/44, app. 54, Kyiv, Ukraine, pereverza.kate@gmail.com, *Iryna Smolina*, *Dmytro Fishman*, *Alexis Pasichny*

Growing level of complexity and interdisciplinarity of modern scientific problems became well known issue among the researchers. Operational Research sphere is also affected by this trend. To solve the problem, more and more educational innovations and initiatives have to be developed within both regular and extended academic curriculum. As an example of initiatives for enhancing the academic programme, during the presentation we will discuss an experience of the international project Summer School AACIMP and its impact on OR development in the NTUU "KPI'.

3 - The experience of the summer school in Optimization and Decision Support Systems for Supply Chains

Giuseppe Bruno, Dipartimento di Ingegneria Industriale, Università Federico II di Napoli, Piazzale Tecchio n.80, I80125, Napoli, IT, Italy, giuseppe.bruno@unina.it, *Ana Amaro*, *Miguel Casquilho*, *Albert Corominas*, *Andrea Genovese*, *Juan Manuel Garcia Lopez*, *Amaia Lusa*, *Johan Magnusson*, *Henrique Matos*, *Joao Miranda*, *Sergio Rubio*

The second edition of the Summer School in Optimization and Decision Support Systems for Supply Chains wil held in Portalegre (PT) July, 8-20, within the Erasmus Intensive Programme. The main topic is focused on the opportunities of using optimization models and methods to tackle real problems related to the SC design and operations with a special concern to the green aspects. The audience is formed by MSc/PhD students on engineering and logistics specialties coming from many countries. We illustrate the past experience, the program of the current edition and the perspectives for the future.

4 - Smart skills for fragile times

Andrea Aparo, Sapienza, Ansaldo Energia; Sapienza, U. of Rome; Politecnico Milan, Ansaldo Energia SpA, Via N. Lorenzi 8, 16152, Genova, Italy, aparo@well.com, *Marco Fida*

Making better decisions in the real World using advanced analytical is what Operational Research is all about. But the real World is made of human beings, with their mix of ethics, values, beliefs, objectives, dreams, strengths and weaknesses. Analytical methods and stochastically behaving persons must be managed in an integrated way. To do that, humanities flavoured courses have been offered in the framework of the DISD Master Programme. Some of the peculiarities of the programme and courses will be presented, and their impacts commented.

Wednesday, 12:30-14:00

■ WC-02

Wednesday, 12:30-14:00
O1-2

Dynamics of continuous, discontinuous and discrete systems and applications

Stream: Continuous and Discontinuous Dynamical Systems
Invited session

Chair: *Duygu Aruğaslan*, Mathematics, Süleyman Demirel Üniversitesi, Süleyman Demirel University, Faculty of Arts and Sciences, Department of Mathematics, 32260, Isparta, Turkey, duyguarugaslan@sdu.edu.tr

1 - The center-focus problem for a non-smooth planar system with applications in real life
Duygu Aruğaslan, Mathematics, Süleyman Demirel Üniversitesi, Süleyman Demirel University, Faculty of Arts and Sciences, Department of Mathematics, 32260, Isparta, Turkey, duyguarugaslan@sdu.edu.tr

There exist several real phenomena modeled by non-smooth systems which switch between different vector fields in different modes. Hence, it is essential to develop the theory of systems with discontinuous right-hand sides. In this study, the center-focus problem in a non-smooth planar system is considered. It is shown that the results can be applied to real life processes in various fields.

2 - Qualitative analysis of a chemical reaction model with impulsive perturbations
Rezan Sevinik Adıgüzel, Mathematics, Selcuk University, 42075, Konya, Turkey, sevinikrezan@gmail.com, *Duygu Aruğaslan*

Many chemical reactions are subject to sudden changes and are affected by outside environment. In this context, we aim to investigate a chemical reaction model perturbed with variable time of impulses. We consider the dynamics of the model in the neighorbood of the equilibrium point. Based on the parameters of the model, we analyze the type of this equilibrium point and existence of periodic solutions. Also, numerical simulations are given to verify the theoretical results.

3 - Impulsive Expression in Chemical Master Equation and Stochastic Simulation Algorithms
Derya Altıntan, Selcuk University, Turkey, altintan@selcuk.edu.tr, *Vilda Purutcuoglu*, *Ömür Ugur*

The dynamic behaviors of biochemical systems can be described by two approaches, namely, the deterministic method that uses a system of ordinary differential equations (ODE) under steady-state conditions, and stochastic one that is derived by chemical master equations (CME). In theory the deterministic one applies impuls to include abrupt changes in states, but this is not considered in stochastic one. Here our aim is to insert impulses to CME and generate the systems by stochastic simlation algorithms. To assess our method we compare our results with those obtained under impulsive ODE.

4 - Spectral properties of a nonselfadjoint problem with the parameter in boundary conditions
Mevlüde Yakıt Ongun, Mathematics, Süleyman Demirel University, Suleyman Demirel University, Faculty of Arts and Science, Department of Mathematics, 32260, Isparta, Turkey, mevludeyakit@sdu.edu.tr

The Sturmian theory is one of the most actual and extensively developing field in theoretical and applied mathematics. We investigate the nonselfadjoint Sturm-Liouville boundary value problem in the limit-circle case with an eigenparameter generated by the differential equation with discontinuous coefficients and boundary conditions which contains not only end points of the interval, but also a point of discontinuity. Since the boundary conditions are nonselfadjoint, the approach is based on the use of the maximal dissipative operator.

■ WC-03

Wednesday, 12:30-14:00
O1-3

Bilevel facility location

Stream: Variational Inequalities and Bi-Level Problems
Invited session

Chair: *Yury Kochetov*, Information Technology, Novosibirsk State University, aven. Koptyuga, 4, 630090, Novosibirsk, Russian Federation, jkochet@math.nsc.ru

1 - Approximate algorithms for the bilevel facility location and pricing problem
Artem Panin, Novosibirsk State University, Novosibirsk, Russian Federation, arteam1897@gmail.com, *Alexander Plyasunov*

We consider the problem of decision making on the facility location and pricing as a Stackelberg-type leader-follower game. We assume that the facilities can charge the different prices and the objective is to maximize the overall revenue. It is known that the problem is NP hard in the strong sense even for the given facility location. We present a poly-approximate algorithm for this problem and a log-approximate algorithm for the pricing problem when the facility location is given.

2 - An alternating heuristic for the leader-follower facility location and design problem
Yury Kochetov, Information Technology, Novosibirsk State University, aven. Koptyuga, 4, 630090, Novosibirsk, Russian Federation, jkochet@math.nsc.ru, *Nina Kochetova*

Two players, a leader and a follower, open facilities and compete to attract clients from a given market. Each player has a budget and tries to maximize own market share. Each client splits own demand probabilistically over all opened facilities by the gravity rule. The location and design of the facilities are to be found so as to maximize the market share of the leader. We present a simple heuristic for this Stackelberg game based on the best response strategy. Computational results for the discrete games are discussed.

3 - Branch-and-Bound Algorithms for a Competitive Facility Location Problem
Vladimir Beresnev, Operation Research, Sobolev Institute of Mathematics, pr.Academica Koptyuga,4, 630090, Novosibirsk, Russian Federation, beresnev@math.nsc.ru

We study a mathematical model generalizing the well-known facility location problem. In this model we consider two rival sides sequentially placing their facilities and aiming to capture consumers, in order to make maximal profit. We state the problem as a bilevel integer programming problem and consider so-called optimal noncooperative solutions as optimal solutions. We propose a method for calculating an upper bound for the objective function on subsets of solutions and a branch-and-bound algorithm for finding the optimal solution of the problem.

■ WC-04

Wednesday, 12:30-14:00
O4-4

Convex Optimization Algorithms and Applications

Stream: Convex Optimization
Invited session

Chair: *Patrick Combettes*, Laboratoire Jacques-Louis Lions, 4, Place Jussieu, 75005, Paris, France, plc@math.jussieu.fr

1 - A Convex Variational Approach for Restoring Data Corrupted with Poisson-Gaussian Noise
Emilie Chouzenoux, Université Paris-Est Marne-La-Vallée, Bâtiment Copernic, 5, Bvd Descartes,, Champs sur Marne, 77454, MARNE LA VALLEE, France, emilie.chouzenoux@univ-mlv.fr

The Poisson-Gaussian (PG) model accurately describes the noise present in a number of imaging systems. However, most existing restoration strategies rely on approximations of the noise statistics. After establishing the Lipschitz differentiability and convexity of the exact, PG neg-log likelihood, we derive a primal-dual optimization algorithm for the reconstruction of images degraded by a linear operator and corrupted with PG noise. The proposed approach is validated on image restoration examples.

2 - Convergence of accelerated inexact forward-backward splitting algorithm
Silvia Villa, Istituto Italiano di Tecnologia, Italy, silvia.villa@iit.it, *Saverio Salzo*, *Luca Baldassarre*, *Alessandro Verri*

The forward-backward (FB) splitting algorithm is a first order method for composite function minimization. At each step, it requires the computation of a proximity operator. We propose a convergence analysis of accelerated FB methods, when the proximity operator is not available in closed form, and is thus approximated via an iterative procedure leading to a nested algorithm. We show that relying on an appropriate notion of approximations, convergence rates for the two-loops algorithm can be proved for a large class of approximation algorithms.

3 - A signal recovery by integration of the hybrid steepest descent method and the Moreau-Yosida regularization
Isao Yamada, Tokyo Institute of Technology, Japan, isao@sp.ss.titech.ac.jp

Each point in the solution set of nonsmooth nonstrictly convex optimization problems may differ too largely to ignore especially in the cases where the solution space is high dimensional, e.g., in image recovery applications. In this paper, to pick up a most desirable point among the solution set, we propose to use the hybrid steepest descent method for minimization of the Moreau envelope of convex functions over the fixed point set of nonexpansive mappings, e.g., Proximal Forward-Backward splitting operator, Douglas-Rachford splitting operator and Primal-Dual splitting operator, etc.

4 - Parallel-sum approximation of inconsistent common zero problems
Patrick Combettes, Laboratoire Jacques-Louis Lions, 4, Place Jussieu, 75005, Paris, France, plc@math.jussieu.fr

We consider the generic problem of finding a common zero of a family of maximally monotone operators acting on a Hilbert space. This problem models in particular convex feasibility problems and it has numerous applications. In many concrete instances, the original problem is inconsistent and must be approximated. We investigate a general approximation scheme based on parallel sums, which will be seen to capture various approximation methods. A parallel splitting algorithm will be proposed to solve this problem and several applications will be discussed.

■ WC-05

Wednesday, 12:30-14:00
O4-1

Optimal Control Applications 1

Stream: Optimal Control
Invited session

Chair: *Sebastian F. Walter*, IWR, Heidelberg University, Im Neuenheimer Feld 368, 69120, Heidelberg, Germany, sebastian.walter@iwr.uni-heidelberg.de

1 - Universal boomerang in Newtonian aerodynamics
Sergey Kryzhevich, Department of Mathematics, University of Aveiro, Campus Universitário de Santiago, 3810-193 , Aveiro, Portugal, kryzhevicz@gmail.com, *Alexander Plakhov*

We consider a 2D motion of a disk in a rarified media. Assume that the local structure of the boundary of the disk (so-called roughness) is invariant with respect to some small rotations. The rough structure can affect the dynamics of the center of the disk. This is the Magnus effect, well-known in gas dynamics. We show that this effect can be controlled, i.e., it is possible to select an arbitrarily small roughness (in the sense of Hausdorff distance) and take initial values of the dynamics so that the trajectory of the center of the disk approximates any initially selected curve.

2 - Mixed Integer Optimal Control Problems with switching costs
Konstantin Palagachev, Institute on Mathematics and Applied Computing, University of the Federal Armed FOrces at Munich, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, konstantin.palagachev@unibw.de

We investigate Mixed Integer Optimal Control Problems with a switching costs term. This problem class contains continuous and discrete valued controls. The switching cost term measures the cost of a switch in the controls and it can be used to penalize frequent switches In addition, we consider constraints depending on both, discrete and continuous controls. Finally we present numerical results for an aircraft landing model in which a smooth behavior of the controls is crucial for the aircraft's stability and passenger's comfort.

3 - Control of Movements for Solids in Multiphase Media
Dmitry Zavalishchin, Optimal Control, Institute of Mathematics and Mechanics UB RAS, S.Kovalevskoy str.,, 16, 620990, Ekaterinburg, Russian Federation, dzaval@mail.ru

To optimize the energy flow of solids in multiphase viscous media we study the problem an optimal control. Mathematical model describing the motion of a body in the form of a hybrid dynamical system is proposed. Necessary optimality conditions are deduced. The formalization of the optimal control problem allows us to apply the classical variational procedure and to obtain necessary optimality conditions in the form of Euler-Lagrange.

4 - Towards real-time experimental design of self-calibrating systems
Sebastian F. Walter, IWR, Heidelberg University, Im Neuenheimer Feld 368, 69120, Heidelberg, Germany, sebastian.walter@iwr.uni-heidelberg.de

We investigate the mathematical properties and challenges of real-time capable methods for online experimental design at the example of an ODE model of a quadrocopter in 2D. The model contains unknown parameters such as the max thrust force. An uncalibrated IMU estimates acceleration and speed of rotation. We report on preliminary results between an offline and online approach to optimally control the quadrocopter to calibrate both the sensors and the quadrocopter model.

■ WC-06

Wednesday, 12:30-14:00
O4-2

Large Scale Optimization for Industrial Design Problems

Stream: OR and Scientific Computing
Invited session

Chair: *Bela Vizvari*, Industrial Engineering, Eastern Mediterranean University, Gazimagusa, Mersin 10, Turkey, vizvaribela@gmail.com

1 - Large Scale Optimization for Industrial Design Problems
Bela Vizvari, Industrial Engineering, Eastern Mediterranean University, Gazimagusa, Mersin 10, Turkey, vizvaribela@gmail.com

Industrial design problems have to be solved only once. Any solution which is accepted by the design engineer has a long term effect. Therefore it has a great importance to solve these problems optimally. However, the mathematical models of the industrial design problems are in many cases large scale mixed integer programming problems which might be above the capacity of optimizers. This talk present methods how solvers can be used to obtain good/optimal solutions. Two examples are used: layout problem and chip design problem. Technical details are discussed, as well.

2 - Representing val it governance framework as metamodel
Ana Pajic, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Not Available, Serbia, ana.pajic@fon.bg.ac.rs, *Ognjen Pantelic*, *Nenad Ivezic*

Many empirical studies have shown that the business value from investment in IT projects can be greater than the one being currently achieved. Thus it calls for specific focus on IT governance in order to reach fusion between business and IT goals. The paper addresses a semantically rich metamodel of Val IT framework, which emerged as an answer to the problem of identifying the business value derived from investments in IT. It points out the necessity of comparing IT governance frameworks in order to complement the knowledge of different frameworks and meet the semantic integration challenges.

3 - Parallelisation of the Cluster Benders Decomposition method
LluisM Pla, Mathematics, University of Lleida, JaumeII,73, 25001, Lleida, Spain, lmpla@matematica.udl.es, *Francesc Solsona*, *Josep Lluis Lerida*, *Jordi Mateo*

The L-shape algorithm is a decomposition method used to solve stochastic linear problems via scenario analysis. This paper propose two parallelisations: the first one is the parallelisation of the classical algorithm of decomposition and the second one is the parallelisation of the Cluster Benders Decomposition proposed by Laureano et al.. This study presents a comparison between the computational costs of executing these algorithms in serial or in parallel mode. The final goal of this paper is to apply this technique in solving real cases with a minimal computational time.

■ WC-07

Wednesday, 12:30-14:00
O4-3

Polynomial Optimization

Stream: Copositive and Polynomial Optimization
Invited session

Chair: *Daniel Plaumann*, Mathematics, University of Konstanz, Fachbereich Mathematik, Fach D203, 78457, Konstanz, Germany, Daniel.Plaumann@uni-konstanz.de
Chair: *Miguel Anjos*, Mathematics and Industrial Engineering & GERAD, Ecole Polytechnique de Montreal, Montreal, Quebec, Canada, anjos@stanfordalumni.org

1 - Solving polynomial bilevel problems
Philipp Renner, Economics, University of Zurich, Moussonstrasse 15, 8044, Zuerich, Switzerland, philipp.renner@business.uzh.ch

Bilevel optimization problems are of interest in many applications. In economics the principal agent problem is amongst those models. In it, except in rare cases, the utility of the lower level problem is non convex. Thus the standard techniques from bilevel optimization do not apply. We present a way to solve those problems in case of a polynomial lower level. We use the techniques developed by Lasserre and Parrilo to relax the lower level into a convex optimization problem. We then solve it by non linear programming methods.

2 - Containment problems for polytopes and spectrahedra
Christian Trabandt, Discrete Math, Goethe University Frankfurt, Robert-Mayer-Str. 10, 60325, Frankfurt am Main, Germany, trabandt@math.uni-frankfurt.de, *Kai Kellner*, *Thorsten Theobald*

Spectrahedra are the feasible regions of semidefinite programs. In this talk we study the computational questions whether a given polytope or spectrahedron S_A (as given by a linear matrix pencil A(x)) is contained in another one S_B. Our results concern the computational complexity (extending results on the polytope/polytope-case by Gritzmann and Klee), as well as sufficient conditions to certify containment (whose study was initiated by Ben-Tal, Nemirovski and Helton, Klep, McCullough). We provide a semidefinite hierarchy based on moment relaxations to certify containment.

3 - Using column generation to improve the sum of squares representation of a polynomial optimization problem
John Mitchell, Math Sciences, Rensselaer Polytechnic Institute, 110 Eighth St, 325 Amos Eaton, RPI, 12180, Troy, NY, United States, mitchj@rpi.edu, *Tim Lee*

A sufficient condition that a polynomial be globally nonnegative is that it is representable as a Sum-of-Squares. SOS representability can be determined using a semidefinite constraint. We describe relaxations of this SDP constraint that can be used to ensure nonnegativity for certain polynomials that are not SOS representable. These relaxations exploit the arithmetic mean-geometric mean inequality and can be represented as linear constraints in the dual to the SDP formulation.

4 - Lower Bounds for a Polynomial on a basic closed semialgebraic set using geometric programming
Mehdi Ghasemi, School of Physical & Mathematical Sciences, Nanyang Technological University, SPMS-04-14, 21 Nanyang Link,, 637371, Singapore, Singapore, mghasemi@ntu.edu.sg

We use a result of Hurwitz and Reznick and a result of Fidalgo and Kovacec to give a sufficient condition for a form to be a sum of squares. We apply this result to obtain a new lower bound f_gp for an even degree polynomial f, and explain how f_gp can be computed using geometric programming. We extend this method to obtain a lower bound for a polynomial over certain semialgebraic sets.

■ WC-08

Wednesday, 12:30-14:00
O3-2

Tutorial - D. Bertsimas

Stream: Invited Lectures - Keynotes and Tutorials
Tutorial session

Chair: *Fabio Tardella*, Department of Methods and Models for Economics, Territory and Finance, Sapienza University of Rome, Via del Castro Laurenziano, 9, 00161, Roma, Italy, fabio.tardella@uniroma1.it

1 - A computationally tractable theory of performance analysis in stochastic systems
Dimitris Bertsimas, Sloan School of Management, MIT, Massachusetts Institute of Technology, Bldg E53-363, 77 Massachusetts Avenue, 2139, Cambridge, MA, United States, dbertsim@mit.edu

Modern probability theory, whose foundation is based on the axioms set forth by Kolmogorov, is currently the major tool for performance analysis in stochastic systems. While it offers insights in understanding such systems, probability theory is really not a computationally tractable theory. Correspondingly, some of its major areas of application remain unsolved when the underlying systems become multidimensional: Queueing networks, network information theory, pricing multi-dimensional financial contracts, auction design in multi-item, multi-bidder auctions among others.

We propose a new approach to analyze stochastic systems based on robust optimization. The key idea is to replace the Kolmogorov axioms

as primitives of probability theory, with some of the asymptotic implications of probability theory: the central limit theorem and law of large numbers and to define appropriate robust optimization problems to perform performance analysis. In this way, the performance analysis questions become highly structured optimization problems (linear, conic, mixed integer) for which there exist efficient, practical algorithms that are capable of solving truly large scale systems.

We demonstrate that the proposed approach achieves computationally tractable methods for (a) analyzing queueing systems in the transient domain and queueing networks in the steady-state domain, (b) characterizing the capacity region of network information theory and associated coding and decoding methods generalizing the work of Shannon, (c) pricing multi-dimensional financial contracts generalizing the work of Black, Scholes and Merton, (d) designing multi-item, multi-bidder auctions generalizing the work of Myerson.

This is joint work with my doctoral students at MIT Chaithanya Bandi and Nataly Youssef.

■ WC-09

Wednesday, 12:30-14:00
O3-3

Sponsor - IBM 2

Stream: Sponsors
Sponsor session

Chair: *Paola Festa*, Dept. of Mathematics and Applications, University of Napoli Federico II, Compl. MSA - Via Cintia, 80126, Napoli, Italy, paola.festa@unina.it

1 - The Business of Business Analytics: An Operations Research Perspective
Brenda Dietrich, Mathematical Sciences, IBM TJ Watson Research Center, Route 134, 10598, Yorktown Heights, NY, United States, dietric@us.ibm.com

Big Data and Analytics have captured the attention of the business world, with each term being assigned various definitions and attributes. This talk will address the domain from an Operations Research perspective. The motivation and objectives of business users of analytics will be explored. Trends in data availability will be discussed, along with some examples of nascent business models arising in a data economy. The role of algorithms and computing in distilling patterns, trends and recommendations from the data will be discussed, along with the growing role for OR experts in the business of extracting value from data.

Brenda Dietrich is an IBM Fellow and Vice President. She currently leads the office of technology and strategy for the Business Analytics division of IBM Software Group. She led IBM Research's Mathematical Sciences and Business Analytics Strategy for more than 10 years, and has been active in applying operations research to business analytics for 30 years. She has a PhD in Operations Research and Industrial Engineering from Cornell.

■ WC-10

Wednesday, 12:30-14:00
G5-1

Wireless sensor networks 2

Stream: Telecommunications and Network Optimization
Invited session

Chair: *Andrea Raiconi*, Department of Mathematics, University of Salerno, Via Ponte Don Melillo, 84084, Fisciano, SA, Italy, araiconi@unisa.it

1 - Mixed Integer Linear Models for the Total Coverage Problem with Connectivity Constraint in Wireless Sensor Networks
Maher Rebai, LOSI, University of Technology of Troyes, Troyes, France, maher.rebai@utt.fr, *Hichem Snoussi*, *H. Murat Afsar*, *Faicel Hnaien*

The emerging wireless sensor networks (WSNs) technology provides an inexpensive and powerful means to monitor physical environments. The optimal sensor placement in WSNs should be carried out with coverage and connectivity as two important considerations. While coverage is a metric that measures the surveillance quality provided by a WSN, the connectivity offers a means for sensors to report their data to the sink. In our proposal, we address the problem of deploying wireless sensors to achieve both coverage and connectivity. We propose mathematical linear models to solve the problem.

2 - Load Balancing-based Clustering algorithm for wireless sensor networks
Nadjet Khoulalene, A/ MIRA university, 3 ED N 85 A, Bejaia, Algeria, khoulalene.nadjet@gmail.com

A fully distributed clustering algorithm has been proposed. Our work is distinguished by taking into account the heterogeneity of sensors. On the one hand, given the performances obtained by simulations, showing the reduction in the number of clusters formed from a single sensor (cluster-head). On the other hand, our proposal clearly shows a better distribution of energy, memorial and computational resources of the cluster-heads. This demonstrates the effectiveness of the cluster-head selection algorithm which improves load balancing inside the wireless sensors network.

3 - Routing and connectivity maintenance in the wireless sensor network
Abdelmalek Boudries, University of Bejaia, university of Setif, Algeria, Boumansour Cne Oued-Ghir W- Béjaia, Béjaia, Algeria, am_boudries@yahoo.fr, *Makhlouf Aliouat*, *Rabah Kassa*, *Mahdi Djelouah*

We propose an approach for the routing by taking account of the connectivity maintenance in the wireless sensor networks. Each node contains a weight calculated according to its remaining energy rate. During the routing if the transmitting node receives an update package of a node participated in the routing then it re-examines its routing way choice by comparing the weight of the updated routing way with the weight of the routing ways received at the time of its search of a way for the routing in its routing table. The suggested approach has shown its effectiveness by a scenario example.

4 - A new variant of the Maximum Lifetime Problem for Sensor Networks
Andrea Raiconi, Department of Mathematics, University of Salerno, Via Ponte Don Melillo, 84084, Fisciano, SA, Italy, araiconi@unisa.it, *Raffaele Cerulli*, *Monica Gentili*

Wireless sensor networks involve many real-world contexts. They are generally composed of a large number of devices that monitor the activities occurring on a given area. A critical issue is to maximize the network lifetime, where an obvious constraint is the duration of the sensor batteries. By switching between subsets of sensors that can cover the set of targets, the network lifetime can be significantly prolonged; this problem is widely studied in the literature. In this work we focus on a new variant of the maximum lifetime problem involving reliability issues and heterogeneous sensors.

■ WC-11

Wednesday, 12:30-14:00
G5-3

Competitive location

Stream: Location Analysis
Invited session

Chair: *Boglárka G.-Tóth*, Department of Differental Equations, Budapest University of Technology and Economics, Hungary, bog@math.bme.hu

1 - A new rule for tie breaking in customer's facility choice
Blas Pelegrin, Statistics and Operations Research, University of Murcia, Spain, pelegrin@um.es, *Pascual Fernandez*, *María D. García*

We consider the location problem for an entering firm when the customer chooses a facility with maximum utility to be served. In the location literature ties in maximum utility are broken by assigning a fixed proportion of customer demand to the facilities with maximum utility which are owned by the entering firm. In this paper we study the location problem assuming that customer demand is equally shared by all the facilities with maximum utility. A mixed integer linear programming formulation of the problem is given and a study with data of Spanish municipalities is also presented.

2 - The Huff versus the Pareto-Huff customer choice rule in competitive location
Pascual Fernandez, Statistics and Operations Research, University of Murcia (Spain), Spain, pfdez@um.es, *Blas Pelegrin*, *Julius Zilinskas*, *Algirdas Lančinskas*

In the Huff model the customer splits its demand among all competing facilities according to its attraction. We analyze this model versus the Pareto-Huff model in which the customer splits its demand among the facilities that are Pareto optimal. A competitive location problem on discrete space is considered in which an entering firm wants to locate a fixed number of new facilities for market share maximization when both Huff and Pareto-Huff customer behavior are used. A heuristic procedure is proposed to obtain the best solutions to the location models arising from each customer behavior.

3 - Solving a planar centroid problem with endogenous demand
Jose Fernandez, Estadistica e Investigacion Operativa, Universidad de Murcia, Campus de Espinardo, 30100, Espinardo - Murcia, Spain, josefdez@um.es, *Aranzazu Gila Arrondo*, *Juana López Redondo*, *Pilar M. Ortigosa*

A chain (the leader) wants to set up a single new facility in a planar market. A follower will react by locating another single facility. Both the location and the quality of the new leader's facility have to be found so as to maximize the profit obtained by the leader considering the future follower's entry. The patronizing behavior of customers is probabilistic and the demand varies depending on the attraction for the facilities. A two-level evolutionary algorithm proposed to cope with the problem is shown to be a reliable method, obtaining better results than other heuristic algorithms

4 - A competitive facility location model with muti-deterministic patronising behaviour of customers
Boglárka G.-Tóth, Department of Differental Equations, Budapest University of Technology and Economics, Hungary, bog@math.bme.hu, *Jose Fernandez*

We considered a scenario where several chains are present in a planar market and demand is concentrated at demand points with known locations and fixed buying power. Customers split their demand among the chains by patronising only one facility from each chain, the one with the highest utility, and the demand is split among those facilities proportionally with their attraction. We assume that attraction depends on the customer's view of the quality offered by the facility and its distance to it, through a gravitational or logit type model.

■ WC-12

Wednesday, 12:30-14:00
G5-4

Control with systems thinking I

Stream: Control Theory & System Dynamics (contributed)
Contributed session
Chair: *Julián Benavides*, Finance, Universidad Icesi, Cra 89 10-80, 760032, Cali, Valle, Colombia, jbenavid@icesi.edu.co

1 - Advances in Systems Thinking Approach to Knowledge Management.
Eleni Plastira, Dpt of Industrial Management & Technology, University of Pireaus, Department of Industrial Management & Technology University of Piraeus - 18534 Piraeus, GREECE, 18534, PIRAEUS, Greece, elplastira@hotmail.com, *Dimitrios Emiris*

In this work we present a combination of holons and FCMs to construct a hierarchical, multi-level adaptive model for the representation of corporate knowledge which encompasses expertise and dissemination issues; Organizational knowledge provides a synergistic advantage not replicable in the marketplace that supports business in attaining sustainability; the main guide to build the desired KM model has been the practice of systems thinking, which is a discipline for seeing the structures that underlie complex phenomena by recognizing patterns of change.

2 - Agency theory revisited a systems thinking approach
Julián Benavides, Finance, Universidad Icesi, Cra 89 10-80, 760032, Cali, Valle, Colombia, jbenavid@icesi.edu.co

Agency theory deals with conflicts of interest that influence how counterparties behave and have negative consequences for organizations. We use system dynamics to model the relationship between a manager and an owner. In one extreme case the manager is the owner, on the other the manager is just an employee. Manager's actions can be value enhancing or selfish, with long term consequences for firm survival and manager's payoff. The owner actions define the manager payment and the investment rate. The model is applied to a health services organization to minimize its conflict of interests.

3 - Comparison of several approaches for cyclic scheduling problems
Laurent Houssin, LAAS-CNRS, France, houssin@laas.fr, *Touria Benrahhou*

There is an increasing interest on cyclic scheduling. This kind of problems arise in many contexts such as robotics, manufacturing systems, or multiprocessor computing. This paper considers Cyclic Job Shop Problem (CJSP), which aims finding the tasks's processing ordre at each machine that maximizes the throughput. We present several approaches for the CJSP: two existing procedures and a new one. The first one is a well-known mixed integer linear formulation. We compare these three methods and report computational results.

4 - Exploiting the sparsity with optimal traffic flow control problem
Murat Engin Ünal, Istanbul Technical University, İTÜ Maçka Kampüsü, Beşiktaş İstanbul, 34367, Istanbul, Turkey, Turkey, unalm@itu.edu.tr

Optimal control of freeway traffic flow requires minimization of a function over a convex set. Some methods used to solve this problem require evaluation of gradient of the function. This calculation includes many matrix multiplications and some of the Jacobian matrices encountered are sparse. Since the formulation of the traffic flow problem depends on the neighboring variables, the sparsity is in the form of band matrices. Finding the optimal ordering of variables is an NP-hard problem. The aim of this study is to find a good ordering of the variables to reduce the bandwidth.

■ WC-13

Wednesday, 12:30-14:00
G5-5

Supply chain management

Stream: Traffic
Invited session
Chair: *Stefano Giordani*, Dip. Informatica, Sistemi e Produzione, Universita' di Roma 'Tor Vergata', Via del Politecnico 1, 133, Rome, Italy, giordani@disp.uniroma2.it

1 - Analysis and simulation of the Bullwhip Effect in a supply chain
Pasquale Carotenuto, Istituto per le Applicazioni del Calcolo "M. Picone", Consiglio Nazionale delle Ricerche, via dei Taurini 19, 00185, Roma, RM, Italy, carotenuto@iac.cnr.it, *Francesca Romana Cellucci*, *Stefano Giordani*

One of the most important problems in the coordination of the entire supply chain comes from the fact that the whole system, working on the basis of a future prediction, is strongly affected by unexpected changes in external demand and even small changes can lead to huge distortions in the management of supply to higher levels. This phenomenon is called "Bullwhip Effect". The study carried out has the purpose to analyze the occurrence of Bullwhip Effect varying the parameters of demand, but also to quantify it through a discrete event simulation model.

2 - Analysis of the production chain of alpaca fiber in the region of Puno, Peru
Gladys Maquera, Facultad de Ingeniería y Arquitectura, Universidad Peruana Unión, Salida Arequipa, km. 6. Chullunquiani, Psje. Alfonso Ugarte Mz C-1 Lt 14, Juliaca, Puno, Peru, nelidagladys@yahoo.com, *César Beltrán Castañón*

This research aims to analyze the structure and main function of the value chain of alpaca fiber (lama pacos) in the region of Puno, Peru. To obtain the information, processes and supply chain needs of the methodology used Business Process Model (BPM), identifying the links, actors and processes in the chain. The result of the analysis will identify the problems of the different stakeholders to develop strategies and guidelines that can generate positive effects in terms of the elements of value networks to increase competitiveness.

3 - Optimal design of process-inventory network considering partial backlogging
Gyeongbeom Yi, Chemical Engineering, Pukyong National University, San 100 Yongdang-Dong Nam-Ku, Building 5 Room 212, 608-739, Busan, Korea, Republic Of, gbyi@pknu.ac.kr

This study examines the shortage costs in a supply chain optimization model under the framework of a process-inventory network which is a general multistage system. A product shortage can be mitigated by advancing production/transportation or by purchasing a substitute product from a third party, as well as by a product delivery delay in the supply chain network. Optimal solutions that consider all means for recovering shortage are more complicated than the classical EOQ model with shortages. Three solutions are identified in this paper depending on the parametric range and variable bounds.

4 - An integrated approach in modeling and simulating production and transactional systems
Francesco Aggogeri, Department of Mechanical Engineering, University of Brescia, Via Branze 38, 25123, Brescia, Italy, francesco.aggogeri@ing.unibs.it, *Gian Mauro Maneia*, *Marco Mazzola*, *Angelo Merlo*, *Nicola Pellegrini*, *Nicola Venturi*

We propose a novel logic and approach in modeling and simulating manufacturing and transactional systems using DES tools. An adaptable and flexible DES-based parametric model is developed. The model is able to represent different industrial scenarios and it can be managed by end users without specific knowledge on simulation tools, saving time and avoiding training costs, modeling efforts and analysis. The study shows the whole roadmap and logic of the novel approach from the end user's data capture to simulation run. Acknowledgement to European Commission project COPERNICO (contr.229025-2).

■ WC-14

Wednesday, 12:30-14:00
G5-6

Hybridisation of Metaheuristics with AI Techniques

Stream: Hybridisation of Heuristic for Global Optimisation
Invited session

Chair: *Lhassane Idoumghar*, LMIA Laboratory and INRIA Grand Est, Université de Haute Alsace, 4 rue des frères lumière, 68093, Mulhouse, France, lhassane.idoumghar@uha.fr
Chair: *Julien Lepagnot*, Faculty of Sciences and Techniques, Université de Haute-Alsace, 4 rue des Frères Lumière, 68093, Mulhouse, France, julien.lepagnot@uha.fr
Chair: *Patrick Siarry*, LERISS, Université de Paris 12, 61 avenue du Général de Gaulle, CRETEIL, France, siarry@univ-paris12.fr

1 - Prediction Technique integrated into Particle Swarm Optimization Algorithm
Julien Lepagnot, Faculty of Sciences and Techniques, Université de Haute-Alsace, 4 rue des Frères Lumière, 68093, Mulhouse, France, julien.lepagnot@uha.fr, *Lhassane Idoumghar*

We propose to combine particle swarm optimization (PSO) with a prediction technique and a simplex algorithm. For each particle, a forward linear predictor is used to predict the future best position of the particle from its past best ones. The influence of the predicted position on the particle trajectory depends on the prediction error: the higher the prediction error is, the lower the influence is. The simplex algorithm is initialized with best particles and run if a stagnation criterion is satisfied. The efficiency of the proposed PSO variants is shown using BBOB 2012 benchmark functions.

2 - Optimal planning of weather radar networks using particle swarm optimisation
Redouane Boudjemaa, Department of Mathematics, University Mhamed Bougara of Boumerdes, Faculte des Sciences, Campus Sud, 35000, Boumerdes, Boumerdes, Algeria, rboudjemaa@umbb.dz

This work proposes a particle swarm optimization (PSO) approach for solving optimal placement problem of small low cost x-band weather radars. The objective is to minimise the number of radars while maximising the geographical coverage area. By taking in account terrain blockage regions, various combinations of radar networks are explored. The approach can serve as an analysis tool to assist meteorologist in the selection of future prime sites for the installation of weather radars. Results are classified with respect to coverage-based cost—benefit analysis.

3 - Cooperation of Evolutionary Algorithms and Interval Constraint Programming
Charlie Vanaret, ENAC, France, vanaret@cena.fr

Stochastic algorithms have demonstrated their abilities on nonlinear numerical optimization problems, while deterministic methods struggle to converge within a reasonable time. We present a cooperative algorithm exploiting the efficiency of Evolutionary Algorithms and the reliability of Interval Constraint Programming to achieve proof of optimality for deceptive functions that were up to now deemed as unsolvable. Our approach prevents premature convergence toward local optima and outperforms both deterministic and stochastic existing approaches.

■ WC-15

Wednesday, 12:30-14:00
G5-2

Berth and Crane Operations II

Stream: Container Terminal Operations
Invited session

Chair: *Ali Diabat*, Masdar Institute, United Arab Emirates, adiabat@masdar.ac.ae

1 - Modelling and Solving the Berth Allocation Problem under Availability Constraints
Eduardo Lalla Ruiz, Estadística, I.O. y Computación, University of La Laguna, Spain, elalla@ull.es, *Belen Melian Batista*, *Marcos Moreno-Vega*

The increasing demand for maritime transport as well as competitiveness among container terminals force terminal planners to efficiently reduce the operational costs through the suitable use of the port resources. The berths are key elements among these resources since their inefficient management gives rise to a poor port productivity. In this regard, delays arising from tides and restricted berths and ships schedules are undesirable operational issues difficult to handle by decision-makers. This work proposes a model and a solution approach for the berth planning under these circumstances.

2 - The continuous Berth Allocation Problem in a container terminal with multiple quays
Ramon Alvarez-Valdes, Statistics and Operations Research, University of Valencia, Faculty of Mathematics, Doctor Moliner 50, 46100, Burjassot, Spain, ramon.alvarez@uv.es, *Pablo Froján Abalo*, *Gerasimos Koulouris*, *Jose Tamarit*

This paper addresses the Berth Allocation Problem (BAP), the problem of allocating berth space and time for vessels in a continuous and dynamic container terminal with several quays. The objective is the minimization of the total cost service for all ships, waiting costs, delay costs and costs associated to the position in the quay. We have developed an integer linear model, a greedy algorithm based in priority rules and some metaheuristic procedures, including a Genetic Algorithm and a Squeaky Wheel algorithm. The computational results show the efficiency of the proposed algorithms.

3 - A Hybrid Algorithm for Quay Crane Scheduling Problem
Yusuf Yılmaz, Industrial Engineering, Pamukkale University, Turkey, yusufyilmaz@pau.edu.tr, *Osman Kulak*, *Mustafa Egemen Taner*, *Mehmet Ulaş KoyuncuoĞlu*

Due to oversea transportation which grows day by day, importance of container terminals (CTs) increase and CTs have to be managed effectively. Scheduling of quay cranes, which are one of three essential equipment used in terminals, has an important role in improving the terminal efficiency. In this study, we focus on minimizing the ship completion time. For this purpose, a mixed integer dynamic mathematical model is proposed to solve the quay crane scheduling problem. A hybrid algorithm is developed using genetic algorithm and Lin-Kernighan heuristics.

4 - Large Neighborhood Search for Container Stowage Planning
Dario Pacino, Transport, Technical University of Denmark (DTU), Bygningstorvet 116B, 2800, Kgs. Lyngby, Denmark, darpa@transport.dtu.dk

Over the past two decades, the demand for containerized transportation has seen a continuous increase. In order to satisfy this demand, shipping companies have deployed bigger container vessels, that nowadays can transport over 15,000 containers. This has made container stowage planning an hard and complex problem. Recent research has shown that many industrial size instances of this problem can be efficiently solved using MIP formulations. We wish to complement those results proposing a MIP based LNS approach providing solutions to those instances for which MIPs do not scale.

■ WC-16

Wednesday, 12:30-14:00
G5-7

Dynamic vehicle routing problems and Green Vehicle Routing problems

Stream: Routing Problems
Invited session

Chair: *Jose-Eugenio Leal*, Industrial Engineering, Pontifical Catholic University of Rio de Janeiro, R. Marques de Sao Vicente, 225. DEI. Gavea, 22453-900, Rio de Janeiro, RJ, Brazil, jel@puc-rio.br

1 - A Metaheuristic for Randomized Priority Search Algorithm with Memory for the Dynamic Vehicle Routing Problem with Time Windows
Sezgin Kaplan, Turkish Air Force Academy, Turkey, skaplan@hho.edu.tr, *Ahmet Herekoglu*

In this study, a dynamic vehicle routing problem with hard time windows (DVRPTW) is considered. The vehicle routing problem involve new requests arriving randomly during the service horizon for the initial request set. We propose a metaheuristic for randomized priority search with memory (MetaRaPS-m) for the DVRPTW. The MetaRaPS algorithm combines the construction and improvement mechanism with randomness. Furthermore, memory property is used to consider efficiently the best routes found so far. Finally, computational results are presented for test problems from Lacker's dynamic data set.

2 - A Particle Swarm Optimization for the Dynamic Vehicle Routing Problem
Yonca Erdem Demirtas, Quantitative Methods, Istanbul University-School of Business, Istanbul Üniversitesi İşletme Fakültesi Sayısal Yöntemler, Avcılar, 34851, İstanbul, Avcilar, Turkey, yncerdem@istanbul.edu.tr, *Erhan Ozdemir*, *Umut Demirtas*

The vehicle routing problems (VRP) are studied for many years. Real-world VRP problems may change with time dynamically. The Dynamic VRP (DVRP) differs from the static version in two ways; first, not all information relevant to the planning is known at the beginning of the process and second, information can change after the solution process begins. In this study the DVRP is examined and a Particle Swarm Optimization algorithm is proposed. The most known benchmarks are solved with the proposed algorithm and the results are compared with the previous employed methods in the literature.

3 - Algorithms for Dynamic Vehicle Routing Problems with Time Windows
Jose-Eugenio Leal, Industrial Engineering, Pontifical Catholic University of Rio de Janeiro, R. Marques de Sao Vicente, 225. DEI. Gavea, 22453-900, Rio de Janeiro, RJ, Brazil, jel@puc-rio.br, *Orivalde Soares da Silva Junior*

This work proposes algorithms to solve dynamic vehicle routing problems with time windows. In the dynamic problem, new customers can be assigned to vehicles during the execution of the routes. For the dynamic version six algorithms were proposed, based on the insertion procedure, nearest neighbor, ant colony optimization, random and sequential versions of variable neighborhood search methods. The computational results showed that the models were able to find very good or even the best known solutions to the benchmark instances used in the literature.

4 - Algorithms for the Green Vehicle Routing Problem
Giovanni Righini, D.T.I., Universita' degli Studi di Milano, Via Bramante 65, 26013, Crema, CR, Italy, righini@dti.unimi.it, *Angel Felipe*, *M. Teresa Ortuno*, *Gregorio Tirado*

We study a variation of the vehicle routing problem in which the transportation fleet is composed of electrical vehicles with limited autonomy in need for recharge during the execution of their duties. A battery recharge operation can be done in different ways with different technologies, implying different recharging time and cost. We generalize previously published models by also considering partial recharge, different recharge technologies and battery amortization cost. Preliminary computational results are reported on benchmark instances from the VRP literature.

■ WC-17

Wednesday, 12:30-14:00
G5-8

Optimization problems in the offshore wind industry

Stream: Maritime Transportation
Invited session

Chair: *Magnus Stålhane*, MARINTEK, 7491, Trondheim, Norway, magnus.stalhane@marintek.sintef.no

1 - A two-stage stochastic programming model for determining a vessel fleet to perform maintenance operations at offshore wind farms
Lars Magnus Hvattum, Dept of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, Sentralbygg 1, N-7491, Trondheim, Norway, lars.m.hvattum@iot.ntnu.no, *Hanne Merete Vefsnmo*, *Magnus Stålhane*, *Elin E. Halvorsen-Weare*, *Lars Magne Nonås*

This work considers an offshore wind farm that is gradually built and put in operation, and for which a vessel fleet is required to perform maintenance operations. The fleet is adjusted over time as the wind farm is extended. Preventive maintenance is performed according to a fixed schedule, but corrective maintenance occurs according to stochastic processes. Also considered as uncertain parameters are the wind and wave conditions. Computational results indicate the value of considering the uncertainty in the parameters, and give suggestions for how the fleet composition should be determined.

2 - Fleet size and mix for maintenance operations at offshore wind farms
Magnus Stålhane, MARINTEK, 7491, Trondheim, Norway, magnus.stalhane@marintek.sintef.no, *Lars Magne Nonås*, *Elin E. Halvorsen-Weare*

We present a fleet size and mix model to find the optimal vessel fleet to perform a pre-determined number of maintenance operations at far offshore wind farms. The maintenance operations are classified as either preventive or corrective, each of which is divided into several sub classes. Both new and existing fleet concepts are evaluated together with necessary infrastructure, such as offshore supply platforms and onshore supply bases. The model allows both for the possibility to buy vessels and to charter-in on short term contracts. Some preliminary computational results will be presented.

3 - The Offshore Wind Farm Array Cable Layout Problem – A Planar Open Vehicle Routing Problem
Joanna Bauer, University of Bergen, Norway, joanna.bauer@uib.no, *Jens Lysgaard*

In an offshore wind farm (OWF), turbines are connected to a transformer by cables which cannot cross each other. Finding the optimal cable layout thus amounts to a capacitated open vehicle routing problem with the additional constraints that the routes cannot cross each other. Using real-world OWFs as test instances, we optimize layouts by a hop-indexed integer programming formulation. We develop a heuristic for computing cable layouts based on the Clarke and Wright savings heuristic. It computes layouts on average only 2% more expensive than the optimal layout.

■ WC-18

Wednesday, 12:30-14:00
G5-9

Stochastic Modeling and Simulation V

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de
Chair: *Leonidas Sakalauskas*, Operational Research, Institute of Mathematics & Informatics, Akademijos 4, LT-08663, Vilnius, Lithuania, sakal@ktl.mii.lt

1 - The Simulation Design and Analysis of Distributed Systems: JAVA-RMI, CORBA and WEB SERVICES
Hassina Nacer, Department of computer science, University of bejaia, Universite A/MIRA de bejaia, departement d'informatique, targa ouzamour, 06000, Bejaia, Bejaia, Algeria, sino_nacer@yahoo.fr, *Adel-aissanou Karima*, *Djamil Aissani*

To achieve collaboration between heterogeneous enterprises, the interoperability is required and the integrated vision of a reference is needed. Several middleware are emerged for this purpose. However, quality of services becomes increasingly important to distinguish different criteria. In this paper, we introduce a performance analysis and simulation tools. We model the different middleware as queue networks to analyze their performances on a large scale. The discrete event simulation is used. To validate the proposed models, a simulation program based on Matlab has been developed.

2 - An Evaluation of Order Picking Strategies in a Picker-to-Part Warehousing System Using Simulation
Gonca Tuncel, Department of Industrial Engineering, Dokuz Eylul University, Tinaztepe Campus, Buca, 35160, Izmir, Turkey, gonca.tuncel@deu.edu.tr, *Gökçeçiçek Tuna TaŞoĞlu*

The aim of this study is evaluating and improving of the order picking system in a warehouse so as to minimize the order retrieval time while increasing the picking efficiency. Besides the critical factors such as storage assignment decisions and routing methods, replenishment problem of the storage areas, which is rarely addressed in previous studies, is taken into consideration. Alternative combinations of operating policies are evaluated by simulation. According to the experimental results, the best implementing policy which provides the shortest order retrieval time is determined.

3 - A Simulation Approach to the Light Pipe Packing Problem
Giovanni Lizarraga, FIME, UANL, Pedro del Alba s/n, Ciudad Universitaria, 66450, San Nicolas de los Garza, Nuevo Leon, Mexico, mac_lic@yahoo.com, *Tomas Salais*, *Jania Saucedo*

One of the main problems that pipe manufacturing and distribution companies have are those of distribution routes and load planning of their products. This problem is related with the circle packing into rectangles and circle packing into circles research. Since light pipes are cylindrical objects, they fall into this category. In common practice, the distribution of these types of products is done empirically, usually leading to unnecessary costs. A simulation approach is proposed in this working order to find better solutions to the light pipe-packing problem.

4 - Experiments in Making Simulations Faster with Multi Core Processors
Mark Elder, SIMUL8 Corporation, 141 St James Road, G4 0LT, Glasgow, United Kingdom, mark.e@SIMUL8.com

Unlike Distributed or Parallel simulations that are typically used to obtain faster results when running many simulation replications, this research wanted to look at how closely coupled processors, for example in Multi-Core machines, can be used to gain faster performance of single simulation runs. The paper reports the results of a large number of experiments using real industrial simulation models to try to discover the elements of the internal workings of discrete event simulation engines that can benefit from the simultaneous use of multiple processor cores.

■ WC-19

Wednesday, 12:30-14:00
G5-10

Hub Location 2

Stream: Hub Location
Invited session

Chair: *Sibel A. Alumur*, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu cad. No:43, Sogutozu, 06560, Ankara, Turkey, salumur@etu.edu.tr

1 - Multi-Period Hub Location and Hub Network Design Problems with Modular Hub Capacities
Yusuf Seçerdin, Industrial Engineering Department, TOBB University of Economics and Technology, Söğütözü Caddesi No:43, Söğütözü, 06560, Ankara, -, Turkey, yusufsecerdin@etu.edu.tr, *Sibel A. Alumur*, *Stefan Nickel*, *Francisco Saldanha-da-Gama*

In this study, we consider hub location problems in a multi-period setting. We include hub network design decisions and address both the single and multiple allocation capacitated hub location problems considering modular hub capacities. A mixed-integer programming formulation is proposed for each version of the problem. The objective of both of the models is to minimize total costs while determining the location of hubs, the capacities of the hubs, the allocations of demand nodes to the located hubs, which hub links to operate between the hubs, and the routes of flow for each time period.

2 - A memetic algorithm for the hub location-routing problem
Nathalie Bostel, Université de Nantes / IRCCyN, 44606, Saint Nazaire, France, Nathalie.Bostel@univ-nantes.fr, *Pierre Dejax*, *Mi Zhang*

In many logistic systems for less than truckload shipments, transportation of goods is made through collection/delivery tours to/from hubs concentrating flows in order to take advantage of economies of scale. The design of such a logistic network corresponds to the Hub Location Routing Problem. It consists in locating hub facilities, as well as defining both collection and distribution routes and inter-hubs flows. We present a generic MIP formulation of this problem and a solution method based on a genetic algorithm improved by some local searches. Computational experiments are presented.

3 - A Genetic Algorithm for the Uncapacitated Single Allocation Planar Hub Location Problem
Haluk Damgacioglu, Industrial Engineering, Middle East Technical University, Ankara, Turkey, hdamgacioglu@gmail.com, *Nur Evin Ozdemirel*, *Derya Dinler*, *Cem Iyigun*

Hub location problem is a location-allocation problem that determines the hub locations and assigns spokes to hubs so as to minimize flow and distance weighted cost in a network. In the planar hub location problem (PHLP), hub locations are determined in continuous space. In this study, a mathematical formulation and a genetic algorithm (PHLGA) to solve PHLP in reasonable time are proposed. PHLGA is compared with Weisfield algorithm and other heuristics for special settings of PHLP. Moreover, PHLGA results for the AP data set are also presented.

4 - Hub location and the design of capacitated intermodal hub networks with different service types
Saliha Altuntaş, Industrial Engineering Department, TOBB University of Economics and Technology, Sögütözü cad. No 43, 06560, Ankara, Turkey, saltuntas@etu.edu.tr, *Sibel A. Alumur*

We study hub location and hub network design problems considering different transportation modes and different types of vehicles to serve different service types. We propose a mixed-integer programming formulation of the problem. The aim of the model is to maximize total profits while determining the location of hubs, the allocation of non-hub nodes to hubs, which hub links to establish, and which vehicles to operate to route the demand for different service types between given origin-destination pairs. We use Turkish network data to solve the model by using the commercial solver CPLEX.

■ WC-20

Wednesday, 12:30-14:00
G5-11

Multimodal Public Transportation

Stream: Optimization in Public Transport
Invited session

Chair: *Chistos Zaroliagis*, Computer Engineering & Informatics, University of Patras, 26504, Patras, Greece, zaro@ceid.upatras.gr

1 - Computing Multimodal Journeys in Practice
Thomas Pajor, Karlsruhe Institute of Technology, Germany, pajor@kit.edu, *Julian Dibbelt*, *Daniel Delling*, *Dorothea Wagner*, *Renato Werneck*

We study finding multimodal journeys in transportation networks, including walking, driving, cycling, and schedule-based public transportation. A natural solution to this problem is to use multicriteria search, but it tends to be slow and to produce too many journeys. We propose algorithms to compute a full Pareto set and then score the solutions in a postprocessing step using techniques from fuzzy logic, quickly identifying the most significant journeys. We also propose several heuristics to find similar journeys much faster, making the approach practical even for large metropolitan areas.

2 - Applying Traffic Prediction Techniques to Improve Multimodal Route Planning
Dimitrios Tzovaras, Information Technologies Institute, Centre for Research and Technology Hellas, 6th Km Charilaou-Thermi Rd., Thermi, 57001, Thessaloniki, Thessaloniki, Greece, dimitrios.tzovaras@iti.gr, *Themistoklis Diamantopoulos*, *Ioannis Kasampalidis*, *Dionysios Kehagias*

Modern transportation networks are becoming increasingly diversified and complex. Identification of optimal routes in such networks is a complicated task, due to the constraints imposed by the heterogeneous modes of transportation. Traffic prediction provides accurate estimation about the traffic status of the transportation network on specific time moments. This paper demonstrates how traffic prediction information may be used for improving the quality of multimodal route planning. In our setting a set of known traffic prediction techniques are deployed and preliminary results are shown.

3 - Multimodal Route Planning - Modeling Issues and Recent Algorithmic Approaches
Julian Dibbelt, Karlsruhe Institute of Technology, 76137, Karlsruhe, Germany, dibbelt@kit.edu, *Thomas Pajor*, *Dorothea Wagner*

In this talk we give an overview of recent approaches to location-to-location route planning for multimodal networks consisting of timetable-based public transit, (unrestricted) walking, driving and cycling. We discuss modeling issues arising with each mode of transportation including specialties such as bicycle rental systems. We review recent algorithmic approaches to the problem such as preprocessing techniques that enable fast queries for interactive applications and conclude by discussing several open challenges.

4 - Multi-Modal Transportation under Uncertainty
Tobias Pröger, Institute of Theoretical Computer Science, ETH Zurich, Switzerland, tobias.proeger@inf.ethz.ch, *Katerina Böhmova*, *Matus Mihalak*, *Sandro Montanari*, *Rastislav Sramek*, *Peter Widmayer*

In multi-modal public transportation one searches for a fastest route from A to B, along with the used transfers. However, if an intermediate connection is delayed, subsequent connections may be missed and the travel time may be large. If delays appear frequently, one searches for robust yet quick routes. We present a novel approach to find robust paths, based on past delay snapshots. In our approach, we search for the set of r-approximate paths for each of the delay snapshots. We identify the value of r that is best for getting robust paths, assuming that the delay snapshots are typical.

■ WC-21

Wednesday, 12:30-14:00
G6-1

Machine Scheduling Problems 3

Stream: Scheduling
Invited session

Chair: *Oliver Braun*, Quantitative Methods for Business and Management, Trier University of Applied Sciences, Environmental Campus Birkenfeld, Germany, obraun@gmail.com

1 - Single processor scheduling with time restrictions
Oliver Braun, Quantitative Methods for Business and Management, Trier University of Applied Sciences, Environmental Campus Birkenfeld, Germany, obraun@gmail.com

We are given a set of jobs which are to be scheduled sequentially on a single processor. Given a particular permutation of the jobs, the jobs are processed in that order with each job started as soon as possible, subject only to the following constraint: No unit time interval is allowed to intersect more than a given number B of jobs. We carry out a classical worst-case analysis for this situation and show that any permutation of the jobs can be processed within a factor of 2-1/(B-1) of the optimum when B > 3. For the case B=2, the corresponding factor is 4/3. Both factors are best possible.

2 - The optimal number of used machines in a two-stage flow shop scheduling problem
Enrique (Tzvi) Gerstl, School of Business Administration, The Hebrew University, Mount Scopus, 91905, Jerusalem, Israel, enrique.gerstl@mail.huji.ac.il, *Gur Mosheiov*

We study scheduling problems with a major decision referring to the number of machines to be used. We focus on a two-stage flowshop, where each job is processed on the first (critical) machine, and continues to one of the second-stage machines. Jobs are assumed to have identical processing times and are processed in batches. A setup time is required when starting a new batch. We consider two objective functions: makespan and flowtime. In both cases, a closed form expression for the optimal number of machines is introduced, and a unique sequence of decreasing batch sizes is shown to be optimal.

3 - The research of the algorithm which was built for the polynomially solvable case of the NP-hard problem Lmax for single machine.
Igor Karpov, Laboratory 68, Institute of Control Sciences, Russian Academy of Sciences, Russia, Russia, Moscow, Profsoyuznaya, 65, Moscow, Russian Federation, karpov_sh33_yar@mail.ru, *Alexander Lazarev*, *Dmitry Arkhipov*

We consider the classical NP-hard scheduling problem Lmax for single machine. Polynomially solvable cases was found and an algorithm was constructed for them. We explore the possibility of using of this algorithm in other cases and the difference with the optimal schedule.

4 - Scheduling with agreement graph vs resource constraints
Mohamed Bendraouche, Faculty of Sciences, Saad Dahleb University, Route de Soumaa-Blida, Bp 270 Blida, 09000, Blida, Algeria, mbendraouche@yahoo.fr, *Mourad Boudhar*

In this work, two scheduling problems are addressed: scheduling with agreements (SWA) and resource-constrained scheduling. The main results obtained are: (a) In the case of two machines we have proved that the SWA problem is NP-hard when the processing times are either in 1,3 or in 2,3 even for arbitrary bipartite agreement graphs. (b) A polynomial result has been presented and some NP-hardness results have also been proved for the resource-constrained scheduling problem.

■ WC-22

Wednesday, 12:30-14:00
G6-2

Scheduling in Robotics and Manufacturing

Stream: Scheduling II
Invited session

Chair: *Alena Otto*, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de
Chair: *Liliana Grigoriu*, Operations Research, University Siegen, Germany, liliana.grigoriu@gmail.com

1 - New contributions to the Minimization of tool switches problem
Andreza Cristina Beezão, ICMC, University of São Paulo, Av. Francisco Pereira Lopes, 2020, Ap. 34 E, 13564-002, São Carlos, São Paulo, Brazil, andreza.beezao@gmail.com, *Horacio Yanasse*, *Franklina Toledo*

The minimization of tool switches problem (MTSP) consists on determining the processing order of a set of jobs, as well as the optimal loading of the tool magazine of the machine so that the total number of switches is minimized. In this work, we propose contributions based on the two best-known integer models for the MTSP. Computational experiments showed that this approach is promising.

2 - Efficient Job Insertion in Complex Job Shop Scheduling
Heinz Gröflin, Dept of Informatics, University of Fribourg, Bd de Pérolles 90, 1700, Fribourg, Switzerland, heinz.groeflin@unifr.ch, *Reinhard Bürgy*

In complex scheduling problems, we found job insertion to be valuable in devising constructive and local search heuristics and achieved new benchmarks in problems such as the No-Wait Job Shop and the Blocking Job Shop (without/with machine flexibility; with a rail-bound transportation). We present a new formulation of the job insertion problem which unifies various formulations used previously, examine neighbor insertion generation schemes, and give a strongly polynomial algorithm for finding an insertion minimizing the 1-makespan (lower bound on the makespan). Applications are also presented.

3 - Scheduling in Robotic Cells with Self-Buffered Robotic Cells
Hakan Gultekin, Industrial Engineering, TOBB-University of Economics and Technology, Endustri Muhendisligi Bolumu, TOBB Ekonomi ve Teknoloji Universitesi, Sogutozu Cad. No:43, 06560, Ankara, Turkey, hgultekin@etu.edu.tr, *Emine Gundogdu*

We consider a system consisting of 2 machines and a material handling robot. The robot has a buffer area on itself that moves with the robot. The problem is to schedule the robot moves that maximizes the throughput rate to produce identical parts. We first consider single and double capacity buffer cases and determine the regions of optimality for cycles that produce 1 part in a single repetition. For the infinite capacity buffer case, we define a new class of robot cycles and determine the regions of optimality for this class. We provide managerial insights on using robots with buffer space.

4 - Pure Cycles in Dual Gripper Robotic Cells
Ozden Dalgic, TOBB University of Economics And Technology, Turkey, oodalgic@etu.edu.tr, *Hakan Gultekin*, *M. Selim Akturk*

We consider a manufacturing cell with m identical machines and a material handling robot with 2 grippers. We assume the machines to be flexible enough to perform all the operations a part requires. This assumption leads to a new class of robot moves named pure cycles. We develop an algorithm that generates all feasible pure cycles. We consider the 2-machines case in detail and prove that there are 3 potentially optimal cycles among the huge number of cycles and determine the regions of optimality for these. We provide managerial insights for using 2-gripper robots in such flexible systems.

■ WC-23

Wednesday, 12:30-14:00
G6-3

Non-standard Optimization Methods and Applications 3

Stream: Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited session

Chair: *Jaroslav Ramik*, Dept. of Math. Methods in Economics, Silesian University, School of Business, University Sq. 1934/3, 73340, Karvina, Czech Republic, ramik@opf.slu.cz

Chair: *Martin Gavalec*, Department of Information Technologies FIM, University of Hradec Kralove, Rokitanského 62, 50003, Hradec Kralove, Czech Republic, martin.gavalec@uhk.cz

1 - Infinite Horizon Optimal Control Problems
Pavel Prazak, Dept. of Informatics and Quantitative Methods, University of Hradec Kralove, FIM, Rokitanskeho 62, 500 02, Hradec Kralove, Czech Republic, pavel.prazak@uhk.cz

A brief overview that involves infinite horizon optimal control problems in continuous time is presented. Such problems can be frequently found in economic dynamics models and especially in literature dealing with the economic growth. First, the analogy of necessary conditions as in Pontryagin maximum principle will be presented. Then some remarks on transversality conditions follow. The paper contains a few solved and illustrative problems as well with the purpose to better understand the abstract concepts. The work has been supported by the Czech Science Foundation project 402/09/0405.

2 - A Mann's type Method for Pseudomonotone Equilibrium Problems
Susana Scheimberg, COPPE/ Engenharia de Sistemas e Computação-Instituto de Matemática,COPPE/PESC-IM, Universidade Federal do Rio de Janeiro, Caixa Postal 68511,, Bloco H/319, 21941-972, Rio de Janeiro, RJ, Brazil, susana@cos.ufrj.br, *Paulo Sergio Marques Santos*

We propose an algorithm for solving Equilibrium Problems where the bifunction is pseudomonotone. The algorithm is based on a modified Mann scheme, using a reflection technique, given by Konnov, and a subgradient-type projection method. The projection is done onto suitable convex polyhedra. Convergence properties of the algorithm are established under few assumptions. Some numerical results are reported.

3 - Relevance of the membership functions type on forecasting performance of the multidimensional Takagi-Sugeno fuzzy inference systems
Danilo Bedoya Valencia, Ciencias de la Computación y de la Decisión, Universidad Nacional de Colombia, Medellín, Antioquia, Colombia, dabedoyava@unal.edu.co, *Juan David Velásquez Henao*

In multidimensional fuzzy inference systems (FIS) it is unknown which membership functions (MF) type can achieve high accuracy with parsimonious parameterization. The objective of this research is to compare empirically performance in forecasting of two multidimensional Takagi-Sugeno FIS, which differ only in MF type that employ, this in order to establish the contribution of the MF type on explanatory capacity of the model. Results show that MF type can enhance notably the structure of the model simplifying the computations and contributing to better forecasting performance.

4 - History of a dual parametric approach for solving fuzzy mathematical programming
Carlos Cruz Corona, DECSAI, Universidad de Granada, Spain, carloscruz@decsai.ugr.es, *Jose-Luis Verdegay*

The dual parametric approach was one of the most interesting idea for solving fuzzy mathematical linear programming problems. In this work, we present an historical view of this approach, their evolution for solving fuzzy quadratic problems and describe some of their applications to different problems.

■ WC-24

Wednesday, 12:30-14:00
G6-4

Workforce Scheduling and Routing

Stream: Timetabling and Rostering
Invited session

Chair: *Dorota Slawa Mankowska*, Martin-Luther-University Halle-Wittenberg, Grosse Steinstrasse 73, 06108, Halle, Germany, dorota.mankowska@wiwi.uni-halle.de

1 - The Home Health Care Routing and Scheduling Problem with Interdependent Services
Dorota Slawa Mankowska, Martin-Luther-University Halle-Wittenberg, Grosse Steinstrasse 73, 06108, Halle, Germany, dorota.mankowska@wiwi.uni-halle.de, *Frank Meisel*, *Christian Bierwirth*

Providing care to care-dependent people is shifted more often to Home Care Companies. The patients require certain services, which must be performed by qualified staff, preferably within a given time window. This problem is called the Home Health Care Routing and Scheduling Problem. It takes into account individual service requirements of the patients, individual qualifications of the staff and possible interdependencies between service operations. In this talk, we present a new mathematical formulation together with a powerful heuristic method based on a sophisticated solution representation.

2 - Multiskilled personnel scheduling in a shared distribution warehouse
Lars Eufinger, Institute of Transport Logistics, TU Dortmund, Germany, eufinger@itl.tu-dortmund.de, *Uwe Clausen*

In this talk we consider a multiskilled personnel scheduling problem in a shared distribution warehouse. In order to create a working schedule with minimal personnel costs, we present a mathematical optimization approach based on the given tasks, which require different skills of the employees. Therefore, it is necessary to determine when the tasks are processed wisely to find an optimal personnel schedule. To solve real-sized instances it is necessary to develop a fast heuristic solution approach. We present our optimization model and our heuristic with first results on real world test data.

3 - Workforce Scheduling and Routing Problem (WSRP)
J. Arturo Castillo-Salazar, University of Nottingham, United Kingdom, psxjaca@nottingham.ac.uk, *Dario Landa-Silva*

Workforce Scheduling and Routing Problems (WSRP) refer to the routing of employees requiring to perform job related activities at different locations within a day. Activities have predefined time-windows and necessitate specific skills. Employees' preferences are considered. We present WSRP features and the impact of some of them in the problem solution (number of employees and activities). In particular, we show results of applying a mathematical model from the literature to a set of real world WSRP scenarios which include home health care, engineers on field, security officers and home care.

4 - Solving the crew rostering with real instances on a commercial airline, using a simulated annealing algorithm
Lorena Pradenas, Ingeniería Industrial, Universidad de Concepción, Barrio Universitario, Concepción, casilla 160 C, correo 3, Concepción, 4070043, Concepción, Concepción, Chile, lpradena@udec.cl, *Víctor Parada*, *Claudio Henríquez*, *Claudio Henríquez*

In this study, we use a metaheuristic algorithm that generates the rostering, to be followed by the crew, for periods of one month and minimizing deviations concerning: flight times, allocated benefits and days off for each crew member and avoiding conflicts union and absences, among others. The algorithm was implemented and tested with real data of shift and crew belonging to a commercial airline of medium size. The solutions found are better quality of life for the crew and are obtained in less time with regards to the commercial tool currently in use in the airline.

■ WC-25

Wednesday, 12:30-14:00
G9-1

Fuzzy Systems - Industrial Optimization and Systems Planning

Stream: Fuzzy Optimization - Systems, Networks and Applications
Invited session

Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Informative data mining for continuous industrial processes based on a novel fuzzy hybrid learning algorithm
Zhi Bo Zhu, IBM China Research Lab., 201203, Shanghai, China, zhuzhibo@cn.ibm.com, *Feng Jin*, *Wen Jun Yin*, *Wei Wu*, *Ya Nan Zhang*

In continuous industrial processes, an important topic is how to select informative data with their corresponding labels for pattern construction, since data from different patterns are always mixed. This paper presents a novel fuzzy hybrid learning algorithm based on Fisher discriminant analysis and Fuzzy clustering. A maximal membership value based discriminant rule is also presented to construct patterns. Three performance indices are proposed to evaluate the information purification ability of the algorithm. The benchmark case study shows the feasibility and effectiveness of the algorithm.

2 - Fuzzy Cost Multiple Criteria Transportation Problem with Time Restriction.
Alexandra Tkacenko, Department of Applied Mathematics, Moldova State University, Mateevici str.60, MD-2009, Chisinau, Moldova, Moldova, Republic Of, alexandratkacenko@gmail.com

The multicriteria optimization problems with various fuzzy coefficients are the most important, because of its often applications in the managerial decision processes. In this paper is presented an interactive solving approach of the multi-objective transportation problem with fuzzy cost coefficients and time restriction. The approach minimizing the worst upper bound to obtain an efficient solution which is close to the best lower bound of each objective function, find iteratively at least one efficient solution for the multiple criteria transportation model for the certain time interval.

3 - On the fuzzy matrix games and their solution in mixed strategies
Pridon Dvalishvili, Computer Science, Tbilisi State University, University Str. 2, Build. 11, Tbilisi, Georgia, pridon.dvalishvili@tsu.ge

In practice, sometimes information is insufficient, and to name exact values of the elements of game matrix is difficult; there appears a need to express the elements of game matrix by fuzzy numbers. Sometimes it is possible to acquire a certain personal, psychological data about counterpart, which use in classical solutions does not occur. This logically leads to fuzziness of game. We consider mixed strategies for fuzzy games theory and some aspects of sensitivity and stability of a solution.

■ WC-26

Wednesday, 12:30-14:00
G9-7

Combinatorial Optimization and Applications I

Stream: Combinatorial Optimization I
Invited session

Chair: *Silvano Martello*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, silvano.martello@unibo.it
Chair: *Paolo Toth*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

1 - The Micks: A polynomial class of "strong" inequalities for the packing knapsack
Sunil Chopra, Managerial Economics & Decision Science, Northwestern University, 2001 sheridan road, 60208, Evanston, IL, United States, s-chopra@kellogg.northwestern.edu, *Sangho Shim*

We focus on the packing knapsack polytope and a group of inequalities called the Micks. These are polynomial in number but are strong in a variety of ways. They are strong as per Gomory's shooting experiment and hit a large fraction of random vectors from the origin. They are strong in that their absence significantly weakens the LP-relaxation in terms of the ratio of the optimal LP solution to the integer optimum. They are also strong in that their inclusion significantly speeds up branch-and bound.

2 - On cut generating sets and their use in mixed integer programming
Egon Balas, Tepper School of Business, Carnegie Mellon University, 15213, Pittsburgh, PA, United States, eb17@andrew.cmu.edu

A new paradigm for generating cuts in mixed integer programming (Balas and Margot, 2011) identifies a set Q of boundary points of a lattice-free polyhedron, such that the reverse polar of Q provides valid cuts. We discuss ways of producing such sets, compare the generated cuts to those belonging to known families and show that the new paradigm offers ways to generate deep cuts that can otherwise be generated only through several iterations of a standard procedure. We discuss possible ways to apply this approach, and discuss implementation aspects and some preliminary computational experience.

3 - Localized Local Branching
Emanuele Manni, Department of Engineering, University of Salento, via per Monteroni, 73100, Lecce, Italy, emanuele.manni@unisalento.it, *Gianpaolo Ghiani*, *Gilbert Laporte*

In this talk, we describe how the local branching algorithm can take advantage of the structure of a generic MIP problem, to make the search process more efficient, without any human analysis. In particular, we use unsupervised learning to cluster sets of entities originating from a MIP model. This clustering is then used to automatically identify regions of the search space containing the most promising solutions. Computational results on three well-known combinatorial optimization problems show that, on large instances, our procedure outperforms the original local branching algorithm.

■ WC-27

Wednesday, 12:30-14:00
G9-8

High-multiplicity scheduling problems

Stream: Combinatorial Optimization II
Invited session

Chair: *Yves Crama*, HEC - Management School, University of Liège, Rue Louvrex 14 (N1), 4000, Liege, Belgium, Y.Crama@ulg.ac.be
Chair: *Nadia Brauner*, G-SCOP - Grenoble, 46 av Felix Viallet, 38000, Grenoble, France, president@roadef.org

1 - A dynamic programming algorithm for scheduling flexible operations in a three-machine flowshop
Fatma Isler, TOBB University of Economics and Technology, Turkey, fisler@etu.edu.tr, *Hakan Gultekin*

We consider a 3-machine flowshop where, differently from classical flowshop scheduling, each part has a flexible operation that can be performed on either one of the machines. N identical parts are to be produced. With the objective of minimizing the makespan, the problem is to assign the flexible operations to one of the machines for each part. We develop a dynamic programming algorithm that solves the problem to optimality in pseudo-polynomial time. We then prove some properties of the optimal solutions so that, by using these, the running time of the algorithm is further improved.

2 - High-multiplicity scheduling with forbiden instants
Nadia Brauner, G-SCOP - Grenoble, 46 av Felix Viallet, 38000, Grenoble, France, president@roadef.org, *Christophe Rapine*

We want to schedule independent jobs on a single resource under a special unavailability constraint: a set of forbidden instants is given where no job is allowed neither to start nor to complete. We know that a schedule without idle time always exists if the number of forbidden instants is less than the number of distinct processing times appearing in the instance. We propose a strongly polynomial time algorithm for this case under a High Multiplicity encoding where the jobs are grouped in categories and for each category the processing time and the number of jobs (the multiplicity) are given.

3 - Parametrized complexity for single machine scheduling with forbidden start and completion times
Michaël Gabay, Laboratoire G-SCOP, 46 avenue Félix Viallet, 38031, Grenoble, France, michael.gabay@g-scop.grenoble-inp.fr, *Nadia Brauner*, *Christophe Rapine*

We consider a problem where tasks are independent and can neither begin nor end at some dates. The objective is to schedule the tasks on a single machine in order to minimize the makespan. This problem is NP-hard and does not belong to APX. We propose a fixed-parameter algorithm for a particular case of this problem. We show that this case is FPT even under High Multiplicity encoding.

4 - Just-in-time scheduling, balanced words, billiard words, apportionment and Cie.
Vincent Jost, Laboratoire d'Informatique, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, vjost@lix.polytechnique.fr, *Nadia Brauner*, *Yves Crama*

Given n types of products and associated demands d_1... d_n, each requiring one unit of time to produce, we seek a sequence of production as "regular and/or fair" as possible. For n=3 and d_1=3, d_2=2, d_3=1, two valid sequences are 121312 and 121321. There are many ways to define the regularity of a sequence, and the most appropriate one depends on the application context. We review those concepts and contexts, establish links among them, discuss complexity issues and examples showing how seducing axioms/algorithms such as coherence/Webster's method can be discarded in assembly line contexts.

■ WC-28

Wednesday, 12:30-14:00
G9-2

Stochastic programming applications

Stream: Stochastic Programming
Invited session

Chair: *Rüdiger Schultz*, Mathematics, University of Duisburg-Essen, Lotharstr. 65, D-47048, Duisburg, Germany, schultz@math.uni-duisburg.de

1 - Cutting-plane Decomposition Methods for Optimization Problems with Stochastic Order Constraints
Dimitri Drapkin, Mathematics, University of Duisburg-Essen, Forsthausweg 2, D-47057, Duisburg, Germany, dimitri.drapkin@googlemail.com, *Rüdiger Schultz*

We develop model equivalents and cutting-plane decomposition methods for optimization problems with stochastic order constraints induced by linear recourse models with either mixed-integer or continuous variables in the second stage.

2 - Stochastic Shape Optimization with Dominance Constraints
Rüdiger Schultz, Mathematics, University of Duisburg-Essen, Lotharstr. 65, D-47048, Duisburg, Germany, schultz@math.uni-duisburg.de

As a branch of PDE constrained optimisation under uncertainty, stochastic shape optimisation has emerged fairly recently. We illustrate, how shape optimisation of elastic bodies, quite naturally, leads to the two-stage setting of finite-dimensional stochastic programming. When assuming linearised elasticity and uncertainty given by a finite probability space, stochastic shape optimisation problems become numerically feasible. With accent on dominance constrained stochastic programs, we illustrate conceptional similarities with our computational results.

3 - Bilevel stochastic models of coordinated service provision with independent risk neutral and risk averse agents
Paolo Pisciella, Norwegian University of Science and Technology,, 7491, Trondheim, Norway, paolo.pisciella@iot.ntnu.no, *Alexei Gaivoronski*

We develop models for collaborative provision of advanced data services around a service platform operated by a service aggregator as a one leader/multiple followers Stackelberg game. The leader (service aggregator) decides the revenue sharing scheme that maximizes his profit, while followers (service providers) reach a Nash Equilibrium for provision of service components. The origin of risk is random demand. Two approaches are pursued: one being described by a finite number of scenarios and another based on the affinity with newsvendor problems.

4 - Selection of connectivity portfolio for cloud service provision under demand and connection quality uncertainty
Alexei Gaivoronski, Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz vei 1, 7491, Trondheim, Norway, alexei.gaivoronski@iot.ntnu.no, *Per Jonny Nesse*

We consider one possible business model for a network operator in cloud environment: brokering of cloud services and improving their quality by providing superior connectivity possibilities. This leads to portfolio selection problem where a cloud broker selects portfolio of connectivities by striking a balance between profit and risk of violating service level agreements and resulting dissatisfaction of users. Using stochastic optimization problem and real Internet measurements we show that portfolio of several connectivities of medium quality can substantially enhance the quality of service.

■ WC-29

Wednesday, 12:30-14:00
G9-3

Queueing Systems III

Stream: Stochastic Modeling / Applied Probability
Invited session

Chair: *Louiza Berdjoudj*, Mathematics, University of Bejaia, University of Bejaia ,StreetTargua Ouzemour, 06000, Bejaia, Laboratory LAMOS, Algeria, l_berdjoudj@yahoo.fr

1 - A Markov model for measuring service levels in non-stationary G(t)/G(t)/s(t)+G(t) queues
Stefan Creemers, IESEG School of Management, 59000, Lille, France, s.creemers@ieseg.fr, *Mieke Defraeye*, *Inneke Van Nieuwenhuyse*

We present a Markov model to approximate the queueing behavior at the G(t)/G(t)/s(t)+G(t) queue with exhaustive discipline and abandonments. The performance measures of interest are: (1) the average number of customers in queue, (2) the variance of the number of customers in queue, (3) the average number of abandonments and (4) the virtual waiting time distribution of a customer when arriving at an arbitrary moment in time. An efficient, iterative algorithm allows the accurate analysis of small- to medium-sized problem instances.

2 - Estimating the Sensitivity of Rare Events via the Malliavin Calculus
Michael Zazanis, Statistics, Athens University of Economics and Business, 76 Patission str., 10434, Athens, Greece, zazanis@aueb.gr

We consider the problem of estimating the sensitivity of the expectation of functionals of stochastic differential equations, and in particular the probability of rare events, with respect to parameters using the techniques of the Malliavin calculus. A number of different estimators obtained in this fashion are compared in terms of their variance. Applications in risk and queueing processes are given and numerical results are presented.

3 - Approximate solutions to time-dependent queues
Jeff Griffiths, Mathematics, Cardiff University, MATHEMATICS INSTITUTE CARDIFF UNIVERSITY, SENGHENNYDD ROAD, CF24 4AG, CARDIFF, United Kingdom, griffiths@cardiff.ac.uk

There have been large numbers of publications over many years attempting to find analytic, numerical, or approximate solutions to queueing systems where the parameters are time dependent, with little success. In situations with high levels of congestion, it frequently occurs that demand levels exceed capacity for periods of time. In such cases, steady state theory breaks down, resulting in predictions of infinite queue lengths and waiting times. This paper shows how to predict the "time lag" between the peaks of demand and queue length, together with the height of peak queue length.

4 - The Geo/G/1discrete-time retrial queue
Louiza Berdjoudj, Mathematics, University of Bejaia, University of Bejaia ,StreetTargua Ouzemour, 06000, Bejaia, Laboratory LAMOS, Algeria, l_berdjoudj@yahoo.fr

The present investigation is concerned with the analysis of Geo/G/1 discrete-time retrial queue. Using the embedded Markov chain which represents 'the number of customer in the orbit just after the nth service time completion', the necessary and sufficient condition of ergodicity and stationary distribution of the system states are derived. The main performance measures of this system are obtained.

■ WC-30

Wednesday, 12:30-14:00
G9-10

Graphs and Applications

Stream: Graphs and Networks
Invited session

Chair: *Cédric Bentz*, CEDRIC, CNAM, 75003, Paris, France, cedric.bentz@cnam.fr

1 - Generalizing Konig edge-colouring theorem to all graphs
Denis Cornaz, LAMSADE, Universite Paris-Dauphine, Pce Mal Lattre de Tasigny, 75016, Paris, France, cornaz@lamsade.dauphine.fr, *Nguyen Viet Hung*

Konig edge-colouring theorem (1916) states that, for any bipartite graph, the minimum number of matchings covering the edges is equal to the maximum degree of a vertex. We prove that, for any graph, the minimum number of ocm sets covering the edges is equal to the maximum degree of a vertex, where an ocm set is the vertex-disjoint union of odd cycles and one matching, and a graph is covered by collection of ocm sets if any edge is in the matching of some ocm set or in the odd cycle of at least two ocm sets.

2 - Minimal Blockers for the Chromatic Number of a Graph
Christophe Picouleau, CNAM, Laboratoire Cedric, 292 rue saint Martin, 75003, Paris, France, chp@cnam.fr, *Cristina Bazgan*, *Cédric Bentz*, *Bernard Ries*

Given an undirected graph and two positive integers k and d, we are interested in finding a subset of edges of size at most k to delete in such a way that the chromatic number in the resulting graph will decrease by at least d compared to the original graph. Such a set is called a minimum chromatic d-blocker. We investigate this problem in various classes of graphs (complete, split, threshold) and determine its computational complexity. In some of the polynomial-time solvable cases, we also give a structural description of a minimum chromatic d-blocker.

3 - Steiner Problems with Limited Number of Branching Nodes
Dimitri Watel, Computer Science, Supelec E3S, 3 rue Joliot Curie, 91192, Gif Sur Yvette, France, dimitri.watel@supelec.fr, *Dominique Barth*, *Cédric Bentz*, *Marc-Antoine Weisser*

Given an undirected graph, the k-Undirected Steiner Tree problem is to find a minimum cost tree spanning a specified set of k nodes. If this problem and its directed version have several applications in multicast routing, the modeling is not adapted anymore when the number of available branching routers (nodes with outdegree greater than 1) is limited. We introduce the (k,p)-Steiner Tree problems where the goal is to find an optimal steiner tree with at most p branching nodes. We study the complexity and approximability of various cases depending whether the parameters k and p are fixed.

4 - Decomposition Algorithms for Solving the Minimum Weight Maximal Matching Problem
Z. Caner Taşkın, Department of Industrial Engineering, Boğaziçi University, Bebek, 34342, İstanbul, Turkey, caner.taskin@boun.edu.tr, *Tinaz Ekim*, *Merve Bodur*

Given an undirected graph with a weight assigned to each edge, the problem of finding a maximal matching that has minimum total weight is NP-hard. We consider the problem on general graphs and formulate it as an integer programming problem. We also devise a decomposition algorithm based on a combination of integer programming techniques and combinatorial matching algorithms. Our computational tests on a large suite of randomly generated graphs show that our decomposition approach significantly improves solvability of the problem.

■ WC-31

Wednesday, 12:30-14:00
G9-11

MSOM iFORM Special Interest Group Stream II

Stream: MSOM iFORM Special Interest Group Stream
Invited session

Chair: *John Park*, Malaysia Institute for Supply Chain Innovation, Malaysia, jpark@misi.edu.my

1 - Value of Reverse Factoring in Multi-stage Supply Chains
Fehmi Tanrisever, Industrial Engineering, TU/e, Netherlands, f.tanrisever@tue.nl

We show how application of reverse factoring influences the operational and financial decisions of these firms. While some empirical work on reverse factoring exists within research literature, our model constitutes the first analytic treatment of the problem, using the value framework of financial theory. We show how the value of reverse factoring results from, and is conditioned by (1) the spread in external financing costs, (2) the operating characteristics of the supplier, including the implied working capital policy, and (3) the risk-free interest rate.

2 - A newsvendor perspective on value-based management: performance measurement and managerial incentives
Gerd J. Hahn, Assistant Professorship for Supply Chain Management, University of Mannheim, Schloss, Schneckenhof Ost, 68131, Mannheim, Germany, hahn@bwl.uni-mannheim.de, *Moritz Fleischmann*

Approaches for value-based management (VBM) are widely applied to measure performance with respect to shareholder value creation and to derive corresponding managerial incentive schemes. In this presentation, we examine Economic Value Added (EVA) as a prevalent VBM concept and use the well-known newsvendor model to analyze optimal order decisions for both shareholder and manager. A simple performance-based contract is applied to find conditions that incentivize the manager to act in the shareholder's best interest. Numerical analyses illustrate the analytical findings.

3 - Exchange-Rate Risk Mitigation, Production and Financial Hedging, and Predatory Pricing
John Park, Malaysia Institute for Supply Chain Innovation, Malaysia, jpark@misi.edu.my, *Burak Kazaz*, *Scott Webster*

This research investigates a firm's pricing, production planning, and financial hedging decisions under exchange-rate and demand uncertainty while complying with a Value at Risk. The paper makes three main contributions. First, it proves that production hedging is not only a legitimate scheme to maximize profits, but also an effective policy to reduce risk. Second, it shows that even a risk-averse firm can charge a selling price below its manufacturing cost. Third, while financial hedging adds value by reducing risk exposure of the firm, it cannot eliminate production hedging.

■ WC-32

Wednesday, 12:30-14:00
G8-1

Supply Network Dynamics and Disruption Management II

Stream: Supply Chain Optimization
Invited session

Chair: *Xiang Zhu*, Operations, University of Groningen, Nettelbosje 2, 9747 AE, Groningen, Groningen, Groningen, Netherlands, x.zhu@rug.nl

1 - Optimization models for Component Procurement and End-Product Assembly in Supply Chains Subject to Demand and Supply Uncertainty
Ramesh Bollapragada, College of Business, San Francisco State University, BUS 206A, 1600 Holloway Avenue, 94132, San Francisco, CA, United States, rameshb@sfsu.edu

Motivated by the established Trading Agent Competition (TAC-SCM) in Supply Chain Management (http://www.sics.se/tac) environment, the paper (i) presents new adaptive stochastic linear programming models and advanced algorithms to synchronize the procurement of components for assembly into end-products. (ii) provides strategic insight and guiding principles that help enterprises achieve this subject to competitive demand and supply uncertainty. The models are presented in the framework of Excel Spreadsheets.

2 - Modelling the risk management in logistics customs activity in an international supply chain
Elena Smirnova, Commerce and logistics chair, the Saint-Petersburg State University of economy, Sadovaya 21, 191023, Saint-Petersburg, Russian Federation, sam948@mail.ru

Main findings of this study display how cross-border logistics risk management leads to adecrease in negative impact while conducting customs activity by participants of international supply chain. In particular, the proposed approach improves the quality of customs agents services; it increases the level of Russian economic security in general. The article describes the main features of the modelling approach in the Customs sphere for the participants of an international supply chain.

3 - Make-to-Stock or Make-to-Order? Optimal Policies for Supply Strategies under Uncertainties
Xiang Zhu, Operations, University of Groningen, Nettelbosje 2, 9747 AE, Groningen, Groningen, Groningen, Netherlands, x.zhu@rug.nl

We consider a single-stage firm, facing the choice of make-to-stock (MTS) and make-to-order (MTO) supply strategy. For a supply system with a general demand process and an exponential processing time, we prove that a threshold policy is optimal, where the threshold only depends on the cost structure. Further, analytical and numerical results show that when demand uncertainty is high, the firm should follow the MTO strategy to be responsive to market while when the supply uncertainty is high, the firm should follow the MTS strategy to hedge the risk of breakdown and supply disruption.

■ WC-33

Wednesday, 12:30-14:00
G8-3

Lot-Sizing and Related Topics 4

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Bernardo Almada-Lobo*, Industrial Engineering and Management, Faculty of Engineering of Porto University, Rua Dr. Roberto Frias s/n DEIG, 4200-465, Porto, Portugal, almada.lobo@fe.up.pt

1 - Heuristic Methods for The Stochastic Lot-Sizing Problem Under The Static-Dynamic Uncertainty Strategy
Ali Cem Randa, Industrial Engineering, Middle East Technical University, ODTU Endustri Muhendisligi Bolumu, Oda 325, 06800, Cankaya/Ankara, Turkey, randa@metu.edu.tr, *Cem Iyigun*, *Mustafa Dogru*, *Ulas Ozen*

We consider a single-stage inventory system facing non-stationary stochastic demand in a finite planning horizon. The replenishment times are determined and frozen at the beginning of the horizon while decision on the exact replenishment quantities can be deferred until the replenishment time. We consider fixed, variable, holding and penalty costs, and upper/lower limits on order quantities. Finding optimal policy parameters based on dynamic programming requires an exponentially exhaustive search. Hence, we develop heuristics and evaluate their efficiency by numerical examples.

2 - A stochastic dynamic lot-sizing and routing problem
Maurizio Tomasella, Business School, University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, Maurizio.Tomasella@ed.ac.uk, *Roberto Rossi*, *Armagan Tarim*

We study a multi-period distribution network where many nodes face non-stationary random demand. Nodes are replenished by a single truck from a central depot. Minimum service levels have to be met and are stated as a maximum admissible probability of stock-out at each node. We consider a fixed cost for dispatching the truck, traveling costs among nodes/the depot, unit variable replenishment costs and unit inventory holding costs at each node. We minimize expected total transportation, inventory replenishment and holding costs. We discuss a certainty equivalent MILP formulation for our problem.

3 - Stochastic dynamic capacitated lot-sizing problem with setup carry-over
Timo Hilger, Department for Supply Chain Management and Production, University of Cologne, Universität zu Köln, 50923, Köln, Germany, timo.hilger@wiso.uni-koeln.de

A stochastic dynamic capacitated lot-sizing model with fill-rate constraint and setup carry-over is presented. According to the static-uncertainty strategy, it is assumed that all decisions concerning production quantities and time are made in advance for the entire planning horizon. The non-linear optimization model can be reformulated as solvable linear program by approximating the non linear functions of backlog and inventory with a series of piecewise linear segments. Numerical results are presented which demonstrate the quality and the cost saving potential of the solution procedure.

4 - EOQ heuristics for control of stochastic inventory systems
Ioannis Ganas, Dept. of Accounting, Technological Educational Institute (TEI) of Epirus, Psathaki, P.O. Box 169, 481 00, Preveza, Greece, ganas@teiep.gr, *Konstantina Skouri*, *Athanasios G. Lagodimos*, *Ioannis Konstantaras*

In this paper EOQ heuristics for control of inventory systems with stochastic demand are presented. Specifically EOQ type approximations applied as alternatives for the most commonly used inventory control policies: 1) the order quantity/reorder point, (r, Q), 2) the periodic review replenishment interval order up-to, (R, T), 3) the periodic review replenishment batch ordering (r, nQ, T), and 4) the (s, S, T). Comparisons of costs, incurred by using EOQ heuristics and those by using the above mentioned policies, indicate that EOQ heuristics give good solution even when demand is stochastic.

■ WC-34

Wednesday, 12:30-14:00
G8-4

Supply chains: Ordering / Supply chain practice

Stream: Supply Chain Planning
Invited session

Chair: *Nils-Hassan Quttineh*, Department of Mathematics, Linköping University, SE-581 83, Linköping, Sweden, nils-hassan.quttineh@liu.se

1 - Newsvendor Problem with Second Order Option and Transportation Cost

Gizem Sultan Nemutlu, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu Caddesi No:43, Sogutozu, 06560, Ankara, Select a State, Turkey, gnemutlu@etu.edu.tr, *Berrin Aytac*, *Kadir Ertogral*

This study tackles the Newsvendor problem with a second order option and transportation costs. The second order is given, if profitable, at the end of sale season to cover the backordered demand. Transportation costs are incurred for both orders. For the transportation costs we use both the less than truckload and truckload type cost structures. The problem is to determine the first order size that maximizes total expected profit from both orders. We analyze the structure of the problem under this setting and suggest solution approaches to find the optimal order quantity for the first order.

2 - An Assemble-to-Order System with New Generations of Components

Yat-wah Wan, Institute of Logistics Management, National Dong Hwa University, 1 Sec. 2, Da-Hsueh Road, Shou-Feng, 974, Hualien, Taiwan, ywan@mail.ndhu.edu.tw

A single-product assembly-to-order system needs to pre-order components of positive lead times before knowing the exact demand of the product. The selling price of the product, and the costs and the salvage values of the components are of known time sensitive functions. The problem is complicated by the possible launching of new generations of components, which, if actually launched, will have different price and cost functions from the existing ones. This study develops algorithms to determine the optimal ordering quantities and ordering times of components for the system.

3 - The Impact of Global Supply Chain on Product Quality: The Case of Boeing 787

Xin James He, Dolan School of Business, Fairfield University, 1073 North Benson Rd., 06824, Fairfield, CT, United States, xhe@fairfield.edu

This research investigates the impact of global supply chain on product quality by analyzing the Boeing 787 Dreamliner recent lithium-ion battery overheating incidents. Boeing 787, a new and complex product, has outsourced 70% of its parts and components with a redesigned supply chain strategy. The grounding of all 50 Boeing 787s by the FAA has touched the nerve of not only its quality concerns but also its global supply chain management strategy. We try to focus on how Boeing's aggressive supply chain strategy may have contributed to its quality and safety problems.

4 - Supply Chain Planning at a Chemical Process Industry

Nils-Hassan Quttineh, Department of Mathematics, Linköping University, SE-581 83, Linköping, Sweden, nils-hassan.quttineh@liu.se, *Helene Lidestam*

In this talk, we present an optimization model for the supply chain problem at Perstorp, a world-leading company within several sectors of the specialty chemicals market. A solution should consist of a production plan that accounts for production rates for all products, transportations of the products between facilities within the Perstorp company, and sales to contracted customers and to spot market customers. The mathematical model becomes a mixed-integer linear program that is solved using a rolling horizon approach.

■ WC-35

Wednesday, 12:30-14:00
G8-2

Emerging Issues in Automotive OR

Stream: OR Applications in the Automotive Industry
Invited session

Chair: *Thomas Volling*, Institute of Automotive Management and Industrial Production, Technische Universität Braunschweig, Katharienenstr. 3, 38106, Braunschweig, Germany, t.volling@tu-bs.de

1 - Efficient Solution Procedure for Supplier's Production Planning with Uncertain Advance Demand Information

Nobuyuki Ueno, Dept. of Management Information Systems, Prefectural University of Hiroshima, 1-1-71 Ujina-Higashi, Minami-Ku Hiroshima-City, 734-8558, Hiroshima, Japan, ueno@pu-hiroshima.ac.jp, *Koji Okuhara*, *Takashi Hasuike*

We model a supplier's production planning with uncertain advance demand information called 'Naiji' in automobile industries. It is formulated as a stochastic programming problem with an unfulfilled-order-rate constraint and linear production constraints. We propose a new procedure for yielding an approximate solution by using an indicator to evaluate unfulfilled-order-rate under the condition that inventory in two periods is correlated and that its correlation coefficient is unique and same. The procedure is available for planning a weekly master production schedule efficiently.

2 - Interval Arithmetic for Material Requirements Planning in Build-to-Order Car Manufacturing

Thomas Staeblein, Produktion und SCM, Technische Universität München, Arcisstr. 21, 80333, München, Germany, thomas.staeblein@gmail.com

Premium cars can be configured through the use of options (e.g. color, engine, interior equipment), resulting in a very large number of variations customers can actually order. This induces complex dependencies at the material level. We describe an approach for Material Requirements Planning by deploying the mathematical concept of interval arithmetic. We show how to triangulate different sources of information and verify the results with existing Boolean product descriptions. The approach showed an improved accuracy and reduced computational time for a real-world application example.

3 - Auction-based selling of residual capacities in BTO-automobile production with loss-averse customers

Andreas Matzke, Institute of Automotive Management and Industrial Production, Technische Universität Braunschweig, Katharinenstr. 3, 38106, Braunschweig, Germany, andreas.matzke@tu-bs.de, *Thomas Volling*, *Thomas Spengler*

We propose a mechanism to improve capacity utilization for product options at a BTO-automobile manufacturer. During car configuration, customers can choose a product option at a fixed price without any risk. Otherwise they can leave a bid in order to participate in an auction at the end of the selling period. The auction only takes place in the case of residual capacity for that option. Customers are loss-averse. They anticipate negative emotions of not winning the product option when deciding for the auction. We investigate effects on customer behavior and manufacturer profit.

4 - A Traffic Equilibrium Model with Paid and Unpaid Parking

Renger van Nieuwkoop, Management, Technology and Economics, ETH Zuerich, Centre for Energy Policy and Economics, Zürichbergstrasse 18, 8032, Zuerich, Switzerland, renger@vannieuwkoop.ch, *Thomas Rutherford*

This paper describes a traffic flow model with people searching for paid and unpaid parking. Agents' decision where to park reflects trade-offs between time (driving, search and walking) and money (parking fees or road tolls). The model is formulated as a mathematical program with complementarity constraints. The model is used to study the optimal design of policy instruments, taking into account the individual optimization of travel time. In contrast to most other formulations, there is no need for heuristic algorithms and complete enumeration of all possible paths in the network.

■ WC-36

Wednesday, 12:30-14:00
G7-1

Cutting and Packing 5

Stream: Cutting and Packing
Invited session

Chair: *Kelly Poldi*, Federal University of São Paulo (UNIFESP), Rua Talim, 330, 12231-280, São José dos Campos, São Paulo, Brazil, kelly.poldi@unifesp.br

1 - Bin-Packing with linear costs of bin utilization - Application to energy optimization in a data-centre
Hadrien Cambazard, Operations Research, G-SCOP, 46 avenue Felix Viallet, 38000, Grenoble, France, hcambazard@gmail.com, *Deepak Mehta*, *Barry OSullivan*, *Helmut Simonis*

EnergeTIC is a recent project gathering four companies (Bull, Eolas, Schneider Electric and UXP) for optimizing energy consumption in a data-centre. We study the problem formulation defined in the project and a key sub-problem: a bin-packing problem with linear costs of bin utilization. We review and extend known lower bounds for this variant of bin-packing. We present an extended LP formulation where the pricing problem involves a cost bin packing. Finally, we report upper bounds obtained with a large neighborhood search and show that the industrial benchmark can be solved to near optimality.

2 - Improved algorithms for Bin Packing Problems with Item Fragmentation
Alberto Ceselli, OptLab, Università degli Studi di Milano, Polo Didattico e di Ricerca di Crema, 26013, Crema, CR, Italy, alberto.ceselli@unimi.it, *Marco Casazza*

We consider a class of packing problems where items may be fragmented at a price. These arise in diverse application fields like logistics and telecommunications, and have been tackled in the literature with both approximation and mathematical programming techniques. We focus on the case of fragmentations minimization, assuming that a fixed number of bins is given and that splitting does not produce overhead; we present new models and algorithms, exploiting the structure of a suitable graph to reduce complexity. Experiments show that our approach outperforms previous ones from the literature.

3 - A Leftover-Oriented Dynamic Cutting-Stock Problem
Kelly Poldi, Federal University of São Paulo (UNIFESP), Rua Talim, 330, 12231-280, São José dos Campos, São Paulo, Brazil, kelly.poldi@unifesp.br, *Douglas Alem*, *Reinaldo Morabito*

This study develops a leftover-oriented optimization model to the dynamic one-dimensional cutting-stock problem that considers the possibility of large enough residual pieces meeting future orders. Basically, the mixed-integer program permits early production if it helps to reduce trim-loss and/or residual pieces whilst allowing a number of leftovers within a given range. Numerical experiments based on real data from an aircraft company will be discussed vis-à-vis typical myopic static procedures.

4 - A Non-Linear Programming Multi-Stage approach for the Nesting problem
Pedro Rocha, INESC TEC, Faculdade de Engenharia, Universidade do Porto, 4200-465, Porto, Portugal, pmonteirorocha@sapo.pt, *A. Miguel Gomes*, *Rui Rodrigues*, *Franklina Toledo*, *Marina Andretta*

The proposed approach to solve the Nesting problem is based on Circle Covering representation together with Non-Linear Programming (NLP) models to compute admissible piece placement positions, focusing on instances with free-rotations. A multi-stage approach allows large sized instances to be addressed. Improvements for Nesting problems can bring important benefits in several industrial areas.

■ WC-37

Wednesday, 12:30-14:00
G7-4

Multicriteria Decision Making and Its Applications X

Stream: Multicriteria Decision Making II
Invited session

Chair: *Erdem Kilic*, Business Administration, Yeditepe University, İnönü Mah. Kayışdağı Cad., 26 Ağustos Yerleşimi, Ataşehir, 34755 , Istanbul, Turkey, rdmklc@gmail.com
Chair: *José Rui Figueira*, Instituto Superior Tecnico, Technical University of Lisbon, Av. Cavaco Silva, Tagus Park, 2780 - 990 Porto Salvo, 2780 - 990, Lisbon, Portugal, figueira@ist.utl.pt

1 - Integration of Evamix and logarithmic fuzzy preference programming (LFPP) for Technology Selection
Saiedeh Sadat Ahangari, Tehran University, Iran, Islamic Republic Of, s.ahangary@ut.ac.ir, *Ehsan Khanmohammadi*

Technology selection is a challenging decision making domain. In this study, 5 major criteria for technology selection are derived from the literature and the criteria's weights are obtained by using a logarithmic fuzzy preference programming methodology (LFPP), then technologies are ranked based on weights. In this problem the criteria are quantitative and qualitative types so EVAMIX method which is able to rank alternatives without the conversion of qualitative data into quantitative data, is selected. Finally technology are ranked and the best manufacturing technology is selected.

2 - Modeling decision-maker preferences for assignments problems with neural networks
Wiem Tlig, methodes quantitatives, faculté des sciences économiques et de gestions de sfax, route de l'aéroport km 4.5 sfax, sfax, Tunisia, wiem0201@yahoo.fr

To resolve the assignment problems, it consists in adjusting the parameters through the training set and with decision-maker intervention; but usually it is difficult for the decider to expresses his preferences models. This is the reason to propose a model using neural networks for identifying a preference model. We also present a medical application. The classification's result is compared with the result obtained by another classification methods reported on the same data set, including multilayer perceptoron and discriminante analysis.

3 - Fuzzy outranking method for multicriteria assessment of services
Ana Carla Bittencourt Reis, Management Engineering, UFBA, Rua Aristides Novis, Num 02 Federacao, 40210630, Salvador, Bahia, Brazil, anacarlabr@yahoo.com.br, *Maisa MendonÇa Silva*

Services has occupied a prominent position in the world economy and some studies have been developed in order to assess their quality. MCDA (Multiple Criteria Decision Aiding) methods have been applied to a variety of problems involving a multiple criteria evaluation. However, evaluation of services brings with the question of subjectivity and imprecision of input data. Fuzzy analysis can handle this kind of problem. In this paper, we propose a fuzzy outranking method for multicriteria classification of the quality of services, taken into account the difficulty of assessment.

4 - Inverse Bin packing Problem with Multiple Qualitative Criteria
Eugenia Furems, Decision Making, Institute for System Analysis, 9, Prospect of 60 let Octyabrya, 117312, Moscow, Russian Federation, furems-em@mtu-net.ru

The problem of packing the maximum number of objects, estimated upon qualitative criteria, in the given set of bins is considered. It is required that for each non-packed object there are no packed objects less preferable to DM than the former one, in the place of which it could be packed subject to the bins' resource constraint. The problem solution begins with ordering the objects according to DM's preferences. FFD algorithm is applied with some modifications depending on a type of the objects' ordering. The performance of FFD is evaluated on the basis of its lexicographical optimum.

■ WC-39

Wednesday, 12:30-14:00
G7-3

Efficiency and vector optimization with applications

Stream: Vector- and Setvalued Optimization and Applications
Invited session

Chair: *Fabián Flores-Bazán*, Departamento de Ingeniería Matemática, Universidad de Concepción, Avda. Esteban Iturra S/N, Casilla 160-C, Casi 160-C, Concepción, Chile, fflores@ing-mat.udec.cl

1 - Saddle point conditions for cone constrained vector optimization problems
Giandomenico Mastroeni, Computer Science, University of Pisa, Largo B. Pontecorvo 3, 56100, Pisa, Italy, gmastroeni@di.unipi.it

By means of the image space analysis, saddle point conditions for a nonconvex cone constrained vector optimization problem (VOP) are investigated. Exploiting suitable Slater-type conditions involving the notions of relative interior or quasi-relative interior, various results concerning the existence of a saddle point are obtained. Such results generalize to the non convex case previous existing conditions in the literature. Finally, extensions to vector separation in the image space and related vector saddle point conditions are analysed.

2 - Multiobjective Problems and Improvement Sets
Lucia Pusillo, Mathematics, University of Genoa, Italy, via Dodecaneso 35, 16146, Genoa, Italy, Italy, pusillo@dima.unige.it

In classical real-valued optimization problems not always optimal points exists. Often one is content in describing approximate-optima. In the paper Chicco et al. 2011, a new idea of approximate multicriteria solutions based on special sets was introduced, called improvement sets. They express the view of the decision maker on what is substantially better. The concept was generalized to games in Pusillo et al. 2012. In this contribution I make a summary of the results obtained from the introduction of approximate solutions w.r.t. improvement sets arising from the first paper.

3 - Characterization of efficiency via scalarization with ordering sets without solidness
Fabián Flores-Bazán, Departamento de Ingeniería Matemática, Universidad de Concepción, Avda. Esteban Iturra S/N, Casilla 160-C, Casi 160-C, Concepción, Chile, fflores@ing-mat.udec.cl

Some production models in a finance economy require infinite dimensional commodity spaces where efficiency is defined in terms of an ordering cone having possibly empty interior. In this talk a characterization of the equality between efficiency and weak efficiency in infinite dimensional spaces without further assumptions like closedness or free-disposability, is presented.

■ WC-40

Wednesday, 12:30-14:00
Y12-1

DEA Applications III

Stream: DEA and Performance Measurement
Invited session

Chair: *Leonardo Fernando Cruz Basso*, Social Sciences, Universidade Presbiteriana Mackenzie, Av. da Consolação, 930, 01302-090, São Paulo, São Paulo, Brazil, leonardobasso@mackenzie.br

1 - Variable reduction for bank branch efficiency evaluation
Juha Eskelinen, Aalto University School of Business, 00076, Aalto, Finland, juha.p.eskelinen@aalto.fi

DEA is a common tool in bank branch efficiency evaluations. There are often too many outputs and inputs to discriminate the branches. Statistical techniques have been introduced to reduce variables. Approach of Jenkins and Anderson and Principal component analysis combined with DEA were tested with proprietary data from Helsinki OP Bank. These techniques suggest different returns to scale. Also importance of the banking services in evaluation differs significantly. Recognizing the implications of the variable reduction techniques is vital for the acceptance of an efficiency estimator.

2 - Likelihood Ranking of Decision Making Units
Markku Kallio, Aalto University School of Business, 00076, Aalto, Finland, markku.kallio@aalto.fi, *Merja Halme*, *Merja Halme*

Assume that input-output vectors represent a random sample of a multinormal distribution. Unlike in DEA we assume common prices and find maximum likelihood estimates for them. The profit based ranking criterion for each DMU is the likelihood that the random profit is at most the profit of that DMU. No assumption on the production possibility set is made. Return based ranking is defined similarly. The approach can be used parallel to DEA. We demonstrate both ranking methods and DEA resultsain case of 25 bank branches of Helsinki OP Bank.

3 - Data envelopment analysis approach for measuring the efficiency of a distribution companys' branches
Filiz Şenyüzlüler, Industrial Engineering, Zirve University, Zirve Üniversitesi Mühendislik Fakültesi, Kızılhisar Kampüsü 27260 Gaziantep, 27260, Gaziantep, Turkey, filissen@gmail.com, *Ömer Akgöbek*, *Mahmut Ermayasıl*

In this study, Data Envelopment Analysis is used to determine the relative efficiency of a distribution company's different branches in the same city considering yearlong data collected from each branch. The common variables were determined and the annual numerical data for these variables were acquired. Then, the gathered information was expressed as a linear programming model to calculate the efficiency score of each branch. Later, the linear programming models were solved separately and efficiency scores were measured. As a result, efficiency scores for each branch have been tested.

4 - Public bus passenger transportation company efficiency measurement of Sao Paulo city using the data envelopment analysis in 2011.
Leonardo Fernando Cruz Basso, Social Sciences, Universidade Presbiteriana Mackenzie, Av. da Consolação, 930, 01302-090, São Paulo, São Paulo, Brazil, leonardobasso@mackenzie.br, *Urbano Bueno Hernandes Jr*

The performance appraisal measures developed and applied at companies allow them to carry out self-assessments and to seek improvement plans, among others. One of the ways of seeking refinement is through the use of benchmarking, in which companies become involved in a learning system, comparing organizations or even sectors. Data Envelopment Analysis (DEA) can identify those, among several productive units, that are efficient and inefficient. An attempt was made to ascertain whether there is a relation between operationally efficient and financially efficient companies.

■ WC-41

Wednesday, 12:30-14:00
Y12-5

Environmental Applications

Stream: Decision Making under Uncertainty and Environmental Applications
Invited session

Chair: *Thomas Archibald*, Business School, University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, T.Archibald@ed.ac.uk

1 - Asset Management Modelling: An Example from the Water Industry
Thomas Archibald, Business School, University of Edinburgh, 29 Buccleuch Place, EH8 9JS, Edinburgh, United Kingdom, T.Archibald@ed.ac.uk

Scottish Water is responsible for the supply of clean water and the removal of waste water throughout Scotland. This requires the efficient management of large systems of assets many of which have very long lifecycles. A general approach to the problem using Markov decision process models will be presented. The practical challenges of using such a model, including data and computational issues, will be discussed. Finally a decomposition method for a simplified version of the problem will be developed.

2 - Long Term Asset Management in Water Industry Using Repeated Whittle Index Heuristics
Jake Ansell, Business Studies, The University of Edinburgh, 29 Buccleuch Place, EH4 1ET, Edinburgh, United Kingdom, J.Ansell@ed.ac.uk

Maintenance is a major cost for water companies, as for all utilities. There are many assets of diverse form including pipe networks, pumps, water and waste-water treatment plants and reservoirs. Developing single asset 'optimal' plans is not efficient in such circumstances and there is a need for multi-asset 'optimal' solutions. Within Scottish Water, a method based on the Whittle Index has been implemented. Consideration is given to repeated use of the Whittle Index Heuristic to develop the outcome space and hence determine stable long term asset plans.

3 - Modelling degradation of infrastructure network assets
Andrew Brint, Management School, Sheffield University, 9 Mappin Street, S1 4DT, Sheffield, South Yorkshire, United Kingdom, A.Brint@sheffield.ac.uk

The accurate prediction of asset conditions is an important element of any maintenance strategy for distribution networks. We investigate predicting future conditions by generating asset condition deterioration paths that can then be fitted to observations. The characteristics that we want from the generated deterioration curves are for the average curve to equal a specified curve, for the curves to have the desired spread about this curve and for the required amount of tracking i.e. the amount of crossing. We consider how to define tracking before analysing different generation approaches

4 - Managing the quality of returns in a product recovery system with uncertainty
Sarah Marshall, Department of Management Science, University of Strathclyde, G1 1QE, Glasgow, United Kingdom, Sarah.E.Marshall@strath.ac.uk, *Thomas Archibald*

Product recovery describes the process by which used products are returned to their manufacturers, before being sold on the original or a secondary market. The quality of returned goods is a significant issue as it can affect the type of recovery that is performed. This paper models a system in which returns are classified as either high or low quality and investigates two recovery strategies: only high quality returns, or high and low quality returns. A Markov decision process is used to obtain an optimal policy and compare the two strategies. Associated managerial implications are discussed.

■ WC-42

Wednesday, 12:30-14:00
Y12-3

Policy Analytics 3

Stream: Policy Analytics
Invited session

Chair: *Gilberto Montibeller*, Dept. of Management, London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.montibeller@lse.ac.uk

1 - Facilitated modeling for spatial decision processes
Valentina Ferretti, Department of Regional and Urban Studies and Planning, Politecnico di Torino, Viale Mattioli 39, 10125, Torino, Italy, valentina.ferretti@polito.it, *Gilberto Montibeller*

There is a growing need for participative processes in the environmental planning and decision-making context. In particular, spatial decision problems are complex due to multiple and conflicting objectives, presence of multiple stakeholders and uncertainties about impacts. In this talk we explore how facilitated modeling could support participative planning by considering best practices for spatial multicriteria evaluation along the key decision analytic phases (model structuring, preference elicitation, aggregation of partial performances, sensitivity analysis and overall communication).

2 - Decision aid for the assessment of health facilities
Brice Mayag, university Paris Dauphine, Place du Maréchal de Lattre de Tassigny, F-75775 , Paris cedex 16, France, brice.mayag@dauphine.fr, *Alexis Tsoukiàs*, *Michel Zam*

The assessment of health facilities is one of the most important public policy of our modern societies. In the context of multi criteria decision aid, we present how this type of problem can be modeled by a hierarchical model of criteria, and how it can be solved through the online software named "decision cloud".

3 - Using Systems Thinking to Undertake a Review of Child Protection in England
David Lane, BISA, Henley Business School, Whiteknights, RG6 6UD, Reading, United Kingdom, d.c.lane@henley.ac.uk

This paper concerns qualitative system dynamics. 'Child protection' activities and the circumstances that lead to the Department for Education's Munro Review are outlined. Two specific contributions are then described. First, a systems-based diagnosis of the 'prescription culture' that had grown up. Second, via group model building, the creation of a complex systems map showing unanticipated consequences and damaging feedback effects. This map gave shape to the range of issues the review had to address and provided an organising framework for the recommendations that were made.

4 - Defining urban development policies. A proposal of an assessment model.
Giovanna Fancello, Architecture, Design and Urban Planning, University of Sassary, Via Alessandrini n 9, 08022, Dorgali, Italy, Italy, gfancello@uniss.it

Urban quality of life is a challenge for urban planning. Poor areas are the places in the city where public policies to improve urban quality of life and support the individual development are mostly needed. Urban development policies within Sen's capability framework have to improve "urban capabilities" in poor areas. But how to identify an urban area as a poor one? And which policies answer to urban poor areas problems? In this paper I propose a model to define and assess public policies in poor urban contexts.

■ WC-43

Wednesday, 12:30-14:00
Y12-2

Decision Support, Policy-making & Decision Analysis

Stream: Decision Support Systems
Invited session

Chair: *Fatima Dargam*, SimTech Simulation Technology, Ries Strasse 120, 8010, Graz, Austria, F.Dargam@SimTechnology.com
Chair: *Isabelle Linden*, Departement of Business Administration, University of Namur, 8 rue Rempart de la Vierge, 5000, Namur, Belgium, isabelle.linden@fundp.ac.be

1 - A New Fuzzy Multi-criteria Decision Making Approach for supplier selection problem
Hacer Guner Goren, Department of Industrial Engineering, Pamukkale University, Kinikli Campus, Kinikli, Denizli, Turkey, hgoren@pau.edu.tr, *Osman Kulak*

In recent years, Axiomatic Design (AD) has been widely used as a multi criteria decision making approach. To evaluate alternatives in fuzzy environments fuzziness is included in the AD approach. However, these approaches are not suitable for decision problems having a hierarchy. Therefore Hierarchical Fuzzy Axiomatic Design Approach (HFAD) is presented to deal with this kind of problems. We extend HFAD to include risk factors for the first time in literature and propose a new approach. The application of the new approach is shown on a real world supplier selection problem.

2 - Water treatment evaluation for a plant using a hybrid method based on DEMATEL and ANP
Erdem Aksakal, Industrial Engineering, Gazi University, Gazi University Faculty of Engineering, Maltepe, 06570, Ankara, Turkey, eaksakal@gazi.edu.tr, *Metin Dagdeviren*, *Ihsan Yüksel*

Water is a natural resource and the basis of the life. Therefore it is one the most important thing for lifecycle. Nowadays with the rising of population density it is becoming a very limited resource in many cases. For the firms; except out of having enough water, some of them need to use the water with appropriate quality. Because of getting the water supply hard, firms try to have this necessity with different techniques. In this study we examine the water treatment method for a new plant.

3 - Using System Dynamics in Exploring Ecosystem and Policy-making Mechanism of Taiwan's Digital Content Industries
Pin-Chen Jiang, Department of Asia-Pacific Industrial and Business Management, National University of Kaohsiung, 700, Kaohsiung University Rd., Nanzih, District,, 81148, Kaohsiung, –, Taiwan, bobby00515@gmail.com, *Ting-Lin Lee*, *Chi-Cheng Huang*

The purpose of this study is to attempt to use system dynamics to explore the complex ecosystem and policy-making mechanism about the digital content industry in Taiwan, and then try to amend the policy direction of this system to enhance the performance in Taiwan. From the result of the simulation, it could be observed that in order to ensure the continuous increment of industrial scale and human resources, this study proposed two problems that need to pay attention to: 1.) the government must continue financial support, 2.) the supply and demand talents problem.

4 - Determining direct mailing policy with a decision support system
Rim Boudali, marketing, ESSEC, 3 rue abou zakaria el hafsi, 1089, Montfleury, Tunis, Tunisia, rym.boudali@actisecurity.com

Facing increasing brands competition caused by the fast changes in consumer demands and the influence of new communication technology, several firms used the direct marketing to save a profitable long-term relationship with consumers. Direct mailings are an important tool of communication which allow for personalized way to inform and make offers for consumers. We provide a decision support system (DSS) based on the ABC classification with multiple-criteria using weighted linear optimization. The designed DSS seems to be an efficient tool to help the direct mailer on the mailing policies.

■ WC-44

Wednesday, 12:30-14:00
Y12-4

Learning and Trading in Social Networks

Stream: Game Theoretical Network Models
Invited session

Chair: *Ilan Lobel*, Stern School of Business, NYU, 10012, New York, United States, ilobel@stern.nyu.edu

1 - Does one Bayesian make a difference?
Manuel Mueller-Frank, University of Oxford, United Kingdom, muellerfrank.manuel@gmail.com

This paper develops a model of repeated interaction in social networks among privately informed agents with differing degrees of sophistication. I show that in finite networks consisting exclusively of non-Bayesian agents, who update according to the DeGroot (1974) model, all agents generically fail to aggregate any subset of the privately held information. However, the presence of at least one Bayesian agent in a strongly connected network is shown to be generically sufficient for each agent, that is Bayesian or non-Bayesian, to perfectly aggregate the private information of all agents.

2 - Strategic Learning and the Topology of Social Networks
Omer Tamuz, Mathematics and Computer Science, Weizmann Institute of Science, 76100, Rehovot, Israel, omertamuz@gmail.com

We consider a Bayesian game of pure informational externalities, in which a group of agents learn a binary state of the world from conditionally independent private signals by repeatedly observing the actions of their neighbors in a social network. We show that the question of whether or not the agents learn the state of the world depends on the topology of the social network. In particular, we identify a geometric "egalitarianism" condition on the social network graph that guarantees learning in infinite networks, or learning with high probability in large finite networks.

3 - Bilateral Trading in Networks
Daniele Condorelli, Economics, University of Essex, United Kingdom, dcond@essex.ac.uk, *Andrea Galeotti*

In many markets, goods flow via a sequence intermediaries, information is asymmetric, and trading opportunities are incomplete. We study a dynamic model of bargaining in networks with asymmetric information that captures these three features. We show that the equilibrium price dynamic is non monotonic and that traders who intermediate the object arise endogenously and attain a profit. This profit depends on their network location. Inefficiencies may arise in equilibrium, but disappear in the limit when the time horizon goes to in

finity and traders become perfectly patient.

■ WC-45

Wednesday, 12:30-14:00
Y10-3

On allocation problems

Stream: Cooperative Game Theory
Invited session

Chair: *Sirma Zeynep Alparslan Gok*, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and Sciences, Suleyman Demirel University, Department of Mathematics, 32260, Isparta, Turkey, zeynepalparslan@yahoo.com

1 - Transportation network architecting based on bi-level game between city administration and navigation providers
Alexander Krylatov, Saint-Petersburg state university, Russian Federation, partizan-sasha@yandex.ru, *Victor Zakharov*

Non-general topology network of parallel links is studied. The transportation network design problem for such a topology is considered as a Stackelberg game. The lower-level players represented by two navigation providers try to assign flows of their customers using available capacities of links so to minimize mutual interference. The upper-level player represented by the city administration tries to allocate positive capacity between available parallel links knowing response of navigation providers to any allocation so to minimize the whole travel time of demand traffic.

2 - Characterization of the core of lane covering games via dual solutions
Behzad Hezarkhani, Department of Industrial Engineering, Eindhoven University of Technology, 5600 MB , Eindhoven, Netherlands, b.hezarkhani@tue.nl, *Marco Slikker*, *Tom Van Woensel*

In lane covering games, shippers cooperate to reduce the total cost of cycles that cover their requirements in a given network. We categorize the various situations associated with these games and determine the cases for which a complete characterization of core via dual solutions are possible.

3 - Cost Allocation in City Logistics
Stefan Engevall, ITN, Linköping Institute of Technology, Linköping Institute of Technology, 60174, NORRKÖPING, Sweden, stefan.engevall@liu.se, *Maud Göthe-Lundgren*, *Joen Dahlberg*

In this paper, a cost allocation problem arising in a city logistics situation is studied. We study the concept of City Distribution Centre (CDC), where goods from several independent freight forwarders are sorted and transited to new routes & vehicles for an efficient city center distribution. The purpose of this paper is to investigate how the operational distribution costs of the distribution, including a CDC, can be shared between different involved stakeholders using concepts from cooperative game theory, such as the Nucleolus and the Shapley Value. Numerical examples are also provided.

4 - Measuring the Importance of Variables on Efficiency Evaluation via Super-efficiency Model and Cooperative Game
Yang Min, Management, University of Science and Technology of China, Hefei, China, yangustc@mail.ustc.edu.cn, *Yongjun Li*, *Liang Liang*

In order to help decision makers select a proper set of variables for the management in planning and monitoring, it is necessary to determine the importance of each input or output variable on performance measurement. This paper finds that the marginal roles of variables on efficiency evaluation may not be well reflected under CCR framework, for the efficiency score of each DMU cannot be allowed more than one. We use Shapley-value index as the solution of the cooperative game to determine the importance of the variable under evaluation.

■ WC-46

Wednesday, 12:30-14:00
Y10-1

Search Games II

Stream: Game Theory and Combinatorial Optimization
Invited session

Chair: *Kensaku Kikuta*, School of Business Administration, University of Hyogo, Gakuen-nishi 8-2-1,Nishi-ku, 651-2197, Kobe, Japan, kikuta@biz.u-hyogo.ac.jp

1 - Inspection games and crime prevention: an evolutionary perspective
Wei Yang, Mathematics and Statistics, the University of Strathclyde Glasgow, 1033 Livingstone Tower, 26 Richmond Street, G1 1XH, Glasgow, United Kingdom, w.yang@strath.ac.uk, *Vassili Kolokoltsov*

We present a model of inspection games with an evolutionary perspective. We replace the conventional payoff maximisation with the idea that individuals modify their strategies after observing the experiences of others. The proportion of individuals who play a particular strategy is then subject to evolutionary pressure over time. Further, social norms and a forward-looking inspector are considered in the model. Results on the relation between the crime rates and the levels of law enforcement will be presented. This is a joint work with Vassili Kolokoltsov and Hemant Passi.

2 - A multi-stage predator-prey problem
M.José Fernández-Sáez, Departamento de Estadística e I.O., Universidad de Murcia, Facultad de Matemáticas, Campus de Espinardo. Universidad de Murcia, 30071, Murcia, Spain, majose@um.es, *Noemi Zoroa*, *Procopio Zoroa*

In a certain region there is a predator and a herd of prey. Predator has to catch K prey along M days to survive. Every one of these days the group of prey goes to drink to the same place but goes to feed to a zone selected among h different ones. Predator can search for a prey in one of these h zones or can wait in the place where prey go to drink. The situation is modelled as a two-person, zero-sum, multi-stage game, considering the different possibilities for catching probabilities. Optimal strategies in every stage and the value of the game are obtained in a wide range of cases.

3 - A search game on a finite graph with arbuitrary searcher starting points
Kensaku Kikuta, School of Business Administration, University of Hyogo, Gakuen-nishi 8-2-1,Nishi-ku, 651-2197, Kobe, Japan, kikuta@biz.u-hyogo.ac.jp, *Vic Baston*

Two-person zero-sum search games on a network are analyzed. The hider must choose a node and remain there while the searcher can choose the node at which he starts. For detecting the hider the searcher needs to conduct a search at the node chosen by the hider. Searching a node involves a cost. The searcher also incurs travelling costs represented by distances on the edges. The costs are known to both players and the searcher wants to minimize his total costs. Upper and lower bounds for the game value are obtained. They are shown to coincide for some networks including Hamiltonian ones.

4 - Committing to an imperfectly observable strategy in patrolling security games
Nicola Basilico, Politecnico di Milano, Italy, basilico@elet.polimi.it, *Nicola Gatti*

In a patrolling security game (PSG), a Defender moves trying to detect the Attacker while the Attacker tries to compromise some area. We adopt a Stackelberg game where the Defender commits to a strategy. The credibility of such commitment comes from the capability of the Attacker to observe the Defender's movements and derive knowledge about her strategy. We present the general model of a PSG and we introduce a situation where the Attacker partially knows the Defender's strategy, being her observation capabilities limited, e.g., she can observe the Patroller only over some areas.

■ WC-47

Wednesday, 12:30-14:00
Y10-2

Demand Forecasting in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Cinzia Cirillo*, Civil and Environmental Engineering, University of Maryland, 1179 Glenn M. Hall, 20742, College Park, MD, United States, ccirillo@umd.edu

1 - Short-term demand of hotel bookings: forecasting and optimization
Ilaria Foroni, Metodi Quantitativi per le Scienze Economiche ed Aziendali, Università degli studi di Milano-Bicocca, 20126, Milano, Italy, ilaria.foroni@unimib.it, *Anna Fiori*, *Mariangela Zenga*

Revenue Management finds optimal inventory allocation as well as price setting in order to maximize revenue. An important decision to be made is whether to accept a booking request or to reject it. Because future demand is uncertain, forecasting techniques play a strategic role in RM. In this work we develop a variety of forecasting methods which nest statistical tools from event history analysis into pickup practices, incorporating external events which are likely to influence booking decisions. The forecasted results will be used to improve decision strategies to maximize expected revenues.

2 - A non-parametric algorithm for choice-based demand forecasting in revenue management
Shadi Sharif Azadeh, Mathematics, Polytechnique Montreal, Montreal, Quebec, Canada, shadi.sharifazadeh@polymtl.ca, *Gilles Savard*

In revenue management, precise demand forecasts play a critical role. Registered bookings are constrained to booking limits. Usually parametric methods are used to uncensor demand which is costly to implement. We propose an algorithm taking availability constraints into account. First, we linearize the mathematical model by implementing different relaxations. Then, we introduce a new approach which considers daily registered bookings and product availabilities simultaneously. The precision of results has been verified by both synthetic and real data that belongs to a major railway company.

3 - Dynamic Discrete Choice Model for Railway Ticket Cancellation and Exchange Behavior

Cinzia Cirillo, Civil and Environmental Engineering, University of Maryland, 1179 Glenn M. Hall, 20742, College Park, MD, United States, ccirillo@umd.edu, *Pratt Hetrakul*, *Fabian Bastin*

We propose an inter-temporal choice model of ticket cancellation and exchange for railway services where customers are assumed to be forward looking agents. A dynamic discrete choice model (DDCM) is applied to predict the timing in which ticket exchange or cancellation occurs in response to fare and trip schedule uncertainty. The approach is applied to simulated and real ticket reservation data for intercity railway trips. Estimation results indicate that the DDCM provides more intuitive coefficients and better prediction capabilities when compared to static multinomial logit models.

■ WC-48

Wednesday, 12:30-14:00
Y11-1

BSDEs and different levels of Information in Finance

Stream: Financial Mathematics and OR
Invited session

Chair: *Claudia Ceci*, Department of Economics, University of Chieti-Pescara, V.le Pindaro 42, 65127, Pescara, Italy, c.ceci@unich.it

1 - Backward Stochastic Differential Equations under Partial Information

Alessandra Cretarola, Department of Mathematics and Informatics, University of Perugia, via Vanvitelli, 1, 06123, Perugia, Italy, alessandra.cretarola@dmi.unipg.it, *Claudia Ceci*, *Francesco Russo*

We study backward stochastic differential equations (in short BSDEs) in the case where there are restrictions on the available information and discuss a financial application to local risk- minimization. More precisely, we first provide existence and uniqueness results for the solution of BSDEs driven by a general martingale under partial information and then, we use these achievements to investigate the local risk-minimization approach for partially observable semimartingale financial market models. Finally, we discuss the complete information case in presence of jumps in the underlying.

2 - A Benchmark Approach to Risk-Minimization under Partial Information

Katia Colaneri, Department of Economics, University "G. d'Annunzio", Italy, katia.colaneri@unich.it, *Alessandra Cretarola*, *Claudia Ceci*

We investigate the risk-minimizing strategy with restrictions on the available information under the benchmark approach in an incomplete semimartingale financial market. We characterize the optimal strategy through the Galtchouk-Kunita-Watanabe decomposition of the benchmarked claim under partial information and provide its description in terms of that under full information via predictable projections. Finally, we apply the results to a Markovian jump-diffusion market model where the risky asset prices dynamics depends on a stochastic factor which is not observable by investors.

3 - Quadratic BSDEs with jumps: solutions and applications

Carlo Mancini, University of L'Aquila, Italy, carlo.mancini@dm.univaq.it

Inspired by utility optimization problems in finance, in this paper we prove the existence of the solution to a class of BSDEs driven by a Brownian motion and a jump process, whose generator shows quadratic growth in the Brownian component and exponential growth with respect to the jump term. Existence and uniqueness of the solution is established first for bounded terminal value, then we extend the existence result to the unbounded case. A possible application is represented by the study of optimal consumption strategy for recursive utility models.

4 - Loss of completeness by addition of information in financial markets.

Barbara Torti, Matematica, Università di Roma Tor Vergata, Roma, Italy, torti@mat.uniroma2.it, *Antonella Calzolari*

Completeness of financial markets corresponds to predictable representation property for the semimartingale X that models the price of the risky asset. We discuss the loss of this property by enlargement of the reference filtration. Then we show that this happens either when the information begins to increase from a positive time or when it increases by addition of the information carried by another semimartingale Y, enjoying the predictable representation property and with martingale part strongly orthogonal to the martingale part of X.

■ WC-49

Wednesday, 12:30-14:00
Y11-2

Marketing and Business Analysis

Stream: Data Mining in the Financial Sector
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Mikhail Kuznetsov*, Moscow Institute of Physics and Technology, Russian Federation, mikhail.kuznecov@phystech.edu

1 - The Impact of dog celebrity type and consumer involvement on the efficiency of internet banner advertisement in the dog-allowed restaurant

Chin-Yi Fang, Graduate Institute of Sport, Leisure & Hospitality Management, National Taiwan Normal University, 162, Sec 1, Ho-ping East Road, 10610, Taipei, Taiwan, chinyifang@gmail.com, *Chieh-Ju Chu*

The pet-related hospitality industry is experiencing a significant growth. There is a paucity of paper to investigate the pet related advertisements (ADS) performance. This study employs the data envelopment analysis to evaluate the efficiency for internet ADS of dog-allowed restaurants using five inputs and four outputs. Further analysis based on truncated regression with bootstrapped procedure indicates that the dog endorser type and the level of consumer involvement have the significantly impact on the efficiency of internet banner ADS for the dog-allowed restaurants.

2 - Balancing the trade-off between privacy and profitability in social media using NMASNT

Devina Vyas, Computer Science, SSIPMT Raipur, Sejabahar, 492015, Raipur, Chhattisgarh, India, Dvnessie81091@gmail.com, *Rahul Ranjan*, *Charul Charul*, *Durga Prasad Guntoju*

One of the new realities of social media is that targeted marketing paradigm can be implemented while personal information can be used to ensure that advertising is only designed and displayed for a select group of consumers in which advertisers stand to gain most from this. However, to gather the data used for targeted marketing requires some degree of privacy intrusion by advertisers and its create trade-off between privacy and profitability. So In this paper we propose an innovative model NMASNT that balances the trade-off, while being productive without compromising user privacy.

3 - Deploying Dynamic Ensemble Selection To Tackle Concept Drift in Predictive Customer Analytics
Koen W. De Bock, Department of Marketing; IESEG Expertise Center for Database Marketing (IESEG-ECDM), IESEG School of Management, 3, Rue de la Digue, 59000, Lille, France, k.debock@ieseg.fr

Predictive analytics provides a key toolbox for marketing decision makers. While many software packages facilitate the process of building predictive models, it remains resource-intensive. One issue is the observed deterioration of prediction accuracy over time, a process referred to as concept drift. In business, scarce resources introduce the need for models that last longer. In this study, dynamic ensemble selection is used to counter concept drift in customer analytics. Experiments demonstrate the presence of concept drift in customer analytics and the relevance of the suggested approach.

■ WC-50

Wednesday, 12:30-14:00
Y11-3

Topics in Revenue Management and Pricing

Stream: Pricing and Consumer Behavior
Invited session

Chair: *Ozge Sahin*, John Hopkins University, 21287, Baltimore, United States, ozge.sahin@jhu.edu

1 - Should Event Organizers Prevent Resale of Tickets?
Izak Duenyas, University of Michigan, 48109, Ann Arbor, United States, duenyas@umich.edu, *Yao Cui*, *Ozge Sahin*

Common wisdom suggests that ticket resale is harmful to event organizers' revenues. Surprisingly, we find that when fixed pricing policies are used, event organizers in fact benefit from reductions in consumers' and speculators' resale transaction costs. Even when multiperiod pricing policies are used, an event organizer may still benefit from ticket resale if his capacity is small. Moreover, we propose a novel ticket pricing mechanism of ticket options. We show that ticket options reduce ticket resale significantly and result in significant increases in event organizers' revenues.

2 - Coordinating Product Launch Decisions in Pharmaceutical Industry
Ozge Sahin, John Hopkins University, 21287, Baltimore, United States, ozge.sahin@jhu.edu, *Mehmet Altug*

We evaluate the consequences of pioneer drug launch and pricing decisions on pharmaceutical profits and social welfare taking into account the reference pricing and parallel import activities from lower priced countries to higher priced ones. We also investigate whether the parallel import activity is always harmful to the firms. Interestingly we find that both the society and the pharmaceutical companies may benefit from parallel imports.

3 - Product line pricing facing budget constrained consumers
Stefan Mayer, Department of Analytics & Optimization, University of Augsburg, Willi-Stör-Str. 7, 86159, Augsburg, Germany, stefan.mayer@wiwi.uni-augsburg.de, *Claudius Steinhardt*

Product line pricing is defined as a seller's task to select prices that maximise his total revenue. We consider a setting where the consumers' purchase decisions are based on the "max surplus"-rule and subject to individual budget constraints. In addition, products are limited in capacity such that the consumers' choice set may vary over time resulting in dynamic substitution effects. We propose mathematical models for the seller's decision problem that incorporate each consumer's knapsack problem both exactly and heuristically and present methods for their solution.

■ WC-51

Wednesday, 12:30-14:00
Y11-4

Portfolio Optimization

Stream: Financial Optimization
Invited session

Chair: *Suleyman Ozekici*, Department of Industrial Engineering, Koç University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, sozekici@ku.edu.tr

1 - Portfolio Selection with Hyperexponential Utility Functions
Suleyman Ozekici, Department of Industrial Engineering, Koç University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, sozekici@ku.edu.tr, *Turan Bulmus*

We analyze a single-period portfolio selection problem where the investor maximizes the expected utility of the terminal wealth. The utility function is hyperexponential. This is due to the fact that the risk tolerance of the investor at the end of the period depends on the random state of the market at that time. It is well-known that an investor is memoryless in wealth for exponential utility functions with some known risk tolerance. However, we show that this is no longer true if the utility function is hyperexponential and obtain characterizations on the optimal policy.

2 - Risk disparity is better than risk parity for portfolio selection
Francesco Cesarone, Department of Business Studies, University of Rome 3, Via Silvio D'Amico 77, 00145, Rome, Italy, fcesarone@uniroma3.it, *Fabio Tardella*

The Risk Parity approach to portfolio selection is based on the principle that the fractions of the capital invested in each asset should be chosen so as to make the total risk contributions of all asset equal among them. We show that this approach is theoretically dominated by an alternative similar approach that does not require such equality but only appropriate inequalities.

3 - Optimal deleveraging with market impact
Jingnan Chen, Industrial and Enterprise Engineering, University of Illinois at Urbana-Champaign, 1002 W Clark St, Apt 201, 61801, Urbana, Illinois, United States, jchen98@illinois.edu, *Liming Feng*, *Jiming Peng*, *Yinyu Ye*

We consider an optimal asset deleveraging problem where the objective is to meet specified leverage ratio at the minimal trading cost. Under linear price impact, the problem reduces to a quadratic program with quadratic and box constraints. A Lagrangian method is proposed to solve the NP-hard problem under certain mild conditions. Some analytical results are obtained that can provide guidance on designing good trading strategy.

4 - Margin Minimization of Multi-Leg Spreads and Portfolio Selection
Yuanyuan Chen, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, Room 801, PGH 1, CUHK, Shatin, N.T., Hong Kong, Hong Kong, yychen@se.cuhk.edu.hk, *Duan Li*

We study a tractable mathematical model to minimize the margin of a multi-leg spread, a portfolio of main spreads, by a strategy-based approach using the integer vector model of extended option spreads (Matsypura and Timkovsky, 2013). We prove that the calculation of the optimal value can be achieved by linear programming and develop conditions to check arbitrage. We further consider a portfolio selection problem formulation by integrating such new spreads with their margin requirements into the model.

■ WC-52

Wednesday, 12:30-14:00
B13-1

Forecasting III

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Mohsen Hamoudia*, Strategic Marketing and Business Intelligence, France Telecom Group - Orange, 5, Allee Clos des Charmes, 95610, Eragny, France, mohsen.hamoudia@orange.com

1 - Hybrid logistic curves and contradictions based approach for long-term technology forecasting
Roland De Guio, LGECO, INSA Strasbourg, 24 bd de la Victoire, 67084, Strasbourg, France, roland.deguio@insa-strasbourg.fr, *Dmitry Kucharavy*, *Arturo Niño de Zepeda*

The paper presents a method using in a complementary way a quantitative approach based on logistic model analysis and a recent qualitative method based on contradiction network analysis. It will be shown how the qualitative method allows interpreting results of the quantitative approach and defining the features of the future technologies. The way it reduces cognitive bias of both quantitative and qualitative approaches is discussed. The methodology was applied, tested, and refined through several forecasting projects since 2003. The method will be illustrated with real case examples.

2 - Forecasting innovation diffusion with limited data: a missing data approach
Christos J. Emmanouilides, Department of Economics, Aristotle University of Thessaloniki, 541 24, Thessaloniki, Greece, cemman@econ.auth.gr

New product forecasting soon after market introduction is a demanding task since available data are limited. This paper makes progress by treating information shortage as a missing data problem. Nonparametric statistical models are used to impute the early part of real diffusion series. Forecasts are generated by several diffusion models estimated on (a) actual data (baseline case), and (b) imputed data, using a variety of forecast combination schemes. With imputation, the improvements in models' forecasting accuracy relative to the baseline are statistically significant and sizeable.

3 - Trust and Information in Internet Connectivity Cycles: A Game theoretic Approach.
Emanuele Giovannetti, Institute for International Management Practice, LAIBS, Anglia Ruskin University, East Road, CB1 1PT, Cambridge, United Kingdom, emanuele.giovannetti@anglia.ac.uk

The evolution of the Internet shows cycles in connectivity between operators. We explain these cycles as resulting from the imperfect ability of Providers to monitor their Customers. Providers introduce temporary spells of disconnection, to reduce their Customers' incentives to free ride. We estimate two econometric models focusing on the probability and length of the punishment phases.Operators' asymmetry and history of connectivity are the main factors determining both the length and the probability of the occurrence of the disconnection phases and the evolution of the Internet.

4 - Econometric Modeling and Forecasting of the Mobile 3G markets
Mohsen Hamoudia, Strategic Marketing and Business Intelligence, France Telecom Group - Orange, 5, Allee Clos des Charmes, 95610, Eragny, France, mohsen.hamoudia@orange.com

In the majority of studies related to 3G developments, the growing paths were estimated largely by diffusion models including Bass models and their various specifications such the multi-generation modeling. As this market has now reached the maturity level in many countries, and as we have available data about explanatory variables related to the 3G market, we suggest in this paper the use of the econometric modeling applied to ten different countries. We analyze the accuracy of estimated models and compare their forecasts to other ones generated by alternative models from other sources.

■ WC-53

Wednesday, 12:30-14:00
B13-2

Stochastic Programming in Energy Systems

Stream: Energy systems and markets
Invited session

Chair: *Gerardo Perez Valdes*, IOT, NTNU, Trondheim, Norway, gerardo.valdes@iot.ntnu.no

1 - Solving large multi-stage stochastic mixed integer problems with the Branch and Fix Coordination algorithm
Adela Pages Bernaus, IOT, NTNU, Alfred Getz veg, 3, 7491, Trondheim, Norway, adela.pages@iot.ntnu.no, *Gerardo Perez Valdes*, *Asgeir Tomasgard*

Branch and fix coordination (BFC) is an algorithm designed to solve large multi-stage stochastic mixed integer problems. By relaxing some of the non-anticipativity constraints (NAC), the original problem can be broken down into several smaller subproblems. This algorithm fits well to parallelization, as each subproblem can be solved by a processor and a master processor, which performs a branch-and-bound type of solution algorithm, uses the solutions of the subproblems while ensuring that the relaxed NAC are satisfied. The parallel BFC algorithm and computational results will be presented.

2 - Parallel solution of linear stochastic problems through decomposition
Jesus M. Latorre, Institute for Research in Technology, ICAI Comillas Pontifical University, Spain, jesus.latorre@iit.upcomillas.es

This work presents a decomposition method for the parallel solution of linear stochastic problems. It is based on Benders decomposition and formulates subproblems for each scenario, leading to subproblems as independent as possible. Several variants are discussed, concerning subproblem formulation and the information exchange pattern, and their impact on performance is analysed. A hydrothermal coordination model of realistic size is solved using these methods, and the numerical results shown help in assessing the previous discussion.

3 - Modelling the value of end-user energy storage in smart grids
Pedro Crespo Del Granado, Management Science, Lancaster University, 4 Slaidburn Dr. Hala, LA1 4QX, Lancaster, United Kingdom, p.crespodelgranado@lancaster.ac.uk, *Zhan Pang*, *Stein W. Wallace*

Today's increasing deployment of renewable energy in combination with smart grid technology is creating the opportunity for energy storage to be a more prevalent and adopted technology in the near future. We believe that local decentralized energy generation presence in communities and households could create a new kind of demand elasticity if they are hypothetically coupled with energy storage. Through a dynamic optimization model, we model the end user flexibility effect in peak times to see how this re-adjusts the grid supply-demand equilibrium as well as its impact to electricity prices

4 - Contract Portfolio Optimisation in the Brazilian Energy System
Gerardo Perez Valdes, IOT, NTNU, Trondheim, Norway, gerardo.valdes@iot.ntnu.no, *Luiz Armando Steinle Camargo*, *Dorel Soares Ramos*

In this work, we analyse the case of a Brazilian wind- and hydro-electricity producer whom can enter the energy market by either signing contracts with clients or selling its production at market prices. We use stochastic LP and MILP models to maximize the producer's expected revenue, taking into account the condicional value at risk, and find either the optimal selection of a set of contracts, or the optimal volume allocation among pre-selected contracts. The model's results are expected to support the trading strategies of producers under the Brazilian Energy Market rules.

■ WC-54

Wednesday, 12:30-14:00
B14-1

Simulation in Environmental Management and Optimization in Energy Consumption

Stream: Energy, Environment and Climate
Invited session

Chair: *Ronald Pelot*, Industrial Engineering, Dalhousie University, 5269 Morris St., PO Box 15000, B3H 4R2, Halifax, Nova Scotia, Canada, Ronald.Pelot@Dal.ca

1 - Modelling future solutions for the Spanish cement industry

Diego García, Energy System Analysis Unit, CIEMAT, Av. Complutense 40, E28040, Madrid, Madrid, Spain, diego.garcia@ciemat.es

Cement production is one of the most energy-intensive industrial processes. Huge CO2 amounts and other pollutants are emitted to the environment. During last decades, and thanks to the great economic growth, the mix of Spanish cement facilities was upgraded, but this is still not enough if one looks at environmental impacts. This work presents an energy modelling exercise for the 2050 horizon through the TIMES-Spain model, where several solutions, such as efficiency improvements, cement declinkerization, fossil fuel substitution, and CO2 capture are taken into account.

2 - Bi-objective warehouse design: travel time versus energy consumption optimization

Francesco Pilati, Department of Management and Engineering, University of Padova, Stradella S. Nicola 3, 36100, Vicenza, Italy, pilati@gest.unipd.it, *Daria Battini*, *Marco Bortolini*, *Mauro Gamberi*, *Fabio Sgarbossa*

Aim of traditional warehouse design is to maximize the storage and picking performance through the travel time minimization. This determines a building configuration that conflicts with the reduction of consumed energy, required for warehouse conditioning. This work suggests a bi-objective warehouse design, considering both travel time and energy consumption as objective functions. Exploiting the Pareto frontier approach, this work investigates the warehouse configurations that represent a remarkable trade-off between these two optimization problems.

3 - A method for prioritizing potential marine oil spill culprits

Ronald Pelot, Industrial Engineering, Dalhousie University, 5269 Morris St., PO Box 15000, B3H 4R2, Halifax, Nova Scotia, Canada, Ronald.Pelot@Dal.ca, *Andrew Szeto*

Canada's National Aerial Surveillance Program monitors ship based oil pollution in Canada's oceans. Often the source of pollution is unknown as there are no vessels found in the immediate vicinity at the time of spill detection. The oil spill trajectory is hindcasted using the General NOAA Operational Modeling Environment (GNOME) and temporal and spatial intersections of the trajectory swath with historical traffic paths are found using GIS. The Analytical Hierarchy Process (AHP) is used to rank possible polluters who had crossed the area of the spill based on time and proximity criteria.

4 - A Small Scale Geothermal Power Plant in Denizli-Turkey for Sustainable Energy Studies

Engin Cetin, Electrical&Electronics Engineering, Pamukkale University, Kinikli, 20070, Denizli, Turkey, engincetin@pau.edu.tr, *Mahmut Hekim*, *Hasan Ozden*, *Mehmet Anil Bozkurt*

Geothermal power plants are very popular among power generation systems. In last quarter of 2012, a small scale geothermal power plant which has 2.52 MW power capacity was constructed in City of Denizli, Turkey. This power plant has nine turbine-generator units. In this renewable energy system, each generator is feeded by 100 0C geothermal fluid. In this study, this geothermal power plant is examined. SCADA system of the power plant, generator units, geothermal wells, re-injection wells, and electricity generation data are studied for sustainable energy studies.

■ WC-55

Wednesday, 12:30-14:00
B14-2

Decision Making in Inventory Systems

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Marc Pirlot*, Mathematics and Operational Research, Université de Mons UMONS, Faculté Polytechnique, Rue de Houdain 9, B-7000, Mons, Belgium, marc.pirlot@fpms.ac.be
Chair: *Anastasia Motrenko*, Applied mathematics and management, MIPT, Moscow, Russian Federation, pastt.petrovna@gmail.com

1 - Maintenance decisions under uncertainty

Ruud Teunter, Operations, University of Groningen, PO Box 800, 9700AV, Groningen, Netherlands, r.h.teunter@rug.nl

In both theory and practice, optimal maintenance decisions are usually based on the assumption that the lifetime distribution is known exactly. In real life, the parameters of that distribution are estimated, often using limited data. We study the effect on the maintenance frequency and associated cost savings of taking uncertainty in the parameters into account. This reveals important insights. For instance, somewhat counter-intuitive, more uncertainty sometimes leads to postponement of maintenance activities. Also, the cost savings from taking uncertainty into account can be considerable.

2 - Collection of Recyclable Materials with Unknown Filling Rate

Maria Elbek, Economics and Business, Aarhus University, Fuglesangs Allé 4, 8210, Aarhus V, Denmark, meandersen@econ.au.dk, *Sanne Wøhlk*

We consider an approach for scheduling the multi-period collection of recyclable materials. Citizens can deposit glass and paper for reuse in cubes located at several collection points. The accretion rate of material in the cubes is stochastic. To establish a high service level for the citizens, cubes may not be over-filled. Inspired by theory on the Inventory Routing Problem (IRP), we present a heuristic solution method for scheduling of emptying cubes and related transportation to final destinations, in order to minimize the total operation cost.

3 - ABC inventory classification with multiple-criteria using metaheuristics

Hadhami Kaabi, Higher Institute of Management of Tunis, Tunisia, hadhamikaabi@gmail.com, *Talel Ladhari*

This work presents two metaheuristics for inventory classification problems where the inventory items are classified based on multiple-criteria such as Annual Dollar Usage, Inventory Costs, Lead Time and Critical Factor. The first metaheuristic is particle swarm optimization while the second is genetic algorithm. More precisely, this work addresses the problem of optimizing a set of weights of criteria, where the sum of all weights is 1. The obtained results are compared with some of the inventory classification techniques of the literature.

4 - ASYMPTOTIC RESULTS FOR A SEMI — MARKOVIAN INVENTORY MODEL OF TYPE (s,S) WITH GENERAL INTERFERENCE OF CHANCE

Ozlem Ardic, Department of Industrial Engineering, TOBB University of Economics and Technology, Sogutozu Cad. No: 43, Ankara, Turkey., 06560, Ankara, Turkey, oardic@etu.edu.tr, *Basak Gever*, *Tahir Khaniyev*

In the study, a semi—Markovian inventory model of type (s,S) is considered. A stochastic process X(t) describing this inventory model is constructed. Under weak conditions, the ergodicity of X(t) is proved and exact formulae for ergodic moments are found. Within some assumptions for the interference of chance, the asymptotic expansions for the ergodic moments are obtained. Applying Monte—Carlo simulation method, closeness of obtained approximation formulae to exact expressions is tested. Derived approximation formulae are used for solving an optimal stock control problem.

■ WC-56

Wednesday, 12:30-14:00
B15-3

Applied Mathematics Desk: Industrial Experiences and Success Cases in Italy - Session III

Stream: OR Applications in Industry
Invited session

Chair: *Antonino Sgalambro*, Istituto per le Applicazioni del Calcolo "Mauro Picone", National Research Council (CNR), Via dei Taurini 19, 00185, Roma, Italy, a.sgalambro@iac.cnr.it

1 - Modelling for Optimization in Trading of Securities

Umberto Dellepiane, Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti, Sapienza Università di Roma, via Ariosto, 25, 00185, Roma, Italy, dellepiane@dis.uniroma1.it, *Stefania Renzi*, *Stefano Lucidi*

The goal of trading consists in gaining profit by buying/selling a security: the difference between the entry and the exit price in a position determines the profit or loss of that trade. A trading strategy is used to identify proper conditions to trade a security. The role of optimization consists in finding the best conditions to start a trading maximizing the profit. A strategy is trained on a chosen batch of data (training set) and applied on a next one (trading set). Given a strategy, there are different issues to deal with, to obtain the best performances from the optimization.

2 - Global Black-Box Optimization in Trading of Securities

Stefania Renzi, Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti, Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, renzi@dis.uniroma1.it, *Umberto Dellepiane*, *Stefano Lucidi*

Given a trading strategy, a reliable global optimization method must be chosen and then an efficient algorithm based on that method has to be implemented. Since the objective function is not defined in closed form, the optimization problem calls for a black-box methodology. Different global optimization methods have been selected on the same batch of a security time-series (item) comparing the results. This study is aimed to highlight possible relationships between the behavior of the particular item and the performance of the global optimization techniques.

3 - Risk-based retail demand forecasting

Raffaele Maccioni, ACT Operations Research, Italy, raffaele.maccioni@act-operationsresearch.com, *Stefano Lucidi*, *Franco Dorigo*, *Marco Felician*, *Enrico Procacci*

Multi-market and multi-price dynamics, fast-changing consumer's behaviour and promotional responses, make it difficult to keep forecast errors low. These, in turn, are likely to lead to decision making failures. Drawing on specific retailers' needs, this work shows a new approach (risk-based demand management) applying advanced predictive analytics and optimization techniques to revenue, procurement, inventory and distribution processes. This approach has been applied to a fashion retailer system in a real-world experience.

4 - A critical self-assessment by an academic spin-off company

Antonio DiCarlo, Dipartimento di Matematica & Fisica, Università Roma Tre, Via Corrado Segre, 6, I-00146, Roma, Italy, adicarlo@mac.com, *Michele Vicentino*

Technology & Research for Security (TRS) was launched in 2008 by Università Roma Tre with the mission to implement the R&D project Smart Systems for the Security of Critical Infrastructures, supported by a government grant. The main applications targeted by TRS are small area protection and integrative security management. Applied maths has a lot to do with this, especially virtual geometric modelling and software agents ruled by finite-state automata. After five years of great expectations and mixed results, the time is ripe for reflecting on what went right and what wrong in our endeavour.

■ WC-57

Wednesday, 12:30-14:00
B15-4

Machine Learning and Business Analytics

Stream: Business Analytics and Intelligent Optimization
Invited session

Chair: *Sebastian Maldonado*, School of Engineering and Applied Sciences, Universidad de los Andes, Av. San Carlos de Apoquindo 2200, Las Condes, Santiago, Chile, smaldonado@uandes.cl

1 - Identifying Relevant Attributes in Conjoint Analysis using Support Vector Machines

Sebastian Maldonado, School of Engineering and Applied Sciences, Universidad de los Andes, Av. San Carlos de Apoquindo 2200, Las Condes, Santiago, Chile, smaldonado@uandes.cl

One of the main tasks of conjoint analysis is to identify consumer preferences about potential products. Accordingly, different estimation methods have been proposed to determine the corresponding relevant attributes. We present a new approach to identify the attributes that consumers use to evaluate alternatives in a choice-based conjoint context. Our method has two appealing characteristics (i) it is grounded on Support Vector Machines, that has proved important predictive ability and (ii) it obtains a more parsimonious representation of consumer preferences than traditional models.

2 - Knowledge based feature selection for unsupervised learning: theory and application

Alex Seret, Decision sciences and information management, KU Leuven, Naamsestraat 69 KU Leuven, 3000, Leuven, Vlaams-brabant, Belgium, alex.seret@kuleuven.be, *Sebastian Maldonado*, *Richard Weber*, *Bart Baesens*

This work is based on the fact that a clustering task, such as segmentation, should not be entirely unsupervised if e.g. interesting insights into the subjective importance of the variables exist. In other words, if the analyst is able to assign preferences in the form of priorities to the respective variables, he/she should be able to do so. We propose a framework to select features combining business knowledge with advanced data mining methods and implement it in a direct marketing setting.

3 - Improving SVM for classification in Social Networks

Juan Hormazábal, Departamiento de Ingeniería Industrial, Universidad de Chile, José Miguel Carrera N601 Depto. N509, 8320000, Santiago, Santiago, Chile, juanpablohff@gmail.com

In general, features describing the individual cases are used in classic SVM approaches. Recently, social networks have shown to reveal many interesting features, in this way the idea of our research is to incorporate the information from a social network into a SVM model for classification. In particular, we propose to change the SVM model, by explicitly taking into account information from an individuals community. The main idea is that those cases belonging to the same community would also be more likely to be classified in the same class than in a classic SVM approach.

4 - A fuzzy feature selection for supervised classification

Mario Guarracino, National Research Council of Italy, Italy, mario.guarracino@cnr.it, *Maria Brigida Ferraro*

Although many classification methods take advantage of fuzzy sets theory, the same cannot be said for feature reduction methods. In this paper we explore ideas related to the use of fuzzy sets and propose a novel fuzzy feature selection method tailored for the Regularized Generalized Eigenvalue Classifier (ReGEC). The method provides small and robust subsets of features that can be used for supervised classification. We show, using real world datasets that the performance of ReGEC classifier on the selected features well compares with that obtained using them all.

■ WC-58

Wednesday, 12:30-14:00
B15-6

Systems and Computational Biology, and Data Mining in Nature

Stream: Computational Statistics
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Theodore Trafalis*, Industrial Engineering, University of Oklahoma, 202 West Boyd, Rm 124, 73019, Norman, OK, United States, ttrafalis@ou.edu

1 - Estimators of Mover Stayer Model

Elena Almaraz Luengo, Estadística e Investigación Operativa, Facultad de Ciencias Matemáticas (UCM), c/Arroyo de la Media Legua 68, 2ºB, 28030, Madrid, Spain, ealmarazluengo@mat.ucm.es, *Eduardo Almaraz Luengo*

Mover-Stayer model introduced by Blumen, Kogan and McCarthy (1955), consists of a mixture of two independent Markov chains one with degenerate transition probability matrix I and the other with unknown transition probability matrix P. In this model there are two groups of individuals, the stayers (who with probability 1, will remain in their initial state throughout the observed period) and the movers (who move among the different states of the chain). The aim of this work is to estimate the parameters of the matrices of the model and to propose an algorithm to obtain these estimators.

2 - On multiple cores/periphery partitioning problem: formulation and algorithm

Sandrine Mouysset, IRIT-UPS, 2 rue Camichel, 31000, Toulouse, France, sandrine.mouysset@enseeiht.fr, *Pierre Hansen*, *Sylvain Perron*

In many fi

elds such as social network analysis and data mining, the core/periphery structure is widely used. But in the general case, the data could describe multiple cores and one periphery in which the cores de

fine multiple compact clusters and the periphery a sparse cluster. So the bipartitioning problem should be adapted and we propose to formalize the multiple cores/periphery structure as a mixed 0-1 quadratic programming. Then an algorithm using column generation methods for detecting this structure is suggested and tested on numerical experiments.

3 - Partial Occupation Time Statistics and the Business Cycle

Alexander Karalis Isaac, Economics, Maths and Stats, Birkbeck College, Malet Street, Bloomsbury, WC1E 7HX, London, United Kingdom, lkara04@mail.bbk.ac.uk

A test statistic is developed for questions of the type 'is state A associated with events E'. The probability that a discrete Markov chain visits a certain state n times in a subset of dates in the sample period is derived. Bootstrap schemes are presented for such distributions, in a range of models. As an example, the stability of the forecasting relationship between the risk-free interest rate and economic output is examined. Results suggest a significant relationship between failure of the forecasting relationship and recessions, even after accounting for the small sample distribution.

4 - Machine-learning classifiers for imbalanced tornado data

Theodore Trafalis, Industrial Engineering, University of Oklahoma, 202 West Boyd, Rm 124, 73019, Norman, OK, United States, ttrafalis@ou.edu, *Indra Adrianto*, *Michael Richman*

We apply a midpoint threshold adjustment on the probabilistic outputs of support vector machines (SVMs), logistic regression, random forest, and rotation forest for tornado prediction. Feature selection with SVM- recursive feature elimination was also performed to identify the most important features or variables for predicting tornadoes. The results showed that the threshold adjustment on SVMs provided better performance compared to other classifiers.

■ WC-59

Wednesday, 12:30-14:00
B15-5

Soft OR and Multimethodology II

Stream: Soft OR / Systems and Multimethodology
Invited session

Chair: *John Mingers*, Kent Business School, Kent University, CT2 7PE, Canterbury, Kent, United Kingdom, j.mingers@kent.ac.uk

1 - The US origins of soft OR ?

Frances O'Brien, Warwick Business School, University of Warwick, Gibbet Hill Road, CV4 7AL, Coventry, United Kingdom, Frances.O-Brien@wbs.ac.uk, *Robert Dyson*

Soft OR and problem structuring have been associated mainly with OR in the UK and Europe. There have been attempts to break into the US market and in particular into the prestigious US OR-related journals, to little avail. This paper explores the hypothesis that elements of soft OR can be found in the works of some of the OR pioneers, a number of whom hail from the US.

2 - Development of WASAN using the 4 Pillars of PSMs and a case study of a UK Police force

Chris Smith, Operational Research and Management Sciences, University of Warwick, Doctoral Programme Office, Warwick Business School, CV4 7AL, Coventry, West Midlands, United Kingdom, christopher.smith.11@mail.wbs.ac.uk, *Duncan Shaw*

This paper develops the theoretical understanding of the Waste and Source Analysis (WASAN), a qualitative methodology developed to reduce avoidable waste. The authors demonstrate WASAN can be considered a generic Problem Structuring Method (PSM) by showing two elements. Firstly that WASAN is a generic methodology by implementing it in a problem context suitably different from which it was designed. Secondly WASAN shares a common framework with existing PSMs. To do this the paper identifies four pillars that underpin established PSMs then compares this framework with WASAN.

3 - Energy behaviours modelling: An integration of soft OR methodologies

Marta Lopes, INESC Coimbra, ESAC-IPC, Coimbra, Portugal, mlopes@esac.pt, *Carlos Henggeler Antunes*, *Nelson Martins*

There has been an increasing interest and recognition of the role of energy behaviours in energy efficiency. However, as a complex issue, energy behaviours are difficult to address. Energy behaviours modelling have been using different disciplinary approaches from concept maps in social sciences to quantification of energy use in engineering models, but an interdisciplinary modelling strategy is required. The role of soft OR tools to model energy behaviours is explored, including Soft Systems Methodology, System Dynamics and causal maps, in particular in behavioural change field experiments.

4 - Integrating the DPSIR framework with Hollings' panarchy theory for modelling the marine environment.

Jonathan Atkins, Business School, University of Hull, HU6 7RX, Hull, United Kingdom, j.p.atkins@hull.ac.uk, *Amanda Gregory*

Management of marine environments involves engaging with a complex adaptive system of linked natural, social and designed systems. The system defies holistic representation in popular models such as the DPSIR (Drivers-Pressures-State Change-Impact-Responses) framework. We take a critical look at the DPSIR framework, and turn to Hollings' panarchy theory and draw on the causal loop mapping technique to model this complexity, and report on the design of an expert participative workshop based on a marine case study.

■ WC-60

Wednesday, 12:30-14:00
B15-7

Intelligent Systems and Transportation

Stream: Information and Intelligent Systems
Invited session

Chair: *Muhammed Yasin Çodur*, Engineering and Architecture/civil, Erzurum Technical University, Erzurum Technical University Engineering and Architecture Faculty Civil Engineering department no :408, 25240, Erzurum, Turkey, mycodur@gmail.com

1 - The Modeling with Clustering Analysis of the Provinces in Turkey According to Traffic Accidents at the Year 2011
Ahmet Atalay, Narman Vocational High School, Ataturk University, Narman Vocational High School, 25530, Narman, Erzurum, Turkey, atalay_ahmet@hotmail.com, *Muhammed Yasin Çodur*, *Ahmet Tortum*

In this study, death and injury rates for each province were calculated by using data about road traffic accidents (RTAs) happening in Turkey for the year 2011. Clustering analysis was made according to these rates by using both classical k-means technique and fuzzy c-means technique. Provinces were divided into five clusters by clustering analysis conducted in these two techniques. The provinces having highest death and injury rates were determined. The results obtained were compared. It was observed that fuzzy c-means gave at least as accurate and consistent results as did k-means.

2 - Erzurum North Ring Road Accident Prediction Model with Artificial Neural Network
Muhammed Yasin Çodur, Engineering and Architecture/civil, Erzurum Technical University, Erzurum Technical University Engineering and Architecture Faculty Civil Engineering department no :408, 25240, Erzurum, Turkey, mycodur@gmail.com, *Ahmet Atalay*, *Ahmet Tortum*

There has been considerable research conducted on the development of models for predicting traffic accidents on highway facilities. Over the last few years, there has been an increase in the application of Artificial Neural Network (ANN) for modeling accident predictions. A case study, accident prediction models for The North Ring Road of Erzurum/Turkey were developed by using the historical data, between 2005 and 2010. In conclusion, this study focused on the practicability of the neural network theory for traffic safety analysis.

3 - Delay Estimation at Signalized Intersections Using Artificial Neural Network
Erdem Dogan, Civil Engineering, Kirikkale University, Kırıkkale University, Engineering Faculty (Muh. Fak.) Department of Civil Engineering, 71451, Kirikkale, Turkey, edogan@kku.edu.tr, *Ali Payıdar Akgüngör*, *Ersin Korkmaz*

In this study, ANNs are employed to model delay estimation. While intersection approach volumes, cycle times and left turn lane existence are utilized as input parameter, average delay per vehicle and average stops per vehicle are obtained as the output parameters. Approach volumes are randomly generated for each lane, then Synchro Traffic Simulation Program is run 200 times with all generated data, and outputs are obtained from simulations. The results show that ANNs models can estimate delays and stop rates are in acceptable ranges.

4 - Team-oriented assembly line balancing and a case study
Hamid Yılmaz, Industrial Engineering, Ataturk University, Ataturk Univesity, Industrial Engineering, 25000, Erzurum, Turkey, hamidyilmaz@gmail.com, *Mustafa Yilmaz*, *Selçuk Kürşat İşleyen*

An assembly line balancing problem is examined drawing inspiration from real life that differs from the conventional one as there are multi-manned workstations, where workers are assigned to teams with limitations of workstation's maximum team capacity. Team numbers can rise with the number of tasks. But at same time, because of the stations' physical situations, there will be limitations of maximum working team numbers in a station. For this purpose a heuristic assembly line balancing procedure and mathematical model of the problem are used and illustrated.

■ WC-62

Wednesday, 12:30-14:00
R18-1

Emerging Applications of Finance in Economics and Environment I

Stream: Emerging Applications of Finance in Economics and Environment
Invited session

Chair: *Omer Kayhan Seyhun*, Banking and Financial Institutions Department, Risk Centralization Division, Central Bank of Turkey, Istiklal Street No 10, Ulus, 06100, Ankara, Turkey, kayhan.seyhun@tcmb.gov.tr
Chair: *Kasirga Yildirak*, IAM, METU, 06531, Ankara, Turkey, kasirgayildirak@gmail.com.tr

1 - Detrended Fluctuation Analysis as a Statistical Tool to Determine the Exchange Rate
Nurbanu Bursa, Statistics, Hacettepe University, Hacettepe Üniversitesi İstatistik Bölümü Beytepe Kampüsü, TR-06800, Ankara, Turkey, Turkey, nurbanubursa@hacettepe.edu.tr, *Hüseyin Tatlidil*

We investigated Euro/Turkish Lira daily exchange rate time series from 04.01.2007 to 22.02.2013 by applying the Detrended Fluctuation Analysis (DFA). This econophysics technique is a simple but very efficient scaling analysis to estimate the power-law long-term correlations of non-stationary time series, in which a detrending step is necessary to obtain the local fluctuations at different time scales. Our results illustrated that Turkish exchange rate time series has negative long-range dependence or anti-persistence.

2 - Modeling Exhange-Rate Returns with Flexible Distributions
Alper Corlu, Administrative Sciences, Boston University, United States, corlu@bu.edu, *Canan Gunes Corlu*

Despite its popularity in modeling financial returns, it is well known that the normal distribution is inadequate in skewed and heavy- tailed exchange rate returns. To this end, various flexible distributions that capture the asymmetric and tailed behavior of returns have been proposed. We perform a comprehensive numerical study to compare the performances of the generalized lambda distribution, the skewed t distribution, unbounded Johnson family of distributions, normal inverse Gaussian distribution, and the skew hyperbolic student t distribution in modeling major currencies.

3 - The Circulation Mode of Account Receivable for Small and Medium Enterprises
Shuzhen Chen, School of Management, University of Science and Technology of China, No. 96, Jinzhai Road, 230026, Hefei, China, csz@mail.ustc.edu.cn, *Liang Liang*

Circulation of account receivable creditor's rights (Circulation of ARCR) is an innovative financing mode for SMEs to convert their accounts receivable into liquid assets, with pilot projects launched in Hefei and Tianjin City in China. This circulation mode is an advantageous financing method since SMEs' financing needs can be immediately satisfied by transferring the certificate. Related risks have been analyzed on basis of COSO risk management framework, and a pricing model is given for the amount applied for certificate.

4 - Regime dynamics of euro area industries
José G. Dias, BRU - Business Research Unit, ISCTE - Instituto Universitário de Lisboa, Edifício ISCTE, Av. das Forças Armadas, 1649-026, Lisboa, Portugal, jose.dias@iscte.pt, *Sofia B. Ramos*

This paper analyzes country versus industry factors in European stock market dynamics. This dichotomy is framed as a hierarchical market structure by a two-step approach: first, time series indexes are filtered using a regime switching model; then, based on the Kullback-Leibler distance between posterior probabilities, the hierarchical market structure is revealed. Time series of 79 industry-country indexes from ten countries of the euro area show that industry factors are more important in explaining stock market heterogeneity.

■ WC-63

Wednesday, 12:30-14:00
R18-2

Logistics and Maritime III

Stream: OR and Maritime Studies
Invited session

Chair: *Xianghua Gan*, The Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, M642 Li Ka Shing Tower, The Hong Kong Polytechnic University, Hung Hom, KLN, Hong Kong, x.gan@polyu.edu.hk

1 - An Application of Forecasting Techniques for Container Throughput in Thailand Ports

Veerachai Gosasang, Engineering, University of the Thai Chamber of Commerce, 126/1 Vibhavadi Rangsit Road, Din Daeng, 10400, Bangkok, Thailand, veerag1968@hotmail.com, *Tsz Leung Yip*, *Watcharavee Chandraprakaikul*

The aim of this paper is to forecast container throughputs by an integrated model of two techniques: (1) time series forecasting for predicting all the factors, and (2) cause-and-effect forecasting using multivariate regression and multilayer perceptron methods. We identify which factors affecting container throughputs and then collected data from various sources. The monthly, quarterly and yearly data at Thailand Ports are used. The results are compared in terms of root mean squared error and mean absolute error. It should be a robust technique for forecasting container throughputs.

2 - Strategic purchasing and cost performance: Moderating roles of buyer asset specificity and trust

Kwong Yeung, Logistics and Maritime studies, Hong Kong Polytechnic University, M630 M building, Yuk Choi Road, Hung Hom, Nil, Kowloon, Hong Kong, China, lgtsunny@polyu.edu.hk

Strategic purchasing is likely to be an effective strategy to minimize operational cost in the manufacturing industry. Drawing on the transaction cost economics (TCE) and resource-based view (RBV), we apply structural equation modeling to empirically test the model, using data collected from manufacturers in Hong Kong and the Pearl River Delta region of China. We posit that strategic purchasing can reduce cost and this cost minimization process is moderated by buyer asset specificity and trust. Our findings provide theoretical and practical insights for operations management.

3 - Operational Stategies of Merchants in Daily Deal Promotions

Xianghua Gan, The Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, M642 Li Ka Shing Tower, The Hong Kong Polytechnic University, Hung Hom, KLN, Hong Kong, x.gan@polyu.edu.hk

Daily deal sites like Groupon provide merchants a new advertisement channel and help merchants to attract new customers. However, many merchants complain that total cost of doing a daily deal promotion is too high, and stop using this new marketing tool. This presents some intriguing questions: How to evaluate accurately the benefits and costs of doing a daily deal promotion? What kind of operational strategies can help a merchant to decrease total cost in a promotion? In this paper, we address these questions and obtain different operational strategies for different types of merchants.

4 - Towards a Counterfeit-Proof Global Supply Chain

Morteza Pourakbar, Decision and Information Sciences, Rotterdam School of Management, Netherlands, MPourakbar@rsm.nl, *Rob Zuidwijk*

In this paper we look at the economic trade-offs of container inspection when Customs and supply chain partners decide to collaborate in order to mitigate the risk of counterfeit products entering the legitimate supply chains. Customs can set higher inspection rates for containers but it might cause unwanted congestion for business partners. In this research, strategic behaviors of Customs, business partners and counterfeiters are modeled using a game-theoretic approach. We extend the model to various realistic situations and analyze the results.

■ WC-64

Wednesday, 12:30-14:00
R18-3

Crisis and Disaster Modelling

Stream: Humanitarian Operations Research
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de
Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de

1 - Multi-Criteria Location Planning and Vehicle Routing as part of Large Scale Evacuation Logistics

Marc Goerigk, Technische Universität Kaiserslautern, 67653, Kaiserslautern, Germany, goerigk@mathematik.uni-kl.de, *Horst W. Hamacher*, *Philipp Heßler*

In case of an emergency like a bomb disposal within a city, it becomes necessary to evacuate a large part of the population. We consider the use of public transportation in this process and, more specific, the problem of determining both pickup points of evacuees and shelter locations. A realistic operations research model necessitates the use of multiple criteria such as evacuation time, cost of maintaining shelters, equal utilisation of pickup points, etc. We present an integrated model and report on our experience implementing a real-world instance of the city of Kaiserslautern, Germany.

2 - Ambulance Location Problems from the Viewpoint of Congestion

Keisuke Inakawa, Dept. of Management Science and Engineering, Akita Prefectural University, 84-4 Ebinokuchi, Tsuchiya, Yurihonjo, 0150055, Akita, Japan, inakawa@akita-pu.ac.jp

We consider ambulance location problems from the viewpoint of congestion of emergency calls. In the situation of high congestion, the nearest ambulance might be busy for a previous patient sometimes. In that case, the second or third nearest ambulance that needs a longer response time will be dispatched, if it is available. Thus, the congestion of emergency calls makes a mean response time delay. We propose a model using queueing theory to analyze in detail the situation of congestion. Finally, we introduce a numerical example for a city in Japan, adopting the actual emergency data.

3 - Multicriteria Analysis in the Logistics of the Reconstruction of Zones Affected by Natural Tragedies

Adriana Kroenke, PPGMNE/Mathematics, UFPR/FURB, Rua Antônio da Veiga, 140, 89012-971, Blumenau, Santa Catarina, Brazil, didlen@terra.com.br, *Nelson Hein*, *Volmir Wilhelm*

This study analyzes the use of MCDM tools in the re(construction) activities conducted after the natural tragedy that took place in Blumenau — Brazil, in 2008. Due to the fact that many families have been left without their homes, the municipality established the relocation of these people to housing projects that were built since then. The evaluation of the risks and costs of the areas was obtained through Analytic Hierarchy Process and the process of choosing the materials for the construction of the buildings was conducted through the Electre I method.

4 - Scenario-based Comprehensive Assessment of Civil Security Solutions
E Anders Eriksson, Defence Aanlysis, FOI, 16490, Stockholm, Sweden, e.anders.eriksson@foi.se, *Christian Carling*
In FP7 and - hopefully - H2020 EU is investing significant funds into civil security. We have by now participated as 'civilised' military OA staff in a series of European security projects and in the paper we reflect on the analytic needs. We argue that comprehensiveness is required both in the threats/missions domain — to be covered by scenarios — and in the solutions domain where defence inspired TEPID-OIL type approaches to the multi-attribute character of solutions are useful but need to be further broadened to capture the inherently societal nature of civil security.

■ WC-65

Wednesday, 12:30-14:00
R18-5

Quality Function Deployment

Stream: OR in Quality Management
Invited session

Chair: *Gulser Koksal*, Industrial Engineering, Middle East Technical University, Inonu Blvd., 06800, Ankara, Turkey, koksal@metu.edu.tr

1 - An integrated model of Quality Function Deployment for financial organizations in an unstable economic environment
George Paltayian, Department of Business Administration, University of Macedonia, 156 Egnatia Street, 54006, Thessaloniki, Thessaloniki, Greece, gpaltag@uom.gr, *Andreas Georgiou*, *Katerina Gotzamani*, *Andreas Andronikidis*
Service quality is one of the primary competitive weapons in financial services. Fiscal crisis and recession of the Greek economy have rendered credit institutions vulnerable. Customers feel insecure and have less trust in financial services, increasing the competition. We present a formulation of a QFD model integrated with AHP, ANP and GP, to investigate strategies for improving performance, starting from the "voice' of the customers and incorporating internal and external variables. The model consists of three Houses of Quality and the importances feed a ZOGP model.

2 - Review and Analysis of Fuzzy Optimization Models in QFD
Güzin Özdağoğlu, Business, Dokuz Eylul University, Turkey, guzin.kavrukkoca@deu.edu.tr, *Aysun Kapucugil-İkiz*, *Aşkın Özdağoğlu*
Quality Function Deployment (QFD), a well-known methodology, dedicated to translating customer needs (qualitative information) into technical activities (quantitative format) to develop products and services. There are some technical issues in classifying and prioritizing customer needs and defining the relations between the needs and technical characteristics. As a promising approach, fuzzy logic is recently used for overcoming these issues. This paper presents a review and analysis of fuzzy optimization models applied in QFD literature in terms of complexity and intensity levels.

3 - Determining customer requirements for advanced product quality planning (apqp) in automotive sector
Burcu Ozcan, Industrial Engineering Department, Kocaeli University, Turkey, burcu.ozcan@kocaeli.edu.tr, *Ozlem Aras*, *Yildiz Yulugkural*
Advanced Product Quality Planning is a structural method which provides the product to satisfy the customer by identification of the customer requirements step by step. In this paper, it is aimed to contribute the process design improvement studies by defining the customer requirements in the APQP Phase of New Product Launching Process. In accordance with this aim, considering other competitors, critical customer requirements are determined by Quality Function Deployment Method (QFD) and customer satisfactions are increased by guaranteeing these requirements in the process flow.

4 - A Service Package Development Methodology for Technoparks
Gulser Koksal, Industrial Engineering, Middle East Technical University, Inonu Blvd., 06800, Ankara, Turkey, koksal@metu.edu.tr, *S. Nazli Wasti*, *Berna Tarı Kasnakoglu*
In this study, a methodology is developed for technoparks to develop services for their stakeholders. The methodology utilizes Quality Function Deployment, marketing and rating approaches to propose a simple and effective service development mechanism. Its application for tenants of a technopark is demonstrated.

■ WC-66

Wednesday, 12:30-14:00
R18-4

Sustainable Management for Resources, Conservation and Recycling IV

Stream: Optimization for Sustainable Development
Invited session

Chair: *Sadia Samar Ali*, Operations Management, Fortune Institute of International Business , New Delhi - 110057, India, Plot No.5 Rao Tula Ram Marg, Opp Army R&R Hospital, Vasant Vihar, New Delhi - 110057, 201009, New Delhi, India, sadiasamarali@gmail.com

1 - Two — Phase Optimisation of Reverse Logistics Networks Considering the Quality of Returned Products
Dobrila Petrovic, Faculty of Engineering and Computing, Coventry University, Priory Street, CV1 5FB, Coventry, United Kingdom, D.Petrovic@coventry.ac.uk, *Ali Niknejad*
A reverse logistics network with two recovery routes, including repair and remanufacturing, a disposal route and a standard forward production route is considered. Demand and quantities of returned products of different quality levels are assumed to be uncertain and are modelled using fuzzy sets. In the first phase of an optimisation model, a fuzzy controller determines quality thresholds for each of the route. In the second phase, a fuzzy mixed integer optimisation model determines the inventory stocks and quantities of products to be produced by each route.

2 - Effects of Employee Participation and Consultation on Safety Performance towards Logistics Sustainability in Malaysia
Huinee Au Yong, Universiti Sains Malaysia, Malaysia, ayhn@yahoo.com
Employees are important to logistics for persons who deal with risks. Poor safety and health record may have impact on the reputation and operational capabilities. Survey questionnaires about safety and health issues were distributed. One hundred and three employees completed the survey. Employee demographic variables do not have safety implications. Results emphasize management-employee exchange in enhancing workplace safety. Organizations should foster positive interaction. These results should help to allay concerns about staff retention when implementing safety management practices.

3 - Best Practices of Supply Chain Management: A Closed Loop Supply Chain Management Approach
Sadia Samar Ali, Operations Management, Fortune Institute of International Business , New Delhi - 110057, India, Plot No.5 Rao Tula Ram Marg, Opp Army R&R Hospital, Vasant Vihar, New Delhi - 110057, 201009, New Delhi, India, sadiasamarali@gmail.com
The green supply chain management has been emerging as a new innovation that is being used by organizations to develop strategies in order to achieve objectives worldwide. This paper examines the relationship between the operations of forward and reverse logistics and the environmental performance measures in closed loop supply chain network design. The result shows that the proposed real life case model is able to support the logistics decisions in a closed loop supply chain efficiently and accurately.

4 - A comparative analysis of multiple criteria decision making methods for assessment of housing affordability

Vida Maliene, School of the Built Environment, Liverpool John Moores University, Byrom Street, L3 3AF, Liverpool, United Kingdom, v.maliene@ljmu.ac.uk

Housing affordability is a multi-dimensional issue, yet it is typically assessed in terms of economic criteria. Multiple criteria, including economic, environmental and social aspects must be considered in order to formulate a comprehensive and sustainable assessment of housing affordability. The need arises for a methodology to evaluate housing affordability based on multiple evaluation criteria. This paper presents an empirical application and comparison of different multiple criteria decision making (MCDM) techniques for the purpose of assessing housing affordability.

■ WC-69

Wednesday, 12:30-14:00
R19-3

Global Health

Stream: Stream of INFORMS Society for Public Programs, Service and Needs
Invited session

Chair: *Dionne Aleman*, Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, M5S 3G8, Toronto, ON, Canada, aleman@mie.utoronto.ca

1 - Improving HIV early infant diagnosis (EID) supply chains in sub-Saharan Africa

Jonas Oddur Jonasson, Management Science and Operations, London Business School, Regent's Park, NW1 4SA, London, United Kingdom, jjonasson.phd2010@london.edu, *Sarang Deo*, *Jérémie Gallien*

Early diagnosis of HIV infected infants is essential in resource limited settings. An Early Infant Diagnosis (EID) system is a network of clinics and laboratories, for testing blood samples. Each laboratory is a batch arrival, batch service queue. We derive an approximation of waiting time in such queues as a univariate function of utilization. This approximation is incorporated in two optimization formulations to maximize participation in EID systems. The results are validated using a general simulation model, based on data provided by the operators of the Mozambique EID network.

2 - The Global Fund's Grant Disbursement Process and Central Drug Stockout Risks in Africa: Model and Analysis

Iva Rashkova, London Business School, NW1 4SA, London, United Kingdom, irashkova.phd2009@london.edu, *Jérémie Gallien*, *Prashant Yadav*

A simulation model with validated predictive accuracy was used to quantify the joint impact of procurement lead times, disbursement inter-arrival times and rating transitions for 53 African countries on warehouse availability of a single pharmaceutical product facing constant demand. We find that (i) African Global Fund recipients currently face heterogeneous intrinsic stockout risks because of existing disbursement and procurement dynamics; and (ii) adjusting disbursement amounts to reflect historical disbursement schedules is more effective than bridge financing or a buffer stock.

3 - Appraisal of critical success factors for controlling infectious disease outbreaks using the DEMATEL method

Thomas Dasaklis, Department of Industrial Management, University of Piraeus, 80 Karaoli & Dimitriou str., 18534, Piraeus, Attica, Greece, dasaklis@unipi.gr, *Costas Pappis*

Epidemics are very common in the aftermath of natural disasters. Effective response to such outbreaks necessitates the establishment of an emergency supply chain where logistical operations should be managed and key-parties should closely cooperate with each other. The aim of this paper is to identify operational success factors and the possible interrelationships among them for outbreaks control in the generic context of humanitarian emergencies. A multi-criteria decision making method (DEMATEL) is used for determining, appraising and visualizing the causal relationships among these factors.

4 - Graph theory based mitigation strategies and measures for pandemic disease spread

Dionne Aleman, Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, M5S 3G8, Toronto, ON, Canada, aleman@mie.utoronto.ca, *Mario Ventresca*

We study graph-based mitigation strategies to contain disease spread. An agent-based simulation model is used to determine how disease spreads, then a population snapshot is used to construct a social network where arcs are disease transmission. Potential for disease spread is calculated using graph theory metrics. The primary benefit of this approach is speed, while a secondary benefit is the ability to optimize vaccine plans based on the snapshot. We highlight the pitfalls of betweenness and centrality measures. We focus on pandemics, but the approach is applicable to any network contagion.

■ WC-71

Wednesday, 12:30-14:00
R16-1

Health Care Management (Home Health Care)

Stream: Health Care Management
Invited session

Chair: *Amy Cohn*, University of Michigan, United States, amycohn@umich.edu

1 - Minimizing the cost in the daily routes of the Hospital at Home

Sacramento Quintanilla, Matemáticas para la Economía y la Empresa, University of Valencia, Avda. Naranjos s/n, 46071, Valencia, Spain, Maria.Quintanilla@uv.es, *Francisco Ballestin*, *M.Pilar Lino*, *M. Angeles Pérez*, *Vicente Valls*

Doctors and nurses who make up assistance teams in home hospitalization must move daily to different homes where patients are hospitalized. These routes are performed by taxi and are very costly. We have developed efficient metaheuristic algorithms to minimize the cost of travel and meet the constraints defined in the service. The proposed algorithms achieve a significant reduction in both cost and staff waiting times. The algorithms are based on four pillars: solution representation, creating an initial population from what we define as clusters of households, perturbation and local search.

2 - Training Residents: Reconciling Scheduled Work Hours with Random Opportunities to Perform Rare Procedures

Amy Cohn, University of Michigan, United States, amycohn@umich.edu, *Ryan Chen*, *Rishindra Reddy*, *Mark Daskin*, *Andrea Obi*

We consider the training of medical residents, who must perform procedures under the supervision of senior physicians to attain competency. Many procedures arrive randomly and infrequently, such as heart and lung transplants for cardiothoracic surgery residents. Transplants arrive randomly but residents have fixed work patterns. We present a simulation-based tool to demonstrate the conflict between scheduled shifts and emergent surgical opportunities and discuss alternative scheduling paradigms to improve the likelihood of developing competency in training.

3 - A Branch-and-Price-and-Cut solution approach for medium-term home health care planning

Patrick Hirsch, Institute of Production and Logistics, University of Natural Resources and Life Sciences, Vienna, Feistmantelstrasse 4, 1180, Wien, Austria, patrick.hirsch@boku.ac.at, *Andrea Trautsamwieser*

Working plans for home health care nurses should be provided one week ahead. It is of special importance that these schedules fulfill the requirements of labor legislation such as daily breaks, maximum working time per day, and sufficient rest times during the week. Additionally, assignment constraints and time windows have to be considered. We propose a novel Branch-and-Price-and-Cut solution approach (BPC) with a good initial solution obtained by a Variable Neighborhood Search based algorithm. The BPC is able to solve medium sized instances to optimality within reasonable computing times.

4 - Joint assignment, scheduling and routing models to Home Care optimization: a pattern based approach
Maria Grazia Scutellà, Informatica, Universita' di Pisa, Largo B. Pontecorvo 3, 56127, Pisa, Italy, scut@di.unipi.it, *Paola Cappanera*

We propose an integrated model that jointly addresses the assignment of skilled operators to patient visits; the visit scheduling in a planning horizon; the daily operator tour determination. Two variants are studied to balance the operator utilization factor, maxmin and minmax. In both cases, the concept of pattern is introduced to jointly address the decisions. Computational results on real instances show that the pattern generation policy is crucial to solve large instances. Furthermore, maxmin returns more balanced solutions, while minmax better minimizes the operating costs.

■ WC-72

Wednesday, 12:30-14:00
R16-2

Functional Analysis of Genetic Networks

Stream: Computational Biology, Bioinformatics and Medicine
Invited session

Chair: *Aleksandra Swiercz*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, ola@man.poznan.pl
Chair: *Pawel Wojciechowski*, Poznan University of Technology, 60-965, Poznan, Poland, pwojciechowski@cs.put.poznan.pl

1 - Biological and statistical analysis of human cholesterol metabolism based on Petri net modeling
Marcin Radom, Institute of Computing Science, Poznan University of Technology, 60-965, Poznan, Poland, Marcin.Radom@cs.put.poznan.pl, *Dorota Formanowicz*, *Piotr Formanowicz*

Cholesterol is a molecule that plays an important role in human body cells. We have created a model of its metabolism using Petri net and analyzed it on a base of transition invariants. In order to perform a cluster analysis, different distance and clustering algorithms have been tested. For the clusters evaluation, the Calinski-Harabasz measure was used. Combining statistical research with the expert knowledge we were able to choose the optimum clustering. Then, the biological analysis took place on the base of t-clusters, which allowed a deeper insight into the cholesterol metabolism.

2 - Integrating different experimental biological datasets in order to identify genes with similar functional meaning
Marek Blazewicz, Institute of Computing Science, Poznan University of Technology, 60-965, Poznan, Poland, Marek.Blazewicz@cs.put.poznan.pl, *Paola Bertolazzi*, *Giovanni Felici*, *Marta Kasprzak*, *Daniele Santoni*, *Aleksandra Swiercz*, *Agnieszka Zmienko*

In the described research work the main impact has been put on integration of available biological resources in order to help understanding and identifying the functions of different genes building the biological systems. In order to achieve this goal we decided to use efficient heuristics and parallel algorithms. As a direct outcome of this research work, we present an innovative method of grouping genes performing similar functional roles in an organisms. The usage of multiple data sources gives an opportunity to minimize the impact of bias existing in the experimental datasets.

3 - Generalized approach to phylogenetic trees construction
Paweł Kędziora, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznań, Poland, pawel.kedziora@cs.put.poznan.pl, *Jacek Blazewicz*, *Piotr Formanowicz*

One of the most important aspect of molecular and computational biology is the evolutionary history reconstruction of a group of species. The classical phylogenetic tree is constructed for a given group of individuals, which are represented by the leaves of the tree. There is assumption that the individuals come from the same point of time. This paper presents the method, which creates a tree for a group of species observed in different points of time and the results of computational experiments conducted for that method.

4 - Fermat-Weber generalizations for predicting drug sensitivity in tumour cells
Elisabetta Fersini, University of Milano-Bicocca, viale Sarca, 336, 20126, Milan, Italy, fersini@disco.unimib.it, *Enza Messina*

The complexity of biological data related to the genetic origins of tumour cells, originates significant challenges to reveal valuable knowledge that can be used to predict therapeutic responses. To discover a link between gene expressions and drug sensitivity, we propose a framework based on generalization of the Fermat-Weber problem. The goal is to create groups of tumour cells and to identify the most representative genes that potentially could explain the drug response. We propose a relational p-median approach and a comparison with a recent multi-facility location problem.

■ WC-73

Wednesday, 12:30-14:00
R16-3

OR in Water Management I

Stream: OR in Water Management
Invited session

Chair: *Elcin Kentel*, Department of Civil Engineering, METU, Orta Dogu Teknik Universitesi, Universiteler Mahallesi, Dumlupinar Blv. No:1, 06800, Ankara, Turkey, ekentel@metu.edu.tr
Chair: *Halil Önder*, Civil Engineering, Middle East Technical University, Middle East Technical University, Department of Civil Engineering, 06800, Ankara, Turkey, onde@metu.edu.tr

1 - Optimization of water tanks
Corinna Hallmann, DS&OR Lab, University Paderborn, Warburger Strasse 100, 33098, Paderborn, Nordrheinwestfalen, Germany, hallmann@dsor.de

The optimization of German water supply systems has gained more and more attention in recent years. In this work an application is presented which optimizes the dimensions of water tanks in a water supply system. The planning of additional tanks is included in the decision process as well. Therefore the optimal location of those tanks is decided. The application includes a combination of network reduction, mathematical optimization and hydraulic simulation. Especially, the non-convex Mixed Integer Quadratically Constrained Optimization Model is presented.

2 - An approach for planning the renewal of pipes in drinking water networks
Florian Stapel, DS&OR Lab, University of Paderborn, Warburger Str. 100, D-33098, Paderborn, Germany, stapel@dsor.de, *Leena Suhl*

In this talk we present an approach for planning the renewal of pipes in German drinking water networks. We discuss a mathematical programming model for deciding both minimal diameters of pipes and the times for a renewal. Multiple time steps within a planning horizon allow for the consideration of varying demands as well as restrictions on the disposable budget. The resulting non-convex Mixed Integer Nonlinear Program is solved by different MINLP-Solvers. As instances may be huge, performance can be improved by additional preprocessing steps.

3 - Application of Chance Constrained Optimization to Booster Disinfection in Water Distribution Systems
Ezgi Köker, Civil Engineering, Middle East Technical University, Insaat Muhendisligi K3 Binasi Oda No: 106, ODTU, 06800, ankara, Turkey, ekoker@metu.edu.tr, *A. Burcu Altan-Sakarya*

Municipal water quality is sustained by addition of disinfectant, commonly chlorine, to the water distribution network. Chlorine concentration in the network is restricted between maximum and minimum bounds, as exceeding amounts cause occurrence of cancerogenic by-products and insufficient amounts fail to disinfect. A chance constrained linear optimization model of water distribution network is developed considering the randomness of chlorine concentration by probability distributions. Network hydraulics and concentration computations are computed by the network simulation software, EPANET.

4 - Optimal allocation of resources for network systems: water and gas supply case studies
Sergei Schreider, School of Mathematical and Geospatial Sciences, RMIT University, GPO Box 2476V Melbourne, 3001, Melbourne, Victoria, Australia, sergei.schreider@rmit.edu.au

Two optimization formulations were considered: one related to the water allocation another one to the gas supply systems. Their common feature is that the major constraints were related to the resource delivery capacities of the system carriers: channels and pipelines, respectively. Both formulations were considered as a single LP and multiple objective problems solved using compromised programming. The results were used for practical managerial decision making associated with infrastructural development of watersheds and further upgrading of gas supply systems anticipating the demand growth.

■ WC-74

Wednesday, 12:30-14:00
R16-4

OR promotion among academia, businesses, governments, etc.

Stream: Initiatives for OR Education
Invited session

Chair: *Dmytro Fishman*, Mathematics and Computer Science, University of Tartu, Estonia, dmytrofishman@gmail.com
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Olga Nazarenko*, National Technical University of Ukraine "Kyiv Polytechnic Institute", Mayakovskogo avenue 17v, apt.72, 02225, Kyiv, Ukraine, onazzzaro@gmail.com

1 - The science and technology policy evolution of Taiwan
Wen Ju Ko, National university of Kaohsiung, Taiwan, minako1115@gmail.com, *Ting-Lin Lee*

This study aims at further exploring the evolution of all previous National Science Technology Conferences' related policy issues based on the content of the sixth, seventh and eighth ones and corresponding it to the real policy implementation. The research questions: What's the policy focus and the network pattern among the policy issues of the last three National Science Technology Conferences? The result of this study can inspect the comprehensiveness of the government's policy planning process and the consistency of policy implementation.

2 - An Adaptive Curriculum Algorithm for Turkish High School Education System
Berk Orbay, Industrial Engineering, Bogazici University, Suna sok. no:34 Etiler, 34340, Istanbul, Turkey, berkorbay@gmail.com, *Ridvan Elmas*, *Kübra çelikdemir*, *Orkun Sahmali*

A prominent and widely known weakness of the current education system is the lack of customizability for the student's individual learning process. Our proposed algorithm suggests "optimized" weekly study schedules based on a modified version Ministry of Education's curriculum guidelines responding to student performance feedback and study pace. We will also share the results of an implementation of the algorithm aimed to prepare the student for the university entrance examination.

3 - Modeling a digital guide of higher technological education professions
Vassilis Kostoglou, Department of Informatics, Alexander TEI of Thessaloniki, P.O. Box 141, 57400, Thessaloniki, Greece, vkostogl@it.teithe.gr, *Michael Vassilakopoulos*, *Lazaros Tsikritzis*

As vocational orientation and employability are today the principal interests of students and young graduates, a higher education specialties' guide adapted to present needs is undoubtedly a useful tool. This work focuses on the design, structure and contents of a higher education professions' digital guide. Special attention is given to the interactivity and usability of the system, as well as on the extraction of the desired information through combined queries. Modeling targets to the operation of the system in both modes; stand-alone and remotely through the www and mobile devices.

4 - Exploring the Impact of OR Communities of Practice on Economic and Social Development
Martin Kunc, Warwick Business School, University of Warwick, Office E0.10, WBS Social Studies Building, CV4 7AL, Coventry, United Kingdom, martin.kunc@wbs.ac.uk

OR academic communities can have an important role in social and economic development providing practitioners, performing academic research and providing consulting services to local industries and governments. While this role has been discussed, it hasn't been formally measured. This paper presents a framework aimed at OR academic communities, especially in developing countries. The framework will help them to foster their recognition among the stakeholders of their local communities in terms of their impact in social and economic development. Preliminary results are discussed.

Wednesday, 14:30-16:00

■ WD-02

Wednesday, 14:30-16:00
O1-2

Iterative methods for differential equations

Stream: Continuous and Discontinuous Dynamical Systems
Invited session

Chair: *Mevlüde Yakıt Ongun*, Mathematics, Süleyman Demirel University, Suleyman Demirel University, Faculty of Arts and Science, Department of Mathematics, 32260, Isparta, Turkey, mevludeyakit@sdu.edu.tr

1 - Solving a System of Fractional Partial Differential Equations Using Differential Transform Method
Ümmügülsüm Cansu, Seconday Science and Mathematics Education, Middle East Technical University, Middle East Technical University, Faculty of Education seconday Science and Mathematics Education, Ankara, Turkey, Turkey, ummugulsumcansu@yahoo.com, *Ozan Özkan*

In this paper, we propose approximate analytical solutions for systems of fractional partial differential equations (fpde) by using differential transform method. The solutions are obtained in the form of convergent series.The fractional derivatives are described in Caputo sense. The numerical results show the approach is easy to implement to the systems of fpde without any restrictive assumptions. The method introduces a promising tool for solving many linear and nonlinear fpde systems.Finally some examples are solved to illustrate the accurateness and effectiveness of the method.

2 - Exact solutions of some linear and non-linear Schrödinger equations using the differential transform method
Ozan Özkan, Mathematics, Selçuk University, Selçuk University, Science Faculty, Department of Mathematics,Campus, 42031 , KONYA, TURKEY, KONYA, TURKEY, Turkey, oozkan@selcuk.edu.tr, *Ümmügülsüm Cansu*

In this paper, we introduced a modification of the differential transform method using Laplace Transform and Padé approximation to obtain closed form solutions of linear and nonlinear Schrödinger equations. It solves the drawbacks in the standard differential transform method. Examples are presented to show the reliability and simplicity of propose technique.

3 - Effects of generalized piecewise constant delays on the dynamical behaviour of the logistic population growth
Leyla Guzel, Matematik, Süleyman Demirel Üniversitesi, Süleyman Demirel Üniversitesi,Fen Edebiyat Fakültesi, 32260, çünür, Isparta, Turkey, leylaguzel0@gmail.com, *Duygu Aruğaslan*

We extend the logistic population growth model with piecewise constant arguments of generalized type. We investigate the effects of these arguments on the dynamical behavior of the model. Results obtained in the existence of piecewise constant delays are compared with the ones obtained for the classical logistic equation without any argument. In order to illustrate our results, we present numerical simulations.

4 - Multi crack problems in an elastic strip
İlkem Turhan, Mathematics, Dumlupinar University, 43100, Kutahya, Turkey, ilkem.turhan@dpu.edu.tr, *Elçin Yusufoğlu*

In this study, cracked elastic strip is considered. It is assumed that N-collinear cracks whose sides are parallel to the boundaries of strip are located longitudinally. In the view of the theory of elasticity, a system of singular integral equations in which the unknown functions correspond to the derivative of vertical displacements of the points on the crack sides is derived. A quadrature approach is applied to the mentioned system to determine the normalized stress intensity factors (SIFs). The effect of the relative thickness of the strip and mechanical properties are examined.

■ WD-03

Wednesday, 14:30-16:00
O1-3

Theory and methods of bilevel programming and variational inequalities

Stream: Variational Inequalities and Bi-Level Problems
Invited session

Chair: *Alain B. Zemkoho*, Mathematics and Computer Sciences, Technical University Bergakademie Freiberg, Akademiestr. 6, 09599, Freiberg, Saxonia, Germany, zemkoho@student.tu-freiberg.de
Chair: *Oleg Khamisov*, Applied Mathematics, Institute of Energy System, Siberian Branch of the Russian Academy of Sciences, Lermontov street, 130, 664033, Irkutsk, Russian Federation, khamisov@isem.sei.irk.ru

1 - Optimality conditions for optimistic bilevel programming problems using set-valued programming
Maria Pilecka, TU Bergakademie Freiberg, Germany, maria.pilecka@math.tu-freiberg.de, *Stephan Dempe*

In this talk we adapt results for a general set valued optimization problem to an optimistic bilevel programming problem, which consists of minimizing a real valued upper level objective function over a feasible set given by a set valued optimal solution mapping of the lower level problem. We derive optimality conditions under the assumption, that the optimal solution mapping is upper semicontinuous. We use the support function to characterize this mapping and introduce a new concept of a directional convexificator in order to deal with possible discontinuity of the support function.

2 - Methods of nonlinear support functions in bilevel programming
Oleg Khamisov, Applied Mathematics, Institute of Energy System, Siberian Branch of the Russian Academy of Sciences, Lermontov street, 130, 664033, Irkutsk, Russian Federation, khamisov@isem.sei.irk.ru

We consider nonlinear bilevel problems in which the follower problem can be represented by an implicit nonlinear inequality. It is assumed that the inequality-function has upper and lower nonlinear support functions. A global optimization approach is suggested for solving the reduced one-level problem. Cases when the follower problem has such property are discussed and preliminarily computational results are given.

3 - A stochastic Tabu Search for the (r|p)-centroid problem in the plane
Ivan Davydov, Theoretical Cybernetics, Sobolev Institute of Mathematics Siberian Branch of Russian Academy of Science, Pr. Koptyga, 4, 630090, Novosibirsk, Novosibirsk Region, Russian Federation, vann.davydov@gmail.com, *Yury Kochetov*, *Emilio Carrizosa*

We consider the continuous (r|p)-centroid problem in the Euclidean plane. For this bilevel optimization problem we develop a stochastic Tabu Search heuristic, based on the exact approach for the follower problem. We apply the subproblem of finding optimal location for a new facility of the leader. This subproblem allows us to find the best neighboring solution according to the swap neighborhood. It is shown that the subproblem is polynomially solvable for fixed r. Computational experiments shows that our new approach dominates the previous ones.

■ WD-04

Wednesday, 14:30-16:00
O4-4

Regularization and Decomposition methods

Stream: Convex Optimization
Invited session

Chair: *Jacek Gondzio*, School of Mathematics, University of Edinburgh, Edinburgh, United Kingdom, j.gondzio@ed.ac.uk

1 - The penalty-modified barrier Lagrangian function method applied to the resolution of nonlinear programming problems with complementarity constraints
Geraldo R. M. da Costa, electrical engineering, São Paulo University, Sao-carlense, 400 street, 13566-590, Sao Carlos, Sao Paulo, Brazil, geraldo@sc.usp.br, *Guilherme Lage*

This work proposes a new approach for solving nonlinear programming problems with complementarity constraints by the penalty-modified barrier Lagrangian function method. In this approach, the complementarity constraints are transformed into equivalent inequality constraints and the inequality constraints are transformed into equalities by the addition of non-negative slack variables. The non-negativity condition of the slack variables is treated by a modified barrier function with quadratic extrapolation. Then, such modified problem is solved by Newton-Lagrangian method.

2 - Second Order Methods for Strongly Convex L1-Regularization
Kimon Fountoulakis, School of Mathematics, University of Edinburgh, United Kingdom, K.Fountoulakis@sms.ed.ac.uk, *Jacek Gondzio*

Recently there has been an increased interest in large-scale strongly convex L1-regularizations. The community seems to favour the first-order methods for such problems because of their low per iteration cost. We will argue that well-designed second-order methods offer a highly competitive alternative. Convergence analysis will be provided along with extensive computational evidence that the new approach competes favourably with the first-order methods for huge scale problems.

3 - Coupling Proximal Algorithm
Oscar Cornejo, Ingeniería Industrial, Facultad de Ingenieria-Universidad Católica de Concepción, Campus San Andres-Alonso de Ribera 2850, 1, Concepcion, Concepcion, Chile, ocornejo@ucsc.cl

In this talk we are interested in the resolution of the inclusion problem where T is a monotone operator defined on a Hilbert space H, which appears in a wide variety of equilibrium problems such as convex programming and monotone variational inequalities. We modify the Coupling Proximal Algorithm introduced by Moudafi and we present an iterative method for solving convex minimization problems. Further, we obtain results of convergence linear and super-linear for this new algorithm.

■ WD-05

Wednesday, 14:30-16:00
O4-1

Optimal Control Applications 2

Stream: Optimal Control
Invited session

Chair: *Gustav Feichtinger*, Institute of Mathematical Methods in Economics, Vienna University of Technology, Argentinierstraße 8 /E105-4, IWM/ORCOS, 1040, Wien, Austria, gustav@eos.tuwien.ac.at
Chair: *Gernot Tragler*, OR and Control Systems, Vienna University of Technology, Argentinierstr. 8/105-4, A-1040, Vienna, Austria, tragler@eos.tuwien.ac.at

1 - Do Egalitarian Societies Boost Fertility?
Andrea Seidl, Wittgenstein Centre (IIASA, VID/ÖAW, WU), Vienna Institute of Demography/Austrian Academy of Sciences, 1040, Vienna, Austria, andrea.seidl@tuwien.ac.at, *Gustav Feichtinger*, *Alexia Prskawetz*, *Christa Simon*, *Stefan Wrzaczek*

The spreading of egalitarian family values has often been associated with a decline in fertility. However, recently a rebound in fertility has been observed in several industrialized countries. A possible explanation of this trend may be the spread of egalitarian values that induced institutional changes that foster the combination of parenthood and the egalitarian lifestyle. We study the diffusion from traditional to egalitarian gender-behavior and its impact on fertility. We consider the effects of different policy measures on different - potentially conflicting - policy goals.

2 - Optimal control models of renewable energy production under fluctuating supply
Elke Moser, Institute of Mathematical Methods in Economics, Vienna University of Technology, Argentinierstraße 8, 1040, Wien, Österreich, Austria, elke.moser@tuwien.ac.at, *Dieter Grass*, *Gernot Tragler*, *Alexia Prskawetz*

The probably biggest challenge for climate change mitigation is to find a secure low-carbon energy supply, which especially is difficult as renewable sources underlie strong volatility. We therefore consider the energy sector of a small country that optimizes a portfolio consisting of fossil and/or renewable energy to cover a given energy demand, considering seasonal fluctuations in renewable energy generation. By solving these non-autonomous, optimal control models, we investigate the impact of fossil energy prices on the optimal portfolio composition shown by the obtained periodic solutions.

3 - Optimizing Counter-Terror Operations
Gustav Feichtinger, Institute of Mathematical Methods in Economics, Vienna University of Technology, Argentinierstraße 8 /E105-4, IWM/ORCOS, 1040, Wien, Austria, gustav@eos.tuwien.ac.at

The purpose of the present contribution is to illustrate how methods of optimal control and dynamic games may be applied to terror related problems to provide insights into questions of how to effectively fight terror. In a two-player differential game both opponents have to select the intensity of attacks and counter-attacks both reducing the power of the terrorists. Both the terror organization as well as the government have to take into consideration the trade-off between the utility and the costs of their measures.

4 - An optimal control model of corruption with two states and two controls
Gernot Tragler, OR and Control Systems, Vienna University of Technology, Argentinierstr. 8/105-4, A-1040, Vienna, Austria, tragler@eos.tuwien.ac.at, *Andrea Seidl*, *Gustav Feichtinger*

We consider an optimal control model with two state variables describing the shares of corrupt citizens and corrupt officials, respectively, in sub-populations of constant sizes. The government's objective is to find the optimal mix of law enforcement against these two corrupt groups, which is assumed to raise the corresponding probabilities that an offense will result in a conviction. The inherent feedbacks between both corrupt and non-corrupt citizens and officials generate complex behavior including active path constraints and multiple equilibria.

■ WD-06

Wednesday, 14:30-16:00
O4-2

Recent Advances in OR by Scientific Computing

Stream: OR and Scientific Computing
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Peter Gritzmann*, Mathematics, TU München, Arcisstr. 21, D-80290, Munich, Germany, gritzman@ma.tum.de

1 - Parallelization Framework for Efficient Evolutionary Algorithms in Operations Research
Damir Vucina, FESB, University of Split, R. Boskovica bb., 21000, Split, Croatia, vucina@fesb.hr, *Igor Pehnec*
A parallel computational framework for OR is developed such that: (1) it can be implemented on standard PC networks, (2) existing OR software can be used, (3) computational middle-ware (process- and data flows) can invoke heterogeneous sequential/ parallel processes running on common data-sets. The workflow manages asynchronous processes, data transfers, data-mining, invoking of simulators, rejection of infeasible solutions and simulator instances. It is developed in C# within .net and WCF platforms. Servers exposing services are invoked asynchronously by the client via message-passing.

2 - Quick Visual Interaction with Optimization Models
Oliver Bastert, FICO, Maximilianstr. 35a, 80539, Munich, Germany, oliverbastert@fico.com
This demo will show you how to turn an optimization model into a full optimization application in minutes. Using FICO Xpress-Insight, you can start with an optimization model, create optimization scenarios, and compare and visually analyze the execution results from your PC or your mobile device. In addition, we will give an overview of the FICO Xpress Optimization Suite and its new Xpress-NonLinear components which integrates different non-linear technologies into one solver and makes them accessible.

3 - Refining Algorithm for the Matrix Inverse
Ebru Aydoğan, Department of Computer Engineering, Kirikkale University, Kırıkkale Universty Faculty of Engineering, Department of Computer Engineering, Kırıkkale, Turkey, ebru_ce003@hotmail.com, *Hasan Erbay*
Solving systems of linear equations is one of the important problems in applied sciences and engineering. In the literature there are direct methods and iterative methods for computing the inverse of a matrix. In this paper, we suggest an iterative refinement algorithm for the inverse of o non-singular matrix with high convergence rate than existing algorithms. Numerical results are presented that illustrate the accuracy of the algorithm. The numerical results agree with the theory.

■ WD-07

Wednesday, 14:30-16:00
O4-3

MPECs and Related Topics

Stream: Nonlinear Programming
Invited session

Chair: *Steffensen Sonja*, RWTH Aachen University, 52056, Aachen, Germany, steffensen@igpm.rwth-aachen.de

1 - SOS1 Method for Solving MPEC with an Energy Application
Steven Gabriel, Civil & Env. Engin./ Applied Math and Scientific Computation Program, University of Maryland, 1143 Martin Hall, 20742, College Park, MD, United States, sgabriel@umd.edu
In this presentation we provide details on a recent approach to solve MPECs using a transformation involving SOS1 variables. Two versions of this approach are given: one with just SOS1 variables and one with a penalty-type parameter. We illustrate the method on an energy application.

2 - Semismooth Newton Method for Affine Differential Variational Inequalities
Steffensen Sonja, RWTH Aachen University, 52056, Aachen, Germany, steffensen@igpm.rwth-aachen.de
We study a semismooth Newton method for affine linear differential variational inequalities (DVIs). These problems arise e.g. as differential or dynamic Nash games and comprise the solution of two problems: an ordinary differential equation (ODE) and an infinite dimensional variational inequality (VI). In our approach, the DVI is first discretized, then reformulated as a nonlinear, nonsmooth system and finally solved using a nonsmooth version of Newton's method. In our talk, we present the theoretical properties of this approach as well as some numerical results.

3 - On active set methods for the quadratic programming problem
Anna Daryina, Department of Nonlinear Analysis and Safety Problems, Institution of Russian Academy of Sciences Dorodnicyn Computing Centre of RAS, Vavilova str, 40, Moscow, Russian Federation, daryina@ccas.ru

The active set Newton method developed earlier for mixed complementarity problems is applied to solving the quadratic programming problem with a positive definite matrix of the objective function in general formulation, problems with box constraints and problems with equality constraints and the nonnegativity conditions for all variables. A theoretical justification is given to the fact that the method is guaranteed to find the exact solution in a finite number of steps. Numerical results indicate that this approach is competitive with other available methods for quadratic programming problems

4 - Sl1QP Based Algorithm with Trust Region Technique for Nonlinear Second-Order Cone Programs
Shunsuke Hayashi, Graduate School of Information Sciences, Tohoku University, 6-3-09 Aramaki-Aoba, Aoba-Ku, 980-8579, Sendai, Japan, s_hayashi@plan.civil.tohoku.ac.jp, *Kohei Yasuda*, *Takayuki Okuno*

We propose an algorithm based on Fletcher's Sl1QP method combining the trust region technique for solving Nonlinear Second-Order Cone Program (NSOCP). We first introduce an exact penalty function with respect to second-order cone constraints and then reformulate the NSOCP as an unconstrained optimization problem. However, since each subproblem generated is nondifferentiable, we reformulate it as an SOCP whose objective function is quadratic and constraint functions are affine. We also show that the generated sequence converges to a stationary point of the NSOCP under mild assumptions.

■ WD-08

Wednesday, 14:30-16:00
O3-2

Keynote - A. Letchford

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - The Simple Plant Location Problem: a Case Study in Combinatorial Optimisation
Adam Letchford, Department of Management Science, Lancaster University, Management School, LA1 4YX, Lancaster, United Kingdom, A.N.Letchford@lancaster.ac.uk

The Simple Plant Location Problem (SPLP), also known as the Uncapacitated Facility Location Problem or Warehouse Location Problem, is a classical problem in Operational Research that was introduced in the early 1960s. One is given a set of facilities and a set of clients. One knows the cost of opening each facility, and the cost of assigning any given client to any given open facility. The task is to decide which facilities to open, and then assign each client to an open facility, at minimum cost.

Despite being very easy to state, the SPLP is actually a non-trivial combinatorial optimisation problem. In fact, it was formally proved to be NP-hard by Krarup & Pruzan, 1983. (Roughly speaking, this means that it is unlikely that there exists an algorithm capable of solving every instance in a reasonable amount of time.) Nevertheless, some sophisticated algorithms have been developed for the SPLP, that are capable of computing provably optimal or near-optimal solutions to instances with thousands of facilities and clients.

This keynote talk will give a gentle introduction to the literature on the SPLP. The talk will consist of two parts. In the first part, which will last about 50 minutes, I will survey the literature on the following ten topics:

• integer programming formulations,

- linear programming relaxation,
- cutting planes,
- dual ascent and dual adjustment,
- Lagrangian relaxation,
- greedy constructive heuristics,
- local search heuristics,
- meta-heuristics,
- approximation algorithms,
- variable elimination tests.

In the second part of the talk, which will last about 20 minutes, I will present some new results that I have obtained with a former PhD student of mine, Sebastian Miller. This includes (i) new lower- and upper-bounding procedures for very large-scale instances, (ii) a new class of cutting planes, along with a procedure to generate them, and (iii) some new variable elimination tests, which prove to be particularly effective for instances in which the facilities and clients are located in the Euclidean plane.

■ WD-09

Wednesday, 14:30-16:00
O3-3

Sponsor - ACT-OR

Stream: Sponsors
Sponsor session
Chair: *Michele Monaci*, D.E.I., University of Padua, Via Gradenigo 6/A, 35131, Padova, Italy, monaci@dei.unipd.it

1 - Strong business performance through advanced analytics and optimization

Raffaele Maccioni, ACT Operations Research, Italy, raffaele.maccioni@act-operationsresearch.com

ACT-OR is a math-technology company. ACT-OR's advanced analytics and algorithms drive logistics, marketing, and merchandising performance across store, warehouse, fleet and the supply-chain network. Combined powerful predictive and dynamic optimization and simulation models keep operational efficiency and business risk under control. Since 1996, ACT Operations Research (ACT-OR) is a privately held company with offices in Europe and the USA.

Market.

ACT-OR's purpose-built, on-premise and SaaS solutions scale across multiple verticals, public companies and private SMBs. Top-performers make the difference with ACT-OR's quantitative science-based technology. Due largely to its extraordinarily modest TCO, rapid time to value, and continuing growth in functionalities, ACT-OR gained a reputable market position in retail, logistics and transportation, oil and gas, chemical and pharmaceutical verticals. ACT-OR is currently focused on the international expansion of its business in Europe, the Americas and Asia either with direct offices or channel partners. The company has planned to raise equity capital within the next two years.

Products portfolio: Forecast market analytics.

Before! Predictive Analytics. A powerful sales forecasting platform, Before! Predictive Analytics automatically chooses the best-performing model to draw on when generating forecasts. Its high-speed parallel computing easily processes large amount of data ("big data") and complex calculations from fashion retail verticals. The product runs on cloud's IT architectures. Before!Promo is a purpose-built solution to forecast promotional sales. Before!Market Analytics includes three modules providing retailers with powerful sales insights including sensitive items and multi-level dynamic store benchmarking across assortment mix, promotion effectiveness, shelf-space allocation, but also price life cycle, venue, and store size.

Products portfolio: Investment buying and store replenishment.

OPT Buying. When it comes to purchase inventory, merchandize companies grapple with a trade- off between stock-hoarding costs and customer service level. Weighing in a conscious amount of risk exposure, buyers rely on OPT Buying to optimize the amount of items to stock.

OPT Shipping. A parametric multi-objective optimizer draws on quantitative and qualitative goals to replenish stores from multiple sources.

Products portfolio: Warehouse, transportation and distribution.

OPT Warehouse. A suite of optimization models to optimize picking and stocking processes. Easily integrates with simulation models (e.g., SIMIO, Arena) and WMSs. OPT Runner. A truck scheduling, routing and planning tool for multi-level logistics' networks. Express delivery couriers draw on OPT Runner's purpose-built module optimizing urban distribution. OPT Calendar. When replenishing or just visiting your store network, OPT Calendar finds the optimum schedule while balancing distribution effort and minimizing distribution costs amid constraints. OPT Vessel. A vessel scheduling, routing and planning tool for maritime shipping of oil, coal and containers amid multi-level costs and constraints.

Success cases.

With ACT-OR OPT Runner, a fifteen-thousand-SKU retailer serving multi-hundred stores cutback work hours by 50%, saved 12% of transportation costs while reducing their volatility by 34%. With ACT-OR OPT Warehouse, a ten-thousand-SKU retailer hit higher rack throughput (+16%), shorter stock-to-pick distance (-46%), and a lower let down distance (-49%). With ACT-OR OPT Before! a four-hundred-store food retailer tremendously reduced stock-outs and over stocks when replenishing stores daily with fresh food. A fashion retailer maximized its sales by replenishing its multi-hundred stores with Before! and OPT Shipping.

■ WD-10

Wednesday, 14:30-16:00
G5-1

P2P and Social Networks

Stream: Telecommunications and Network Optimization
Invited session
Chair: *Dilek Gunnec*, Industrial Engineering, Ozyegin University, Istanbul, Turkey, dilek.gunnec@ozyegin.edu.tr

1 - P2P Lookup Services Based on De Bruijn Graph

Amad Mourad, LAMOS, Bejaia University, Bejaia, Bejaia, Algeria, amad.mourad@gmail.com, *Djamil Aïssani*, *Abdelouhab Aloui*

De Bruijn graphs have been proposed for many applications and network routing such as Koorde and D2B. However, most of them suffer from the scalability problem. In this paper, we propose a scalable solution for lookup acceleration and optimisation in peer to peer network based on De Bruijn graph. The proposed scheme inherits both the advantages of Koorde and D2B. Performance evaluations show that the results are globally satisfactory, especially in term of cost lookup.

2 - Herd behavior on innovation diffusion

Chuanzhen Wu, Management School, Xiamen University, China, wuchzhen@126.com, *Di Xu*

Herd behavior has been recognized as a key factor in the process of innovation adoption. We try to find empirical evidence to show how the opinion leader will leverage the adoption of others in the view of social network. The main aims are to (1) find the various correlation of herding patterns and technical compatibility, (2) the correlation of herding and network topology, (3) the evolving process. That will provide evidence for better decision making.

3 - Privacy of multimedia content on Social Networks

Athanasios Zigomitros, Informatics, University of Piraeus, Greece, azigomit@unipi.gr, *Constantinos Patsakis*, *Achilleas Papageorgiou*

Users' privacy is a key element on social networks. People are becoming aware of the dangers that emerge from thoughtless disclosure of information on Social Networks and demand more privacy-aware platforms. Several solutions have been proposed in order to achieve an acceptable level of privacy, however, almost all of them ignore one of the key aspects, multimedia content. Extended experiments show that major SNs do not apply any watermarking or steganographic scheme on their services. Based on this fact, this study illustrates a novel solution, using well-known techniques.

4 - The Least Cost Influence Problem on a Social Network
Dilek Gunnec, Industrial Engineering, Ozyegin University, Istanbul, Turkey, dilek.gunnec@ozyegin.edu.tr, *S. Raghavan*

In this paper, we analyze the diffusion process of a product/information over a social network while incentives are provided to the individuals to maximize the spread. Such catalyzation addresses the trade-off of minimizing the amount of incentives and reaching a greater number of buyers/adopters in the network. The Least Cost Influence Problem is an NP-Hard problem for general networks. However, we show that it is polynomially-solvable on tree networks under the assumption that all neighbors of a node exert equal influence. We propose a dynamic programming algorithm to solve the problem.

■ WD-11

Wednesday, 14:30-16:00
G5-3

Network Location Problems

Stream: Location Analysis
Invited session

Chair: *Andrea Scozzari*, Economia, Università degli Studi Niccolò Cusano - Telematica, Via Don Carlo Gnocchi n.3, 00166, Roma, Italy, andrea.scozzari@unisu.it

1 - The multi-criteria p-facility median location problem on networks
Miguel Angel Pozo, Statistics and OR, Universidad de Sevilla, Seville, Spain, miguelpozo@us.es, *Jörg Kalcsics*, *Stefan Nickel*, *Justo Puerto*, *Antonio Manuel Rodriguez-Chia*

This paper discusses the multi-criteria p-facility median location problem on networks with positive and negative weights. We assume that the demand is located at the nodes with a variable weight according to the criterion under consideration. The goal is to obtain the set of non dominated objective values as well as the corresponding set of Pareto-optimal locations in the graph.

2 - A trip covering location problem on networks with two transfer points and mixed distances
María Cruz López-de-los-Mozos, Matemática Aplicada I, Universidad de Sevilla, Escuela Técnica Superior de Ingeniería Informática, Avda. Reina Mercedes, s/n, 41012 Sevilla (Spain), 41012, Sevilla, Spain, mclopez@us.es, *Juan A. Mesa*, *Anita Schöbel*

In this work we consider a high-speed transportation network embedded in the plane with the Euclidean distance together with a set of origin-destination pairs, and study the problem of locating two points in the network which maximize the number of covered pairs. In order to solve this problem we propose a decomposition method based on first partitioning the network on a collection of subedges, and then solving the restricted problem formulated on each pair of subedges of the partition.

3 - On some location/distribution problems and their associated fair allocation schemes
Justo Puerto, Estadistica e I.O., Universidad de Sevilla, Facultad de Matematicas, 41012, Sevilla, Spain, puerto@us.es

We analyze facility location/distribution models, their resolution problems and some allocation processes that appear to enforce cooperation among their users. These optimization problems are endowed with natural cooperative games where players are the customers and the characteristic value of a coalition is the cost of optimally serving its members. Specifically, we shall address general single facility location problems on networks. In particular, we shall address the cases of total set up cost plus transportation cost and different types of coverage costs (radius and diameter).

4 - Unreliable point facility location problems on networks
Andrea Scozzari, Economia, Università degli Studi Niccolò Cusano - Telematica, Via Don Carlo Gnocchi n.3, 00166, Roma, Italy, andrea.scozzari@unisu.it, *Justo Puerto*, *Federica Ricca*

We study location problems on graphs under the most common criteria: median, center and centdian, incorporating in the objective function some reliability aspects. Assuming that facilities may become unavailable with a certain probability, the problem consists of locating facilities minimizing the overall or the maximum expected service cost in the long run, or a convex combination of the two. We provide efficient algorithms for these problems for the cases of k=1,2, both on graphs and on trees. We show how our approach extends to more general classes of unreliable point location problems.

■ WD-12

Wednesday, 14:30-16:00
G5-4

Control with systems thinking II

Stream: Control Theory & System Dynamics (contributed)
Contributed session

Chair: *Ying-Chin Ho*, Institute of Industrial Management, National Central University, No.300, Jhongda Rd, 320, Chung-Li, Taoyuan, Taiwan, ho@cc.ncu.edu.tw

1 - A Dynamic Simulation Model For Insulin Resistance and Type II Diabetes in the Context of Obesity
Melike Hazal Can, Industrial Engineering, Koc University, Istanbul, Turkey, melikecan@ku.edu.tr, *Aybek Korugan*, *Yaman Barlas*

Type 2 diabetes is a frequently seen endocrinologic disease leading to other serious health problems that may eventually lead to a premature death.Insulin resistance is seen as the starting point of this disorder. A dynamic simulation model is constructed which focuses on the interaction between the body weight and the glucose-insulin regulation, that can realistically reproduce the long term behavior of developing insulin resistance and type 2 diabetes related to obesity. Simulation experiments show that different exercise levels, dietary intakes have impact on insulin resistance.

2 - State Estimation with Runge-Kutta Model-Based Nonlinear Observers
Meric Cetin, Computer Engineering, Pamukkale University, Kinikli Campus,, Computer Engineering, Denizli, Turkey, mcetin@pau.edu.tr, *Serdar Iplikci*, *Selami Beyhan*

In this paper, two nonlinear observers are designed for state estimation of continuous-time nonlinear systems namely Runge Kutta model-based gradient observer and Runge Kutta model-based extended-Kalman filter. These observers have been compared with extended-Kalman filter on a nonlinear servo system w.r.t estimation performance. According the application results, RKEKF has the best performance of state estimation for the servo system and RKGO can be considered to design an observer without parameter selection. Finally, the proposed observers have a considerable place among conventional ones.

3 - Efficient Control of Rail-Guided Vehicles in a TFT-LCD Plant
Ying-Chin Ho, Institute of Industrial Management, National Central University, No.300, Jhongda Rd, 320, Chung-Li, Taoyuan, Taiwan, ho@cc.ncu.edu.tw, *Teng-Sheng Su*

The problem environment of this study is a TFT-LCD bay with an in-line stocker system and a RGV (Rail-Guided Vehicle) system. In this paper, we focus the control problems of the RGV system. We identify three control problems and develop control rules for them. These three problems are task-determination problem, I/O point-clearing problem, and port-clearing problem. Computer simulations were conducted to compare the performance of the proposed rules. It is hoped the knowledge learned from this study can benefit TFT-LCD manufacturers in improving the performance of their RGV systems.

4 - Optimal Self Control of Observable Processor-Sharing Queues
Chia-Li Wang, Applied Mathematics Dept, National Dong Hwa University, Shoufeng, 974, Hualien, Taiwan, cwang@mail.ndhu.edu.tw

Consider the management of an observable processor-sharing queue with homogeneous and heterogeneous customers, that is, customers with the same or different utility functions. We study the customer's decision to join the queue or balk, and obtain conditions of the existence and the uniqueness of the Nash equilibrium policy. We also consider the system administrator's concern in finding the policy that maximizes the profit of the system as a whole. These policies are shown to be different via a coupling argument.

■ WD-13

Wednesday, 14:30-16:00
G5-5

Green Vehicle Routing and Scheduling

Stream: Vehicle Routing and Scheduling with Environmental Considerations
Invited session

Chair: *Tolga Bektas*, University of Southampton, School of Management, Highfield, SO17 1BJ, Southampton, United Kingdom, T.Bektas@soton.ac.uk

1 - An Evolutionary Algorithm for the Heterogeneous Fleet Pollution-Routing Problem
Çağrı Koç, Southampton Management School and CORMSIS, University of Southampton, Highfield SO17 1BJ, Southampton, United Kingdom, c.koc@soton.ac.uk, *Tolga Bektas*, *Ola Jabali*, *Gilbert Laporte*

This paper presents an algorithm, based on hybrid genetic search with adaptive diversity control, for the Heterogeneous Fleet Pollution-Routing Problem (HFPRP). The HFPRP is an extension of the Vehicle Routing Problem with time windows, considers a heterogeneous vehicle fleet, where objective is to minimize fuel consumption. Within the algorithm Adaptive Large Neighborhood Search used as a local search heuristic, and a Speed Optimization Procedure is applied on each candidate solution. This talk will describe the components of the algorithm in detail and present results on its performance.

2 - An Exact Solution for the Pollution-Routing Problem
Emrah Demir, School of Industrial Engineering, Eindhoven University of Technology, 76 Cederlaan, 5616 SC, Eindhoven, Netherlands, e.demir@tue.nl, *Said Dabia*, *Tom Van Woensel*

The pollution-routing problem (PRP) is an extension of the classical VRPTW. The PRP consists of routing a number of vehicles to serve a set of customers and deciding on their speed on each route. We propose an exact solution algorithm for the PRP based on a branch-and-price algorithm. The purpose is to determine the set of routes that minimizes the sum of fuel consumption and total driving time. Considering speed as a decision variable notably complicates the pricing problem, which is solved by means of a tailored labeling algorithm. Computational results support the value of the approach.

3 - The Time-Dependent Pollution-Routing Problem
Tolga Bektas, University of Southampton, School of Management, Highfield, SO17 1BJ, Southampton, United Kingdom, T.Bektas@soton.ac.uk, *Anna Franceschetti*, *Dorothee Honhon*, *Tom Van Woensel*, *Gilbert Laporte*

The Time-Dependent Pollution-Routing Problem (TDPRP) consists of routing a fleet of vehicles in order to serve a set of customers and determining the speeds on each leg of the routes. The cost function includes fuel, emission and driver costs, taking into account traffic congestion. The main idea of this study is to focus on insights drawn from small scale instances and to derive analytical results. More specifically, the talk will describe how allowing for idle waiting at the depot and customer nodes can be used as an effective strategy to avoid congestion and to reduce the total travel cost.

4 - Minimizing emissions in the time and location dependent capacitated vehicle routing problem
Mehmet Soysal, Operations Research and Logistics, Wageningen University, Hollandseweg 1, 6706 KN, Wageningen, Netherlands, mehmet.soysal@wur.nl, *Jacqueline Bloemhof*, *Jack van der Vorst*

Real-world VRP applications need to consider the effects of urban and rush hour traffic on vehicle speed. This paper focuses on two versions of the time and location dependent capacitated VRP, each with a different objective: (i) minimizing total time of operations, (ii) minimizing total emissions. We compare the differences in terms of routing decisions, total time of operations and total emissions between these problems. We also propose a heuristic approach based on random sampling, restricted DP heuristics and simulation. Finally, the results of some computational experiments are discussed.

■ WD-14

Wednesday, 14:30-16:00
G5-6

Hybrid approaches for mixed integer programs

Stream: Hybridisation of Heuristic for Global Optimisation
Invited session

Chair: *Saïd Hanafi*, ISTV2, LAMIH-SIADE, University of Valenciennes, Le Mont Houy, 59313, Valenciennes, France, said.hanafi@univ-valenciennes.fr

1 - Advanced Greedy Algorithms and Surrogate Constraint Methods for the Multi-dimensional Knapsack Problem
Michel Vasquez, LGI2P, Ecole des Mines d'Ales, Parc Scientifique Georges Besse, 30035 Nimes cedex 1, 30035, Nîmes, Gard, France, michel.vasquez@mines-ales.fr, *Fred Glover*, *Saïd Hanafi*

New advanced greedy algorithms and surrogate constraint methods are identified for improving the solution of multi-dimensional knapsack (MDK)problems. We provide a new graduated-probe strategy for selecting variables to be assigned values, and describe ways to utilize our component algorithms with multi-start and strategic oscillation metaheuristics. Finally, we show that our surrogate constraint methods produce inequalities that dominate those previously proposed and tested for solving MDK problems. Our approaches can be adapted to handle variables with general upper bounds.

2 - An interpretation of feasiblity algorithms in Integer programming
Andrew Eberhard, Mathematical and Geospatial Sciences Dept., RMIT University, GPO Box 2476V, 3001, Melbourne, Victoria, Australia, andy.eb@rmit.edu.au, *Natashia Boland*, *Faramroze Engineer*, *Angelos Tsoukalas*

The feasibility pump is a highly successful heuristic for mixed integer linear programming problems. We show that the feasibility pump heuristic can be interpreted as a discrete version of the proximal point algorithm. We provide new supporting theory to show that feasibility pump algorithm implicitly minimizes, over the LP relaxation, a weighted combination of the objective and a term which penalizes lack of integrality. This interpretation suggests alternative ways of incorporating restarts, one of which is the application of cutting planes. Numerical experiments show encouraging results.

3 - An Improved Integer Programming Model for the School Timetabling Problem
Geraldo Ribeiro Filho, Sistemas de Informação, Faculdade Unida de Suzano UNISUZ, Av Louraci Nina Tavares 121, ED Porto Seguro AP 32, 08773-650, Mogi das Cruzes, SP, Brazil, geraldorf@uol.com.br, *Luiz A. N. Lorena*, *Cilene Araujo da Cruz*

This work presents the improved form of a binary integer programming model applied to the school timetabling problem. Pairs of teachers and classes associated to timeslots are modeled as binary integer variables weighted by parameters referring to teachers preferences. Conflicting pairs relative to each timeslot are modeled as constraints. Additional variables are used to model same teacher classes assigned to subsequent joint timeslots, and additional constraints are used to induce, or avoid, such assignments, according to user requirements. Results over real problems are presented.

4 - Hybridisation of MIL formulations and VNS for a variety of routing problems
Said Salhi, Kent Business School, University of Kent, Centre for Logistics & Heuristic Optimisation,, Parkwood Road, University of Kent, CT2 7PE, Canterbury, Kent, United Kingdom, s.salhi@kent.ac.uk, *Mouaouia Cherif Bouzid*, *Hacene Ait Haddadene*

MILP formulations based on 'route first cluster second' and knapsack models are presented. These are easily extendable to deal with several types of routing problems. Examples such as the mTSP, the VRP, the vehicle fleet mix problem and the multi-depot mTSP will be used for illustration. As there is a lack of correlation between the giant tours and the knapsack solutions, a VNS-based heuristic is introduced into the search to generate other perturbed giant tours. Preliminary computational results will be presented for some of the above routing problems.

■ WD-15

Wednesday, 14:30-16:00
G5-2

Yard Operations

Stream: Container Terminal Operations
Invited session

Chair: *Ceyda Oguz*, Department of Industrial Engineering, Koc University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, coguz@ku.edu.tr

1 - Real-time crane scheduling and stack allocation in a container terminal
Rudolf Bauer, WINFOR (Business Computing and Operations Research) Schumpeter School of Business and Economics, University of Wuppertal, Gaußstraße 20, 42119, Wuppertal, Germany, bauer@wiwi.uni-wuppertal.de, *Stefan Bock*, *Paul Göpfert*

We consider a real-world application at a container terminal, where a single crane loads, unloads and transships containers from multiple modes of transportation. Additionally, the crane is utilized for the piling of containers in an affiliated stack storage. In order to minimize the total travel time of the crane efficient scheduling and stack allocation are necessary. Furthermore, new transportation tasks for the crane may arise dynamically. Hence, we propose a real-time approach applying a fast tabu search heuristic. First computational results for several real-world instances are reported.

2 - The stowage-plan driven Marshaling Problem
Marcello Sammarra, Istituto di Calcolo e Reti ad Alte Prestazioni, Consiglio Nazionale delle Ricerche, Via P. Bucci 41-C, 87036, Rende (CS), Italy, sammarra@icar.cnr.it, *Manlio Gaudioso*

Housekeeping operations are yard-to-yard movements of containers inside maritime terminals. We focus on the management of those movements occurring before the loading phase. The aim is to select the export containers to move to the buffer areas, i.e. the containers to be marshaled, taking into account the vessel stowage plan. The objective is to minimize the runtime costs, in terms of the distance traveled by the ground vehicles. We propose a 0-1 Linear Program, a Lagrangean decomposition scheme, a dual ascent procedure for solving the Lagrangean Dual. Numerical results are also discussed.

3 - Container Stacking Strategies for the Storage Yard Management
Christopher Expósito Izquierdo, Estadística, I.O. y Computación, University of La Laguna, Spain, cexposit@ull.es, *Belen Melian Batista*, *Marcos Moreno-Vega*

Container handling operations are one of the main performance indicators of a container terminal efficiency. The container stacking strategies are devoted to handle the containers located on the yard of a terminal in such a way that they can be efficiently accessed. This work is aimed at analyzing the suitability of several stacking strategies when maximizing the productivity of the cranes. Multitude of optimization problems arise in this context with competing objectives stemming from the inherit constraints of the stacking, the technical features of handling equipment and yard layout.

4 - Storage yard management for a transhipment hub port
Ek Peng Chew, Industrial and Systems Engineering, Faculty of Engineering, National University of Singapore, 10 Kent Ridge Crescent, 119260, Singapore, isecep@nus.edu.sg

An important consideration for a transshipment port is that it must be able to turn vessels quickly and this poses a challenge for terminal operators handling mega vessels. Terminal operators focus much attention on implementing quay side equipment technology. However, terminal productivity will not benefit from faster quay cranes unless the storage and retrieval of containers from the storage yard can be done efficiently. The efficiency of the yard in turn is very much dependent on the storage yard plan. A new storage yard strategy will be introduced.

■ WD-16

Wednesday, 14:30-16:00
G5-7

Metaheuristics for Routing Problems I

Stream: Routing Problems
Invited session

Chair: *Jose Brandao*, Management, University of Minho; CEMAPRE — ISEG, Technical University of Lisbon, Largo do Paço, 4704 -553, Braga, Portugal, sbrandao@eeg.uminho.pt

1 - A tabu search algorithm for the vehicle routing problem with backhauls and soft time windows
Jose Brandao, Management, University of Minho; CEMAPRE — ISEG, Technical University of Lisbon, Largo do Paço, 4704 -553, Braga, Portugal, sbrandao@eeg.uminho.pt

The vehicle routing problem with backhauls and soft time windows contains two distinct sets of customers: those that receive goods from the depot and those that send goods to the depot. To each customer is associated an interval of time (time window), during which each one should be served. The time window is soft if it can be violated by a certain amount, which represents an additional cost. This problem is solved applying a tabu search algorithm whose performance is compared with other algorithms from the literature using a large set of benchmark problems.

2 - A genetic algorithm based on insertion heuristics for solving the VRPTW
Gintaras Vaira, Vilnius University, Institute of Mathematics and Informatics, Akademijos St. 4, 08663, Vilnius, Lithuania, gintaras@vaira.net, *Olga Kurasova*

We propose a genetic algorithm based on construction heuristics for the VRPTW. A random insertion heuristic is used to construct initial solutions and to reconstruct existing ones. The location where a randomly chosen node will be inserted is selected by calculating the objective function. The process of random insertion preserves stochastic genetic algorithm characteristics and also allows the generation of feasible individuals. Defined crossover and mutation operators incorporate random insertion heuristics, analyze individuals and select which parts should be reinserted.

3 - A new algorithm based on tabu search to solve vehicle routing problems with time windows
Şahin Erat, Industrial Engineering, Sakarya University, Muratreis, 34664, İstanbul, Üsküdar, Turkey, erat_sahin@hotmail.com, *Emre Tüncel*, *Mustafa Güler*, *Sena Kir*, *Harun Yazgan*

In today's globalized world, transportation became one of the most important challenges for companies in the international arena. The main objective of the companies is to minimize the overall transportation cost. In this study, we considered the vehicle routing problem with time windows which is a very well-known problem since almost 50 years. We constructed a new algorithm based on the Tabu Search method which is more appropriate for real life problems. The proposed algorithm was applied to a manufacturing factory. The results illustrated the efficiency of the proposed algorithm.

4 - Solving the vehicle routing problem with cargo weight considerations
Emmanouil Zachariadis, Department of Management Science & Technology, Athens University of Economics and Business, Greece, ezach@aueb.gr, *Christos Tarantilis*, *Chris Kiranoudis*

We tackle a vehicle routing variant whose objective is to minimize the product of the distance travelled multiplied by the weight travelled along this distance. In comparison to the classic routing objectives, this weighted distance metric is more closely related to the total energy requirements of the vehicle fleet, thus it more precisely accounts for the total fuel consumption. Therefore, it constitutes a suitable optimization objective when the environmental aspects of vehicle routing are considered. Several experiments are executed to examine the key characteristics of the problem.

■ WD-17

Wednesday, 14:30-16:00
G5-8

Maritime transportation and logistics

Stream: Maritime Transportation
Invited session

Chair: *Marielle Christiansen*, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz vei 3, N-7491, Trondheim, Norway, marielle.christiansen@iot.ntnu.no
Chair: *Henrik Andersson*, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Gløshaugen, Alfred Getz vei 3, NO-7491, Trondheim, Norway, Henrik.Andersson@iot.ntnu.no

1 - Fleet renewal in liner shipping: a real life case
Giovanni Pantuso, Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz vei 3, 7491, Trondheim, Norway, pantuso@iot.ntnu.no, *Kjetil Fagerholt*, *Stein W. Wallace*

Based on the case of Wallenius Wilhelmsen Logistics, a major liner shipping company, we present a study on the renewal of the fleet. Our main interest is that of finding the best modeling approach, with special regard to uncertainty. Tests show that stochastic programming can noticeably improve decision making if compared to deterministic programming, and highlight critical elements of the problem.

2 - A heuristic for a routing and scheduling problem of a tramp shipping company offering VMI services
Ahmad Hemmati, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, SBI, 10. etg, Alfred Getz veg 3, 7491 , Trondheim, Norway, ahmad.hemmati@iot.ntnu.no, *Lars Magnus Hvattum*, *Henrik Andersson*

We consider a Vendor Managed Inventory (VMI) service in tramp shipping industry. VMI takes advantage of introducing flexibility in delivery time windows and cargo quantities, and transfers inventory management and ordering responsibilities to the vendor. We propose a heuristic to convert inventories into cargoes and then updating the time windows and quantities based on the information gained during the interacting with an Adaptive Large Neighborhood Search (ALNS) which solve the cargo ship routing problem. Computational results will be presented, discussed and compared with exact solutions.

3 - Formulations for a Problem of Petroleum Transportation
Hugo Harry Kramer, Department of Production Engineering, Universidade Federal Fluminense, Rua Passo da Pátria, 156, Bloco E, 4º andar, Sala 440, São Domingos, 24210-240, Niterói, Rio de Janeiro, Brazil, hugoharry@gmail.com, *Luiz Aizemberg*, *Artur Pessoa*, *Eduardo Uchoa*

We consider a problem of scheduling tankers for transporting oil, considering consumptions over time, inventory capacities and discrete transport lot sizes. We compare the integer programming formulations from the literature with newly proposed ones, over a set of 75 instances. By avoiding symmetries in the branching, the newer formulations obtain very significant gains, solving 42 of those instances for the first time.

4 - Designing a maritime supply chain for the distribution of pellets
Marielle Christiansen, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz vei 3, N-7491, Trondheim, Norway, marielle.christiansen@iot.ntnu.no, *Kristian Andersen*, *Henrik Andersson*, *Roar Grønhaug*, *Aslanbek Sjamsutdinov*

For heating, there is a request to substitute non-renewable energy sources with more environmental friendly sources. The main producer of wood pellets in Norway, and many of its customers, is located close to the coast. The objective of this project was to estimate the profitability of a maritime distribution network instead of the current land-based network. The main decisions are to decide the number and types of ships needed in different seasons and which port storages to use, taking the routing and inventory management into account. We present elements of the model and analyses performed.

■ WD-18

Wednesday, 14:30-16:00
G5-9

Stochastic Modeling and Simulation VI

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Nikolas Tsantas*, Department of Mathematics, University of Patras, Department of Mathematics, University of Patras, 26500, Patras, Greece, tsantas@upatras.gr
Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - Impact of information-based assignment strategies on cycle time performance at wet tools
Anna Rotondo, Dublin City University, Ireland, anna.rotondo@dcu.ie, *John Geraghty*, *Paul Young*

This study investigates the impact of information quality and quantity on the performances of different assignment strategies applied at a wet station operating in a real semiconductor manufacturing facility. The assignment strategies developed to minimise the average cycle time (CT) at the wet station modelled incorporate different levels of information on the system's current status. Their efficacy in generating significant CT reductions has proved robust to different wet stations' configurations and the importance of information-based decision support tools has been demonstrated.

2 - Economic impact of an Ageing population — Microsimulation and CGE approach — case of Slovakia
Ivan Lichner, Economic modeling and analysis, Institute for Economic Research SAS, Sancova 56, 81105, Bratislava, Slovakia, ivan.lichner@savba.sk, *Tomas Domonkos*

Ageing represents one of the raising issues in the current Europe. Main economical consequences in short represent increased pressures on public financing mainly via payments from pension systems and reduction of available work-force that will need from economies to effectively deal with this shortage. On the other hand it would represent an opportunity for companies to focus on the needs of growing market segment. In this work we present results of integrated Microsimulation-CGE approach analyzing the impact of Ageing on small open economy.

3 - Tradeoffs and Optimization of Bundling Decisions for HealthCare Products
Cigdem Gurgur, MANAGEMENT, PURDUE UNIV., DOERMER SCHOOL OF BUSINESS, 2101 EAST COLISEUM BLVD., 46805, FORT WAYNE, IN, United States, gurgurc@ipfw.edu

Our study considers supplier selection and quantity allocation decisions for a health care provider that may purchase new products, as well as refurbished products in managing the end-to-end supply chain. New products are more expensive than the used ones, but can be delivered any time and in any quantity. Refurbished products have the same quality, but they are sold in bundles. We formulated the problem using mathematical programming with stochastic constraints. We use data from a large healthcare provider in Indiana to test the implications of our study.

4 - On the Markovian intra and inter departmental mobility in discrete time
Nikolas Tsantas, Department of Mathematics, University of Patras, Department of Mathematics, University of Patras, 26500, Patras, Greece, tsantas@upatras.gr

We study a multivariate Markov manpower system that embraces an organization's division of its employees into several homogeneous subgroups considered as departments. The proposed framework allows transitions of employees to occur both within the departments (intra-departmental mobility) and between departments (inter-departmental mobility). Via this modeling approach, we incorporate by cost and personnel objectives that illuminate the optimal operation of the system.

■ WD-19

Wednesday, 14:30-16:00
G5-10

Hub Location 3

Stream: Hub Location
Invited session

Chair: *Ivan Contreras*, Concordia University, H3G 1M8, Montreal, Canada, icontrer@encs.concordia.ca

1 - Hub Location with Profits
Armaghan Alibeyg, mechanical and industrial, concordia university, 3455 cote des neiges, H3H 1T6, MONTREAL, Quebec, Canada, a.alibeig@gmail.com, *Ivan Contreras*, *Elena Fernandez*

In this talk, we present the Hub Location Problem with Profits, where it is not necessary to provide service to all demand nodes. A profit is associated with each flow between pair of nodes. The overall goal is the simultaneous optimization of the collected profit, the set-up cost of the hub-and-spoke network, and the transportation cost for routing the flow through the network. Different classes of applications and modeling approaches are identified and compared.

2 - Hub-and-spoke network design for a low-cost carrier in Japan
Mihiro Sasaki, Information Systems and Mathematical Sciences, Nanzan University, 27 Seirei, 489-0863, Seto, Aichi, Japan, mihiro@nanzan-u.ac.jp, *Takehiro Furuta*, *Kazuya Saiki*

We consider network design for a low-cost air carrier (LCC) entering a market where mega carriers have already provided flight services. We assume that the level of captured passengers by LCC in each OD pair is determined by a logit function in which the utility is defined with the price and the frequency of flights provided by each carrier. Using the real data reported by Japan's Government, we estimate the parameters of the logit model. The proposed network design model finds an optimal hub-and-spoke network for LCC and the flight frequency in each air route simultaneously.

3 - The application of hub location problem to the exportation of soybeans in Brazil
Ana Paula Milanez, Densis, State University of Campinas, Avenida Albert Einstein, Cidade Universitária Zeferino Vaz, 13083-852, Campinas, São Paulo, Brazil, pmilanez@densis.fee.unicamp.br

Hub location problem has a wide application in transportation to serve demand for goods between many origins and many destinations. Hubs are special facilities used to switch and consolidate origin-destination flows allowing the reduction of links number and transportation cost. The particular case of soybeans chain in Brazil can be seen as a hub location problem with a special feature of some hubs can hold soybeans. In this way, we propose a new model that combines the hub location problem with stock feature.

4 - The Modular Hub location Problem
Ivan Contreras, Concordia University, H3G 1M8, Montreal, Canada, icontrer@encs.concordia.ca

It has been shown that the common assumption of flow-independent reduced transportation costs in most hub location problems can be an oversimplification, and may not only miscalculate the total cost but may also erroneously select the optimal set of hubs and the allocation pattern. In this talk we present the Modular Hub Location Problem, which explicitly models the flow dependency of transportation costs on all the arcs of the network. Also, it does not assume a fully interconnected hub network and thus, considers the design of the hub-and-spoke network as part of the decision process.

■ WD-20

Wednesday, 14:30-16:00
G5-11

Revenue Management in Public Transport Approaches

Stream: Optimization in Public Transport
Invited session

Chair: *Knut Haase*, Institut f. Verkehrswirtschaft, Lehrstuhl BWL, insb. Verkehr, Universität Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, knut.haase@wiso.uni-hamburg.de

1 - Revenue Maximizing Tariff Zone Planning in Public Transport
Sven Müller, Institute for Transport Economics, Universität Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, sven.mueller@wiso.uni-hamburg.de, *Michael Klier*

Although tariff-zones are applied by the majority of public transport service providers, literature is lacking of quantitative planning approaches which involve the design of tariff-zones and the determination of the corresponding fare (price per zone). We propose a combined fare and tariff-zone planning problem to maximize expected revenue of a public transport company. We perform a series of numerical investigations using GAMS/CPLEX and artificial data to show the applicability of our approach. Further, we intend to employ our approach to the San Francisco Bay Area, California.

2 - Fare Class Choice with Flexible Substitution Patterns
Frauke Seidel, Institut für Verkehrswirtschaft, Universität Hamburg, Lehrstuhl für Betriebswirtschaftslehre, insb. Verkehr, Von-Melle-Park 5, 20146, Hamburg, Germany, frauke.seidel@wiso.uni-hamburg.de

Traditional RM models exhibit the independent demand model assumption. Thus, demand for each fare class is assumed to be independent of the availability of other alternatives and downsell is disregarded. Recently, the development of simplified fare structures results in customers choosing lower available fares which leads to an increase in load factors while revenues decline. Thus, we propose an approach for choice based seat inventory control in a RM optimization model. The independent demand assumption is relaxed by applying a discrete choice model with flexible substitution patterns.

3 - Urban public transit network optimization with simultaneous destination and mode choice
Michael Klier, Institute for Transport and Economics, TU Dresden, 01062, Dresden, Germany, michael.klier@tu-dresden.de

A new model to optimize urban public transportation networks is introduced. It is assumed that individuals decide on the mode of transport and the destination of their trips simultaneously. For each individual we simulate the utilities for all modes of transport and all destinations. We can determine the individual specific public transit utility that is sufficient to cover an individual by public transit. Within a combinatorial optimization model the expected demand for public transit is maximized under a given budget by determining public transit routes and their frequencies.

4 - Impact of number of zones to the solution of the tariff zones design problem
Michal Kohani, Transportation Networks, University of Zilina, Univerzitna 1, 01026, Zilina, Slovakia, kohani@frdsa.fri.uniza.sk

When designing a tariff system, there are several approaches how to design it. One of them is to divide the region into tariff zones where the price of travelling depends on the number of traveled zones. Important factor with significant impact on the solution is the number of created zones. We will introduce a mathematical model of the tariff zones design problem based on counting zones, we will solve it using a universal optimization tool Xpress. We will compare obtained solutions with different values of number of zones in terms of computational time and the solution quality.

■ WD-21

Wednesday, 14:30-16:00
G6-1

Machine Scheduling Problems 4

Stream: Scheduling
Invited session

Chair: *Kadir Ertogral*, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu cd. No:43, 06560, Ankara, Turkey, kertogral@etu.edu.tr

1 - New mixed integer linear programming formulations for single machine scheduling problem with release dates and precedence constraints
Ichraf Zaidi, Informatique, Institut Supérieur de Gestion de Tunis, Building 59 apartment 1-1, Sproless Manouba, 2010, Manouba, Manouba, Tunisia, ichraf.zaidi@gmail.com, *Mrad Mehdi*, *Talel Ladhari*

In this work, we present a comparative study between three mixed integer linear programming (MILP) formulations for single machine scheduling problem under release dates and precedence constraints to minimize the total completion time. These formulations are based on three types of decision variables: assignment and positional date variables, completion time variables and time index variables. The computational results show that medium instances can be solved in moderate CPU time, and reveal that the assignment and positional date variables formulation outperforms the two other formulations.

2 - Novel heuristic rules for weighted total tardiness problem based on a precedence theorem of adjacent jobs
Dae-Sung Jang, Aerospace engineering, KAIST, 291 Daehak-ro, Yuseong-gu, 305-701, Daejeon, Daejeon, Korea, Republic Of, dsjang@lics.kaist.ac.kr, *Han-Lim Choi*

Three new heuristic algorithms are presented for single machine weighted total tardiness problem. One of the algorithms is based on a precedence theorem of adjacent jobs developed by Rachamadugu (1987). Others are combinations of statistical measures of allowance and heuristic rules: WMDD (Weighted Modified Due Date) and the algorithm based on the precedence theorem. The method of combinations is derived from ATC (Apparent Tardiness Cost). Extensive numerical tests show that the presented rules outperform the best existing heuristic rules.

3 - A hybridized problem perturbation and genetic algorithm heuristic for the flexible job-shop scheduling problem
Kadir Ertogral, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu cd. No:43, 06560, Ankara, Turkey, kertogral@etu.edu.tr, *Bilal Meto*

The flexible job-shop scheduling problem (FJSP) can be considered as a generalization of the scheduling problems in production systems. In FJSP, there are alternative machines for the operations of a job. In this study, we suggest a hybrid meta heuristic for FJSP with the objective of minimizing the makespan. Our algorithm has three stages; a problem perturbation heuristic to generate the initial population, a genetic algorithm, and a local improvement phase applied to the last generation of solutions. We show the effectiveness of the suggested algorithm on test problems from the literature.

■ WD-22

Wednesday, 14:30-16:00
G6-2

Scheduling Applications

Stream: Scheduling II
Invited session

Chair: *Alena Otto*, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de
Chair: *Dominik Kress*, Institute of Information Systems, University of Siegen, Universität Siegen, Hölderlinstraße 3, 57068, Siegen, Germany, dominik.kress@uni-siegen.de

1 - A heuristic solution approach for the assembly line worker integration and balancing problem
Mayron César Oliveira Moreira, University of São Paulo, ICMC/USP - Av. Trabalhador são-carlense, 400 - Centro Cx. Postal 668 Sala 1-008, 13560-970, São Carlos, São Paulo, Brazil, mayron@icmc.usp.br, *Alysson M. Costa*, *Cristobal Miralles*

We investigate the Assembly Line Worker Integration and Balancing Problem, an assembly line balancing problem which deals with a large set of homogeneous workers in addition to some heterogeneous workers (in terms of task execution times). This problem appears when trying to integrate workers with disabilities in conventional assembly lines. We propose a mixed-integer model, a constructive heuristic solution method and two local search procedures based on MIP neighborhoods. Computational results show the efficiency and scalability of the proposed approach.

2 - Effectiveness of assigning intermediate milestones to outsourced projects for avoiding tardy completion
Changmuk Kang, Department of Industrial and Information Systems Engineering, Soongsil University, 369 Sangdo-ro, Dongjak-gu, Seoul, Korea, Republic Of, changmuk.kang@ssu.ac.kr, *Byung-Cheon Choi*

Project outsourcing is very common in any industry, such as construction, consulting, and even product development. Whereas the company who outsource their own job to an outside contractor definitely wants to avoid late completion of the project, all the efforts to crash project time are solely upon the contractor. This paper studies effectiveness of assigning intermediate milestones to an outsourcing contractor as a means of drawing their best effort to avoid tardiness by developing a contractor's model for determining crashing effort to minimize the cost of crashing and tardiness penalty.

3 - Scheduling a Satellite Downlink: Real Time Solutions for a Constrained Minimization Problem
Fattaneh Cauley, Quantitative Methods, Purdue University, 1401 Trace 14, 47906, West Lafayette, IN, United States, cauley@purdue.edu, *Stephen Cauley*

In this research a scheduling algorithm is proposed for transmission of information via a satellite to receivers on the ground. The satellite contains a number of antenna-beam areas, which are serviced by a smaller number of agilely switched burst transmitters. The burst times are constant and synchronized across all transmitters. The proposed algorithm is a combination of a traditional scheduling problem and a map coloring problem. It offers near optimal schedule and can be employed on the limited on-board satellite computing hardware given a short time horizon.

4 - On scheduling models for the multiple carrier frequency assignment problem with cumulative interferences
Christian Artigues, LAAS, CNRS, 7 avenue du Colonel Roche, 31077, Toulouse Cedex 4, France, artigues@laas.fr, *Kata Kiatmanaroj*, *Laurent Houssin*

Although the link between chromatic scheduling and multi-carrier frequency assignment (MC-FAP) has been relatively long established (De Werra and Gay, Discr. Apl. Math. 49(1-3), 165-174, 1994), research considering explicitly scheduling models for the frequency assignment problem is sparse. In this talk, we consider realistic MC-FAP problems involving cumulative interferences and we compare experimentally two different scheduling models: one based on a binary approximation of the cumulative interference and one modeling them precisely. Results show the interest of the approximation.

■ WD-23

Wednesday, 14:30-16:00
G6-3

Scheduling

Stream: Scheduling under Resource Constraints
Invited session

Chair: *Joanna Jozefowska*, Institute of Computing Science, Poznañ University of Technology, Piotrowo 2, 60-965, Poznañ, Wielkopolska, Poland, jjozefowska@cs.put.poznan.pl

1 - A network model for the project scheduling problem with periodic payments
Miawjane Chen, Finance, National United University, # 1, Lienda, 36003, Miaoli, Taiwan, miawjanechen@gmail.com, *Shangyao Yan*

We propose a network model for the multi-mode resource constrained project scheduling problem with discounted cash flows, individually including the progress payment and the payment at equal time interval. The objective of the model is to maximize the net present value in the project, subject to related operational constraints. The model is formulated as a nonlinear integer network flow problem with side constraints. A heuristic, coupled with two upper bound solutions, is proposed to solve the model. The test results indicate that the model and the heuristic are useful for project contractors.

2 - Choosing and Scheduling Operations in an operating room
M. Angeles Pérez, Mathematics for Ecomomy, University of Valencia, Avda Naranjos s/n, 46021, Valencia, Spain, angeles.perez@uv.es, *Francisco Ballestin*, *M.Pilar Lino*, *Sacramento Quintanilla*, *Vicente Valls*

Health care office in a hospital has a list of patients awaiting surgery. The decision maker has to plan which operations on the list to do in the following days. The patients have a different priority, depending on their urgency, and the deadline for their operation. This paper studies how to choose the operations so that the priorities and the deadlines of the patients are taken into account and the utilisation of the operating rooms is maximised. Several restrictions should be fulfilled. Some operations must be performed by a specific doctor, others should be performed in the morning, etc.

3 - How to explore the tasks criticalness in project management
Tomas Subrt, Dept. of Systems Engineering, Czech University of Life Sciences, Kamycka 129, 165 21, Prague 6 - Suchdol, Czech Republic, subrt@pef.czu.cz, *Helena Brozova*, *Jan Rydval*

The crucial question of project management is to find out what can cause delaying of the project due date or failure of project objectives. Therefore many authors analyse task criticalness expressed by Criticality Index. Criticalness in our approach is defined in a slightly different way. We derive it from the character of task duration (known or random), resource assignments (in right time and right place), task costs and number of parallel activities. We suppose and compare different multiple criteria approaches to criticalness calculations: multiplicative and additive models and DEA.

4 - An Optimization Model for Outpatient Day Service Operations: a Case Study within the Clinical Management of Chronic Migraine Patients
Domenico Conforti, DIMEG, Università della Calabria, Ponte Pietro Bucci 41C, 87036, Rende, Italy, domenico.conforti@unical.it, *Rosita Guido*

Day Service is a novel hospital services organization for outpatients with complex pathological profiles. Typically, outpatient clinical service standard packages have been defined following the specific clinical protocols and guide lines. In this work, we focused on Day Service management for chronic headache patients. The aim is to analyze and manage Day Service supported by effective and efficient optimization model approach, with the aim to improve quality of care for the patient, clinical service planning and management and to make the best use of available hospital resources.

■ WD-24

Wednesday, 14:30-16:00
G6-4

Rostering and Task Assignment

Stream: Timetabling and Rostering
Invited session

Chair: *Pieter Smet*, CODeS, KAHO St.-Lieven, Gebr. De Smetstraat 1, 9000, Gent, Belgium, pieter.smet@kahosl.be

1 - A decomposition approach for the integrated task and shift scheduling problem
Pieter Smet, CODeS, KAHO St.-Lieven, Gebr. De Smetstraat 1, 9000, Gent, Belgium, pieter.smet@kahosl.be, *Greet Vanden Berghe*

We present a decomposition approach for the single day task and shift scheduling problem. This problem deals with the challenge of assigning tasks to a set of multi-skilled employees, while also determining their shift assignments. We present an algorithm which decomposes the problem into a master problem of assigning tasks and a slave problem of assigning shifts. For larger instances, a general purpose exact solver requires too much time to optimally solve a mathematical model of the integrated problem, whereas the decomposition approach finds the optimal solution very quickly.

2 - A hybrid heuristic for a real world task assignment problem
Michele Garraffa, Politecnico di Torino, 10129, Torino, Italy, michele.garraffa@polito.it, *Pieter Smet*, *Greet Vanden Berghe*

We present a heuristic algorithm for a real world problem in which tasks need to be assigned to a set of multi-skilled employees. The problem is modelled so that the Hungarian algorithm can be used to find the optimal solution in polynomial time. However, due to the large scale of the problem instances and limitations on calculation time, the run time of the Hungarian algorithm is too high to be acceptable. Therefore, we present a hybrid heuristic algorithm which iteratively solves small subproblems to optimality, thereby reducing computation time while still finding high quality solutions.

3 - Integer programming for Midterm Physicians' Scheduling
Bernardo Almada-Lobo, Industrial Engineering and Management, Faculty of Engineering of Porto University, Rua Dr. Roberto Frias s/n DEIG, 4200-465, Porto, Portugal, almada.lobo@fe.up.pt, *Ricardo Gil Santos*, *Fabricio Sperandio*, *José Borges*

This work addresses the midterm physicians' scheduling problem in a continuous environment. We propose a tour scheduling approach with an integer programming model that tackles all physicians' activities simultaneously while respecting the match between physician skills and activities, the physicians' preferences and the overlap in each activity. A flexible shift approach is considered and all constraints have to be respected, except the balancing ones. This approach has been implemented in a top tier Portuguese hospital. Specialties tackled have up to 20 physicians and 4 activities.

4 - An enhanced genetic algorithm for a biobjective bus driver rostering problem
Ana Respício, DI - Centro de Investigação Operacional, Universidade de Lisboa, Campo Grande, Bloco C5, Piso 1, 1749-016, Lisboa, Portugal, respicio@di.fc.ul.pt, *Margarida Moz*, *Margarida Pato*

A noncyclic bus driver rostering problem is approached here considering two objectives that hold the company and the drivers' interests. The problem is proved to be NP-hard and this work proposes an enhanced biobjective genetic algorithm embedding a specific decoder, a utopian/lexicographic elitism, a strength Pareto fitness evaluation, and a local search procedure. A computational study evaluates the individual contribution of the algorithm components. The results disclose how simple enhancements in standard biobjective genetic algorithms can improve the quality of the solutions achieved.

■ WD-25

Wednesday, 14:30-16:00
G9-1

Fuzzy Risk Assessment and Fuzzy Optimization

Stream: Fuzzy Optimization - Systems, Networks and Applications
Invited session

Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de
Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Incomplete fuzzy preference matrix and its application to ranking of alternatives
Jaroslav Ramik, Dept. of Math. Methods in Economics, Silesian University, School of Business, University Sq. 1934/3, 73340, Karvina, Czech Republic, ramik@opf.slu.cz, *Petr Korviny*

Fuzzy preference matrix is the result of pairwise comparison method for solving decision making (DM) problems of finding the best alternative among a finite number of ones. We propose a new method for measuring of inconsistency of fuzzy preference matrix based on the principal eigenvector method. Moreover, we deal with the problem of the incomplete fuzzy preference matrix with some missing elements. We also deal with some important particular cases and propose special methods for dealing with these cases. Several illustrating examples are presented to clarify the proposed theory.

2 - A Fuzzy Goal Programming Model for Irrigation Project Portfolio Optimisation
Bijaya Krushna Mangaraj, Production & Operations Management Area, XLRI School of Business & Human Resources, Jamshedpur-831001, India, C.H. Area(East), Jamshedpur, Jamshedpur, Jharkhand, India, mangaraj@xlri.ac.in

India is a global agricultural powerhouse. Nearly 75% of India's families depend on rural income. Agriculture is its largest user of water. However, development of water resources for irrigation rests mostly on the Government and knowing the effectiveness of its several irrigation projects is a major challenge. To handle such an issue, a fuzzy goal programming model has been utilized for the design of an efficient portfolio of irrigation projects to create maximum irrigation potential with minimum risk. A case study of six medium projects has been considered to demonstrate the model.

3 - Prioritization of Risk Assessment Methods for Occupational Safety with Fuzzy Multi Criteria Decision Making
Ali Fuat Guneri, Yildiz Technical University, Turkey, afguneri@gmail.com, *Muhammet Gul*

Occupational accidents occur frequently in small and medium sized enterprises (SMEs). But most of the enterprises consider the risk assessment process with respect to health and safety as loss of time and money. Therefore a tool is required to determine the risk assessment methods which are suitable for enterprises. This paper prioritizes the risk assessment methods with an apparent multi criteria decision making method under fuzzy environment. As a conclusion the decision making approach is a significant analysis tool to select the right method for occupational safety.

4 - Boundary Constraints as a Method of Fine Tuning Utility Maximization Processes with Genetic Algorithms
Cesar Hernando Valencia Niño, Mechatronics Engineering, Saint Thomas Aquinas University, Av. Padre Leonel Franca, 261, Ap 252, 22451000, Rio de Janeiro, Rio de Janeiro, Brazil, chvn00@gmail.com, *Silvia Nathalia Cáceres Quijano*, *Jorge Guillermo Diaz Rodríguez*

This work used different types of restrictions to fine-tune the utility maximization problem process for a shopping problem in a company. The proposed solution used genetic algorithms as metaheurísitic search method and it is compared with traditional procurement model used by the company. The proposed model presented a substantial improvement in the maximization function. Likewise, there were modified model features to add constraints within which can obtain more useful performance.

■ WD-26

Wednesday, 14:30-16:00
G9-7

Combinatorial Optimization and Applications II

Stream: Combinatorial Optimization I
Invited session

Chair: *Silvano Martello*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, silvano.martello@unibo.it
Chair: *Paolo Toth*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

1 - Euclidean TSP with four point conditions.
Vladimir Deineko, Warwick Business School, Warwick University, The University of Warwick, CV4 7AL, Coventry, United Kingdom, v.deineko@warwick.ac.uk

Identifying polynomially solvable cases of NP-hard optimisation problems is one of the well known branches in combinatorial optimisation. We consider classical travelling salesman problem (TSP). It is known that if the distance matrices in the TSP satisfy the so-called four point conditions, then in some of these cases the optimal solutions can be found in polynomial time. We give polynomial time algorithms for recognising permuted Euclidean distance matrices that satisfy the four-point conditions and therefore can be solved efficiently.

2 - Kernel Search for Capacitated Facility Location Problems
Gianfranco Guastaroba, Department of Economics and Management, University of Brescia, Cda. Santa Chiara 50, 25024, Brescia, Italy, guastaro@eco.unibs.it, *M. Grazia Speranza*

We present a Kernel Search algorithm (KS) for solving Capacitated Facility Location Problems (CFLP). The KS is a heuristic framework based on the idea of intensively exploring a sequence of relatively small-size portions of the solution space. The exploration is guided by the identification of subsets of decision variables and the subsequent solution of the resulting restricted problems by means of an LP/MILP solver. The general KS framework is applied to the solution of CFLP. Variants based on variable fixing are proposed aiming at improving the efficiency of the algorithm.

3 - Planning and routing in urban networks
Kaj Holmberg, Optimization, Mathematics, Linkoping University, Sweden, kaj.holmberg@liu.se

We study the problem of planning service tasks in street networks, and use snow removal as a generic problem. Computerized optimization tools can be a help when dealing with unusual situations. When should each task be done, which vehicle should do the task and how should the vehicles travel between tasks. We address different vehicles, precedence requirements, finishing times, service costs and environmental aspects. We identify usable substructures, such as Chinese/rural postman, asymmetric travelling salesman problems etc, and discuss combined solution approaches, including decomposition.

4 - Genetic and Exact Approaches for the K Clusters with Fixed Cardinality Problem
Lídia Lourenço, Dept. de Matemática, CIO (Universidade de Lisboa), FCT (Universidade Nova de Lisboa), Monte de Caparica, 2829-516 , Caparica, Portugal, lll@fct.unl.pt, *Graça Gonçalves*, *Margarida Pato*

We present an elitist genetic heuristic for the K clusters with fixed cardinality problem, based on a specific encoding identifying the cluster each item is assigned to. Computational results comparing the lower bound given by this genetic heuristic and the lower bound obtained from an enlarged local search algorithm are also presented. For small instances the genetic lower bound is compared with the optimum obtained from a mixed-integer linear formulation. The results show good quality genetic heuristic solutions, obtained in short computing time.

■ WD-27

Wednesday, 14:30-16:00
G9-8

Large-scale vehicle or crew scheduling problems solved with constraint aggregation

Stream: Combinatorial Optimization II
Invited session

Chair: *Francois Soumis*, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca

1 - Taking advantage of degeneracy in mathematical programming
Francois Soumis, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca, *Jacques Desrosiers*, *Issmail Elhallaoui*, *Guy Desaulniers*

I will introduce the basics concepts used by the presentations in the two following sessions. The Improved Primal Simplex uses a reduced master problem obtained by removing degenerated constraints and degenerated variables (i.e., variables producing degenerated pivots) and a subproblem identifying non degenerated improving directions obtained by combining many degenerated variables. I will introduce the specialized version for set partitioning problems used in the two following presentations and the integral simplex used in the following session.

2 - Integrated crew paring and crew assignment by dynamic constraint aggregation
Mohammed Saddoune, École Polytechnique de Montréal and GERAD, 700 cremazie Est, Appt 1A, h2p-1g2, montréal, QC, Canada, mohammed.saddoune@polymtl.ca, *Issmail Elhallaoui*, *Francois Soumis*

The crew scheduling problem is commonly decomposed into two stages which are solved sequentially. Crew pairing generates a set of pairings covering all flight legs. Crew assignment generates anonymous blocks covering all pairings. The simultaneous problem generates a set of blocks covering all flight legs. It is a large set covering problem highly degenerated. We combine the column generation and the dynamic constraint aggregation methods to solve it and save up to 9% on real-life problems.

3 - Integrated personalized crew pairing and crew assignment problem
Atoosa Kasirzadeh, GERAD, 2920, Chemin de la Tour 4th floor, room 4482, H3T 1J4, Montreal, QUEBEC, Canada, atoosa.kasirzadeh@polymtl.ca, *Mohammed Saddoune*, *Francois Soumis*

We present a set-covering formulation and a solution approach based on column generation for the personalized airline cabin crew scheduling problem in which the objective is optimizing the costs and the crew's preferences. The computational results are provided based on a major US carrier data set. In addition, we introduce a heuristic algorithm for integrated crew pairing and assignment problems for having as much as possible similar pairings between pilots and co-pilots, even if pilots and co-pilots schedules are different to satisfy their preferences.

4 - A new way of using stabilization techniques in column generation
Hocine Bouarab, MAGI, Polytechnique, 2900 Edouard Montpetit, H3C 3A7, Montreal, Qc, Canada, hocine.bouarab@gerad.ca, *Guy Desaulniers*, *Issmail Elhallaoui*

Stabilizing the master problem (MP) is an effective way for dealing with degeneracy in column generation (CG). When the subproblem is time consuming, CG is generally stopped before reaching optimality, leading to an infeasible solution when stabilization is used. We propose to use the Improved Primal Simplex algorithm (IPS) where the MP is reduced to eliminate degeneracy and a Complementary Problem (CP) is solved by CG to find descent directions for the MP. The CP is stabilized instead of the MP. We report numerical results on instances of the Multiple Depot Vehicle Scheduling Problem.

■ WD-28

Wednesday, 14:30-16:00
G9-2

Chance constraints optimization

Stream: Stochastic Programming
Invited session

Chair: *Abdel Lisser*, LRI, Universite de Paris Sud, Bat. 650, 91405, Orsay, France, lisser@lri.fr

1 - Decomposition method used for linear stochastic bilevel problems
Charlotte Henkel, Mathematics, University of Duisburg-Essen, Forsthausweg 2, 47057, Duisburg, Germany, charlotte.henkel@uni-due.de

Compared to linear stochastic two-stage programs, linear stochastic bilevel problems (LSBP) exhibit a strongly increased complexity. Nonetheless, decomposition methods known from the former can be used to derive optimal solutions of LSBPs. An algorithm for optimistic LSBPs with discrete distributions is presented as well as an evaluation of the performance.

2 - Stochastic two-player zero sum game with joint probabilistic constraints
Abdel Lisser, LRI, Universite de Paris Sud, Bat. 650, 91405, Orsay, France, lisser@lri.fr, *Jianqiang Cheng*

This paper deals with a stochastic two-player zero-sum game with joint chance constraints, where the payoff matrix entries are random, and the constraints are satisfied jointly with a given probability. We prove that there exists a "weak duality" for the general stochastic zero-sum game problem, i.e., the optimal value of the minimizing player is an upper bound of the one of the maximizing player. Moreover we give an approximation method to the game problem when the payoff matrix entries are independently normally distributed. Numerical results are given.

3 - Decomposition Methods for Two-stage Stochastic Linear Semidefinite Programs with Risk Aversion
Tobias Wollenberg, Mathematics, University of Duisburg-Essen, Forsthausweg 2, D-47057, Duisburg, Germany, tobias.wollenberg@googlemail.com, *Rüdiger Schultz*

In recent years, a growing interest in semidefinite programming under uncertainty is observed. For two-stage risk neutral and risk averse stochastic linear semidefinite programs we discuss structure, stability and decomposition algorithms. In doing so, certain parts of the analysis follow fairly closely the traditional lines of argumentation in stochastic linear programming. Our talk will place accent on those topics where traditional arguments fail or have to be extended. To lesser extent, this concerns structure and stability, while algorithmically alternative ideas had to be developed.

■ WD-29

Wednesday, 14:30-16:00
G9-3

Stochastic Models in Reliability and Risk

Stream: Stochastic Models in Reliability and Risk
Invited session

Chair: *Serkan Eryilmaz*, Industrial Engineering, Atilim University, 06836, Ankara, Turkey, seryilmaz@atilim.edu.tr

1 - Compound Binomial Risk Model with Non-identical Claim Occurrences
Fatih Tank, Department of Statistics, Ankara University, Faculty of Sciences, Department of Statistics, Tandogan, 06100, Ankara, Turkey, tank@ankara.edu.tr, *Altan Tuncel*

The compound binomial model is a discrete time version of the classical compound Poisson model of risk theory. This study is concerned with distributional properties of some random variables associated with compound binomial risk model when the claim occurrences are non-identical. These random variables are potentially useful for an investment strategy and financial arrangements of an insurance company, and for understanding the behavior of a specific portfolio over time. Our method for finding distributions of the corresponding statistics are based on recursive equations.

2 - Joint Reliability Importance For Consecutive-k System
Mahmoud Boushaba, Mathematics, University of Constantine 1, Route Ain El bey, 25017, Constantine, Algeria, mboushabafr@yahoo.fr

In this paper, we study joint reliability importance (JRI) for two type of consecutive-k systems: consecutive-k-out-of-n: F system and m-consecutive-k-out-n: F system (m=2) consisting independent components. We obtain a closed-form formula for the JRI of two components by using the conditional distribution of number of occurrences of failure runs of length k. Finally, we illustrate the results by numerical examples.

3 - An Application of Hidden Markov Model for Turkish Earthquake Data
Ceren Eda Can, Statistics, Hacettepe, Hacettepe Üniversitesi, İstatistik Bölümü Beytepe Kampüsü, TR-06800, Ankara, Turkey, cerenedacan@yahoo.com, *Gül Ergün*

As a powerful and flexible framework for statistical inference on partially observed stochastic processes, Hidden Markov model (HMM) has been successfully applied to many problems, although it is not as widely implemented as it should be in earthquake modelling. Forecasting large earthquakes gives an opportunity to reduce the damage and loss risk. Therefore, an understanding of the nature of earthquakes provides crucial information for hazard analysis. In this study, Poisson-HMM is applied to model the frequencies of mainshock eartquakes in Turkey and temporal seismicity changes are defined.

■ WD-30

Wednesday, 14:30-16:00
G9-10

Graphs and Networks IV

Stream: Graphs and Networks
Invited session

Chair: *Marc Demange*, ESSEC Business School and LAMSADE UMR 7243, Paris, France, demange@essec.edu

1 - Using Dantzig-Wolfe Decomposition to Solve the Linear Bi-Objective Multi-Commodity Minimum Flow Problem
Siamak Moradi, Engineering Science, The University of Auckland, Level 2, 70 Symonds street, Grafton, 1010, Auckland, New Zealand, s.moradi@auckland.ac.nz, *Andrea Raith*, *Matthias Ehrgott*

By integrating Dantzig-Wolfe decomposition with the bi-objective simplex method, we present a new method for solving the bi-objective multi-commodity flow problem. An initial solution with respect to the first objective is obtained by standard Dantzig-Wolfe decomposition. The new method continues iteratively by solving a subproblem for each commodity with network flow constraints and a ratio objective function, where the ratio is improvement of the second objective over deterioration of the first. One of the optimal solutions of these subproblems will be the entering variable.

2 - Management networks and deterrence games
Michel Rudnianski, CNAM, 75004, Paris, France, michel.rudnianski@cnam.fr, *Cerasela Tanasescu*

A relation has been established between the functioning of an organization and the solutions of a game of deterrence. This has led to the development of an algorithm enabling to prevent congestion within a network. Every matrix game of deterrence can be associated with an oriented bipartite graph. Such graph of deterrence can be replaced by a set of paths or digraphs without root characterizing the solution properties. We go one step forward by analyzing the breakdown of a global network into regional networks and proposing a solution enabling to ensure consistency between efficiency.

3 - About some robustness and complexity properties of G-graphs networks
Cerasela Tanasescu, ESSEC Business School, Av Bernard Hirsh, 95000, Cergy, France, tanasescu@essec.edu, *Culus Jean-François*, *Marc Demange*, *Ruxandra Marinescu-Ghemeci*

Given a finite group G and a subset S of G, we consider the related G-graph defined as the intersection graph of the cosets of cyclic groups generated by elements of S. We investigate connectivity and transitivity properties and point out some cases where G-graphs are optimally connected, motivating their use for network design. The main case concerns the class associated to an abelian group and the canonical base. We finally provide a combinatorial characterization of this class as clique graphs of Cartesian products of complete graphs and show that it can be recognized in polynomial time.

4 - The k-Centrum Chinese Postman Problem and a Related Cost Allocation Game
Daniel Granot, University of British Columbia, Vancouver, Canada, daniel.granot@sauder.ubc.ca, *Frieda Granot*, *Harshavardhan Ravichandran*

We analyze the cost cooperative game, (N;ck), induced by the k-centrum Chinese Postman problem in undirected and directed graphs. For the undirected case, we show, for example, that for k = 1, 2, (N; ck) is submodular for all graphs having non negative edge-weights for all locations of the post-office. For k >= 3, we prove that (N; ck) is submodular for all non-negative edge-weights and for all locations of the post office iff the graph is either the cyclic graph on three edges or it is a graph wherein each edge is contained it at most one cycle and these cycles have only two edges.

■ WD-31

Wednesday, 14:30-16:00
G9-11

OM Finance Interface

Stream: MSOM iFORM Special Interest Group Stream
Invited session

Chair: *S. Alex Yang*, Management Science and Operations, London Business School, Sussex Place, NW1 4SA, London, United Kingdom, United Kingdom, sayang@london.edu

1 - Sourcing decisions under exchange rate risk
Alejandro Serrano, ZLC, Zaragoza, Spain, aserrano@zlc.edu.es

The importance of exchange rate risk when selecting suppliers location (domestic versus offshore) has been extensively studied in the literature. However, these models usually assume that demand is deterministic, which may not be a plausible assumption in many settings. We present a model where demand and the cost of the item through exchange rate are both uncertain and possibly correlated. We analyze three price policies.

2 - Optimal Compensation for Newsvendor Managers
Hande Cetinay, Industrial Engineering, Eindhoven University of Technology, Den Dolech 2, Postbus 513, 5600 MB, Eindhoven, Netherlands, h.cetinay@tue.nl, *Fehmi Tanrisever*, *Jan C. Fransoo*

The aim of this paper is to analyze the effect of the conflicting incentives of bondholders and shareholders of a firm operated as a newsvendor. Protected by limited liability, once the debt is issued, shareholders tend to engage in more aggressive operating strategies which result in agency costs. With managerial compensation contracts, we address this agency cost of debt and identify the optimal compensation contract for the newsvendor managers in order to optimize the overall value generation from the operations.

3 - Dynamic Pricing of Peak Production
Heikki Peura, London Business School, United Kingdom, hpeura.phd2010@london.edu, *Derek Bunn*

Peak producers of non-storable products, such as electricity, provide crucial flexible operating capacity to respond to infrequent and transient high demand periods. Faced with these uncertain revenue-earning opportunities, yet usually with significant price-setting power, they need to profit from a limited number of pricing decisions, often operating under financial targets. We study repeated interaction between peak producers with a model that captures both the uncertainty in their short-term revenues and their market power, as well as operational and financial constraints.

4 - The Supply Chain Effect of Bankruptcy Reorganization
S. Alex Yang, Management Science and Operations, London Business School, Sussex Place, NW1 4SA, London, United Kingdom, United Kingdom, sayang@london.edu, *John Birge*, *Rodney Parker*

We study the efficiency of bankruptcy reorganization under several typical supply chain structures. We find that after bankruptcy, a successful reorganization will lower the bankrupt firm's operational cost and that this outcome improves the overall chain efficiency. Reorganization as a possible recourse affects the pre-bankruptcy strategies for different players in the chain significantly and could potentially create value for the distressed firm. The effect of the cost of reorganization on the distressed firm and its competitor is mixed.

■ WD-32

Wednesday, 14:30-16:00
G8-1

Supply Network Dynamics and Disruption Management III

Stream: Supply Chain Optimization
Invited session

Chair: *Silke Malina*, WHU Vallendar, Oberer Neuberg 18, 97877, Wertheim, Germany, silke.malina@boschrexroth.de

1 - Modeling and Analysis of a merge supply chain network with multiple unreliable suppliers
Michael Geranios, Business Administration, University of Aegean, Michalon 8, 82100, Chios, Chios, Greece, mgeranios@aegean.gr, *Michael Vidalis*

The paper analyzes a two echelon merge supply network. The first echelon consists of a distribution center with multiple n identical machines and a shared buffer. The second echelon includes multiple unreliable suppliers. We model this supply network as a continuous time Markov process with discrete states. We explore the structure of the transition matrices and we develop a computational algorithm in order to calculate the system's stationary probabilities and performance measures. We use the algorithm as an optimization tool to figure out which is the best configuration of the system.

2 - Effect of supply chain disruptions on stock prices in aviation and aerospace manufacturing industry - An exploratory analysis
Ronald Mau, College of Business, Embry Riddle Aeronautical University, 997 N. Country Club Drive, 28723, Cullowhee, North Carolina, United States, Ronald.Mau@erau.edu, *Aman Gupta*

Supply Chain Risk Management (SCRM) is characterized by identification and reduction of risks focused on the supply chain associated with material, financial, and informational flows. Using event study methods, we investigate the effect on a firm's equity price (financial flow) related to delays other issues associated with a firm's supply chain. Our initial study has focused on large aircraft manufacturers (Boeing and EADS). On average the firm announcing the disruption experiences a 4 percent drop in share price and the competing firm experiences a 1 percent decline.

3 - Management of Supply Chain Complexity: A Study in the Drive and Control Industry
Silke Malina, WHU Vallendar, Oberer Neuberg 18, 97877, Wertheim, Germany, silke.malina@boschrexroth.de, *Stefan Spinler*

Through an increase of product variety, structures and processes, managers struggle with an increase of supply chain complexity. This increase in complexity leads to a negative influence of a firm's efficiency like lead-times, flexibility and costs. In order to manage complexity, supply chain managers need to know the drivers of it to define appropriate management measures. Based on an in-depth case study in the drive and control industry, we propose a quantitative model based on complex adaptive systems to reflect on appropriate ways to handle complexity.

4 - Balancing time-cost-risk in the supply chain configuration management problem
Elena Rokou, Industrial Management & OR, Mechanical Engineering, National Technical University of Athens, Heroon Polytechneiou 9 9, Athens, Greece, Greece, erokou@mail.ntua.gr, *Konstantinos Kirytopoulos*

A multi-objective approach for balancing time, cost and risks in the supply chain configuration management problem is proposed. The approach takes from the corresponding multi-objective multi-mode project scheduling under resource constraints problem (MRCPSP). The supply chain configuration management problem is modelled as a multi-objective MRCPSP problem and a mix of pareto optimal and weighted sum solution scenarios are generated. An illustrative case is used to show the effectiveness and applicability of the proposed approach.

■ WD-33

Wednesday, 14:30-16:00
G8-3

Lot-Sizing and Related Topics 5

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Christian Almeder*, Chair for Supply Chain Management, European University Viadrina, Große Scharrnstr. 59, 15230, Frankfurt (Oder), Germany, Almeder@europa-uni.de

1 - Solving a multi-item multi-machine capacitated lot sizing problem via a fix and optimize heuristic
Fahimeh Shamsaei, CORE, UCL, Voie du Roman Pays, 34, 1348, Louvain-la-neuve, – Select –, Belgium, fahimeh.shamsaei@uclouvain.be, *Mathieu Van Vyve*

This paper uses a fix and optimize algorithm to solve multi-item multi-machine capacitated lot sizing problem considering predictive maintenance and transportation problems. The capacity decreases over time, unless a predictive maintenance is performed. Our algorithm solves a series of mixed-integer linear programs in an iterative approach. In each instance of these mixed-integer linear programs a large number of binary setup variables are fixed whereas only a small subset of these variables is optimized, together with the complete set of the inventory and lot size variables.

2 - Uncapacitated lot sizing with nonlinear production cost
Ramez Kian, Industrial engineering, Bilkent University, Department of Industrial Engineering,, Bilkent University, Central Campus, 06800, Ankara, Cankaya, Turkey, ramezk@bilkent.edu.tr, *Ulku Gurler*, *Emre Berk*

We consider a finite horizon single item uncapacitated lot sizing problem in which the production costs follow a nonlinear function. This nonlinearity can either originate from environmental factors or from the input-output relation provided in production function. In this work we characterize the optimal solution structure and represent a solution algorithm. Our algorithm gives the global optimal when the setup costs are zero. Complementary conditions for algorithm efficiency and sensitivity analysis based on the numeric study are provided.

3 - A hybrid algorithm for solving an unrelated parallel machine scheduling problem with job splitting
Carina Pimentel, DEGEI, University of Aveiro/Algoritmi Research Center, Campus Universitário de Santiago, Portugal, 3810-193, Aveiro, Aveiro, Portugal, carina@dps.uminho.pt, *Filipe Alvelos*, *Luís Florêncio*

In this presentation we consider the problem of scheduling a set of independent jobs on a set of unrelated parallel machines, considering jobs and machines release dates, setup times and the job splitting property, with due date related objectives. To solve the problem we apply a hybrid approach that results from the interaction between column generation and metaheuristics. The effectiveness of the proposed algorithm is validated through the results obtained on a set of test instances.

4 - Hybrids Methods Applied to Lot Sizing Problems on Parallel Machines
Diego Fiorotto, DCCE, UNESP, São José do Rio Preto, São Paulo, Brazil, diego_fiorotto@hotmail.com, *Silvio de Araujo*

This work addresses a lot-sizing problem with parallel machines, setup time and limited capacity. Based on a previous work that considered the single machine case, the objective of this work is to study hybrid solutions methods in order to obtain high quality lower bounds. The methods studied involve combinations of Lagrangian relaxation and Dantzig-Wolfe decomposition. Two ways of combining the strengths such methods are tested and some computational results are presented comparing the proposed method with methods from the literature, as well as, the optimization package CPLEX 12.1.

■ WD-34

Wednesday, 14:30-16:00
G8-4

Inventory management: Random yield and lost sales

Stream: Supply Chain Planning
Invited session

Chair: *Gudrun Kiesmüller*, Institute of Business Administration, Christian-Albrechts-Universität zu Kiel, Olshausenstr. 40, 24098, Kiel, Germany, g.p.kiesmueller@bwl.uni-kiel.de

1 - An inventory optimization technique based in minimizing lost sales
Fernando Paredes, Escuela de Ingeniería Industrial, Universidad Diego Portales, Av. Ejército 441, Santa Julia 892, Ñuñoa, 298-V, Santiago, Chile, fernandoparedesc@gmail.com, *Javier Pereira*, *Claudio Fuentes*

In this work, we develop an inventory optimization model fundamentally based on the minimization of the expected value of lost sales for a defined investment and number of order levels, per year. The optimal solution of this nonlinear optimization model is obtained by solving the associated Karush-Kuhn-Tucker system by establishing the corresponding optimality conditions using a fixed-point type search strategy. We prove that the objective function is pseudo-convex and that the constraints are defined by quasi-convex functions, ensuring the existence of the global minimum point of the model.

2 - Myopic replenishment policies for lost-sales inventory systems
Marco Bijvank, Rotterdam School of Management, Erasmus University, Netherlands, mbijvank@rsm.nl

We study the problem of managing a single item inventory system under periodic review where excess demand is lost. Demands are stochastic and can be stationary or non-stationary. We are interested in minimizing the long-run average total costs incurred per period. First, we consider an inventory system where the cost function consists of a holding cost proportional to the amount of inventory and a penalty cost proportional to the amount of lost sales. Next, we extend the system to include a fixed order cost. The goal is to develop myopic replenishment policies to control the inventory systems.

3 - A New Heuristic For an Inventory System with Random Yield and Positive Lead Time
Wanrong Ju, Econometric Institute, Erasmus University Rotterdam, Burgmeester Oudlaan 50, H8-23, 3062PA, Rotterdam, Netherlands, ju@ese.eur.nl, *Adriana F. Gabor*, *Jan-Kees van Ommeren*

We study an infinite-horizon periodic-review inventory model with an unreliable supplier. The supplier has a lead time and random yield, which is common in practice. The part of order received is assumed to be binomially distributed. Lead time is considered which has not been done extensively in literature. We propose a simple order-up-to heuristic and find an approximation for the steady-state distribution of the order quantity without any assumption on demand distribution. Our heuristic also works for dual-sourcing model. The performance of the heuristic is tested for several scenarios.

4 - Optimal control of an inventory-production system with state-dependent random yield
Gudrun Kiesmüller, Institute of Business Administration, Christian-Albrechts-Universität zu Kiel, Olshausenstr. 40, 24098, Kiel, Germany, g.p.kiesmueller@bwl.uni-kiel.de

We study a periodic inventory system for a single item with stochastic demand. Orders are placed according to an order-up-to logic and a random yield is observed. In order to improve the production process, periodic inspections are conducted. Approximations are developed to evaluate the average cost for a given order-up-to level and a given inspection interval and we illustrate the existence of optimal policy parameters. The approximations as well as different decomposition approaches are tested in a simulation study and reveal an excellent performance.

■ WD-35

Wednesday, 14:30-16:00
G8-2

Automotive Logistics

Stream: OR Applications in the Automotive Industry
Invited session

Chair: *Thomas Spengler*, Institute of Automotive Management and Industrial Production, Technische Universität Braunschweig, Katharinenstr.3, 38106, Braunschweig, Germany, t.spengler@tu-bs.de

1 - Trucks fleets routing for vehicle transportation
Alain Nguyen, IT, RENAULT, 13 ave Paul Langevin, (API : EQV NOV 3 54), 92359, Le Plessis Robinson Cedex, France, alain.nguyen@renault.com, *Jean-philippe Brenaut*

RENAULT sub-contracts fleets of trucks to transport vehicles from factories to delivery centers in Europe. The optimization problem is to design the most cost-effective circuits for each fleet. A circuit is constituted of delivery arcs and re-position arcs, which represent the repositionning of empty trucks to plants or ports (after their last delivery) so as to reload with new vehicles. We devise a column-generation like method: a sub problem to generate each fleet's candidate circuits, a master problem to select and quantify the optimal subset of circuits at minimal cost.

2 - Incorporating inventory decisions in location-routing problems
Wenyih Lee, Department of Business Administration, Chang Gung University, 259 Wenhua 1st Rd., Kweishan, 333, Taoyuan, Taiwan, leewe@mail.cgu.edu.tw

The classical location-routing problems (LRP) solve facility location and vehicle routing problems while do not take into accounts the inventory related cost. This research extends the classical LRP and proposes a three-level supply chain network design model which simultaneously makes inventory decisions. The objective is to minimize the joint total relevant cost, including warehouse, transportation, production setup, inventory ordering and holding cost. A meta-heuristic algorithm is applied to solve the proposed model. Numerical examples are also demonstrated.

3 - A leveled inventory routing approach for planning periodic milk-runs
Martin Grunewald, Institute of Automotive Management and Industrial Production, Technische Universität Braunschweig, Katharinenstraße 3, 38106, Braunschweig, Germany, m.grunewald@tu-bs.de, *Thomas Volling*, *Thomas Spengler*

Motivated by the success of Japanese car manufacturers, there is an increasing interest in the introduction of leveled logistics concepts. These concepts are characterized by leveled replenishment quantities and periodic pick up and arrival times which are also known as periodic milk-runs. To support the planning of these operationally consistent milk-runs, we propose an approach which combines stochastic vehicle routing with a simple replenishment policy. The replenishment policy makes use of safety stock to level the variability propagated into transportation operations.

■ WD-36

Wednesday, 14:30-16:00
G7-1

Cutting and Packing 6

Stream: Cutting and Packing
Invited session

Chair: *Mauro Russo*, R & D, Uniplan Software srl / Tekla-Mexall, via Manzoni 21, 84018, Scafati (SA), Italy, ma.russo@unina.it

1 - Cutting problems with usable leftovers
Ernesto G. Birgin, Dept. of Computer Science, University of São Paulo, Rua do Matão, 1010, Cidade Universitária, 05508-090, São Paulo, SP, Brazil, egbirgin@gmail.com, *Ricardo Andrade*, *Reinaldo Morabito*, *Debora Ronconi*

In this study we deal with the two-dimensional non-guillotine cutting problem of how to cut a set of rectangular objects with known sizes and quantities to exactly produce a set of rectangular items with specified sizes and demands to be fulfilled. We are concerned with the special case of the problem in which the non-used material of the cutting patterns (objects leftovers) may be used in the future, if it is large enough to fulfill future items demands. We use multilevel mathematical programming models to represent the problem. Illustrative numerical examples are presented and analysed.

2 - Cutting and Packing Problems and A New Heuristic Algorithm for Rectangular Element Placement
Ramazan Yaman, Industrial Engineering, Balikesir University, Balikesir University, Eng. and Arch. Faculty, 10145, Cagis Campus Balikesir, Turkey, ramazan.yaman@gmail.com, *Emrah Albayrak*, *Kadriye Ergun*, *Gulsen Yaman*

Cutting and packing problems are occurred in many areas of industries. From their solutions different disciplines can gain advantages and they gathered to put effort to solve them. When the number of items increased to reach exact solution is not possible in a reasonable time. Meta heuristic algorithms are in development for this purpose. The study describes a heuristic method. It implements placement of 2-D rectangular pieces on finite main piece. Firstly, cutting and packing problems have been classified. In conclusion, performance of developed algorithm is evaluated by example solutions.

3 - An exact dynamic programming procedure for very large-scale unconstrained two-dimensional guillotine cutting problem
Mauro Russo, R & D, Uniplan Software srl / Tekla-Mexall, via Manzoni 21, 84018, Scafati (SA), Italy, ma.russo@unina.it, *Antonio Sforza*, *Claudio Sterle*

We tackle the unconstrained guillotine two-dimensional cutting problem (U2DCP) by a new improved version of the knapsack function based dynamic programming procedure of Gilmore and Gomory (1966). We correct an error found by Herz (1972) and two other errors we found in their procedure. We also integrate it with an original piece pre-processing phase, coordinate reduction by using raster points, and tailored refinements aimed at reducing the memory requirements and the computation time. The proposed procedure solves at the optimum a set of seven very large instances never solved before.

4 - 2DCPackGen: A problem generator for two-dimensional rectangular cutting and packing problems
Elsa Silva, INESC TEC, Porto, Portugal, emsilva@inescporto.pt, *José Fernando Oliveira*, *Gerhard Wäscher*

A major limitation is felt in the two-dimensional cutting and packing problems field, the lack of problem generators widely and commonly used by all researchers in their computational experiments. In this work, a problem generator for every type of class of two-dimensional rectangular cutting and packing problems is developed. The problem generator will strongly contribute to the quality of the computational experiments run with cutting and packing problems and improve the quality of the papers published in this area.

■ WD-37

Wednesday, 14:30-16:00
G7-4

Multicriteria Decision Making and Its Applications XI

Stream: Multicriteria Decision Making II
Invited session

Chair: *José Rui Figueira*, Instituto Superior Tecnico, Technical University of Lisbon, Av. Cavaco Silva, Tagus Park, 2780 - 990 Porto Salvo, 2780 - 990, Lisbon, Portugal, figueira@ist.utl.pt

1 - Performance analysis using Visual PROMETHEE
Bertrand Mareschal, Solvay Brussels School of Economics and Management, Université Libre de Bruxelles, Boulevard du Triomphe CP 210/01, 1050, Brussels, Belgium, bmaresc@ulb.ac.be

We present an extension of the PROMETHEE multicriteria method to performance analysis when two sets of criteria are compared: input criteria that measure the level of resources allocated to actions (units) and output criteria that measure the corresponding activity level of the actions. The proposed approach is implemented in the Visual PROMETHEE software and an actual application in health care is presented.

2 - A Multicriteria Decision Making Approach for Agricultural Policy Design
Laura Riesgo, Dept. of Economics, Pablo de Olavide Univ., Ctra. Utrera km.1, 41013, Seville, Spain, laurariesgo@upo.es, *Francisco J. Andre*

This paper presents a methodological proposal to approach agricultural policy design as a multicriteria problem. The policy maker is assumed to determine the value of the policy instruments in order to optimize his policy objectives taking into account the response of farmers to each policy scenario. Farmers' behaviour is represented by means of the Multiattribute Utility Theory and the farmers' first order conditions are used as behavioural equations that the agricultural authority incorporates as constraints in his policy making problem.

3 - Making Transportation Decisions in the Supply Chain with Promethee
Johanna Trujillo, INDUSTRIAL ENGINEERING, Universidad Católica de Colombia, Cra 90 No. 22C-59 T1 APTO 301, BOGOTA, Colombia, Colombia, jtrujillo@ucatolica.edu.co, *Elsa Cristina Gonzalez La Rotta*, *Javier Vallejo*

This paper is about making decisions for Logistics Transport Function. The methodology was: a) identification of criteria in the framework, b) generation nomenclature and combinations alternatives for Logistics Decision Units not found in the documents reviewed for modes, types of carriers and cargo consolidation degree; c) model validation for criteria and alternatives in a Colombian production company that distributes Green Coffee massively, towards national and international points, to select the best alternative is used Visual PROMETHEE® developed by Bertrand Mareschal, 2012

4 - Ranking through Technique of Order Preference by Similarity to Ideal Vector (TOPSIV)
Hossein Safari, Faculty of Management, University of Tehran, 1234, Tehran, Iran, Islamic Republic Of, hsafari@ut.ac.ir, *Fatemeh Mirzaei Rabor*

One of the commonly used approaches in MCDM1 field is TOPSIS2. Ranking in the TOPSIS method is based on the shortest distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Idea. Similarity approach makes use of the ideal solution concept that the most preferred alternative should have the highest degree of similarity to the PIS. The final index of each alternative across all criteria is determined based on alternative gradient and magnitude in fuzzy environment.

■ WD-39

Wednesday, 14:30-16:00
G7-3

Multiobjective Integer Linear Programming and Optimality Conditions in Multicriteria Optimization

Stream: Vector- and Setvalued Optimization and Applications
Invited session

Chair: *Matthias Ehrgott*, Engineering Science, University of Auckland, Private Bag 92019, 1001, Auckland, New Zealand, m.ehrgott@auckland.ac.nz
Chair: *Andrea Wagner*, Mathematics, Martin-Luther-University Halle - Wittenberg, Theodor-Lieser-Straße 5, 06120, Halle/Saale, Germany, andrea.wagner@mathematik.uni-halle.de

1 - A new algorithm for solving bi-objective integer linear programs
Natashia Boland, School of Mathematical and Physical Sciences, The University of Newcastle, 2308, Callaghan, NSW, Australia, natashia.boland@newcastle.edu.au, *Hadi Charkhgard*, *Martin Savelsbergh*

Single-objective integer linear programs are now reliably solved by powerful commercial solvers. The situation is quite different when it comes to multi-objective problems. Few algorithms that produce all non-dominated solutions, i.e., the complete efficient frontier, are available. We have developed a novel approach for doing so in the case of two objectives, using a simple scheme for partitioning the objective function space and exploiting the power and features of modern integer programming solvers. Computational experiments demonstrate the efficacy of the approach.

2 - Solving Biobjective Linear Programmes Using Biobjective Column Generation
Andrea Raith, Engineering Science, The University of Auckland, UniServices House, 70 Symonds St, 1010, Auckland, New Zealand, a.raith@auckland.ac.nz, *Siamak Moradi*, *Matthias Ehrgott*, *Michael Stiglmayr*

Biobjective LPs can be solved by the biobjective simplex method which iteratively moves between efficient basic solutions by selecting a variable to enter the basis with maximum ratio of improvement of one objective and deterioration of the other. We show how to integrate a column generation approach with this simplex method and how to formulate the required subproblems. New variables to enter the basis are generated by solving a column generation subproblem that finds the required variable of maximum ratio. The advantage is that fewer variables are in the problem formulation.

3 - Multicriteria Approaches for a Private Equity Fund
Christiane Tammer, Mathematics and Computer Science, Martin-Luther-University Halle-Wittenberg, Theodor-Lieser-Str. 5, D-06120, Halle, Germany, christiane.tammer@mathematik.uni-halle.de, *Johannes Tannert*

We develop a new model for a Private Equity Fund based on stochastic differential equations. In order to find efficient strategies for the fund manager we formulate a multicriteria optimization problem for a Private Equity Fund. Using the e-constraint method we solve this multicriteria optimization problem. Furthermore, a genetic algorithm is applied in order to get an approximation of the efficient frontier.

4 - Generalized Multicriteria Location Problems Involving Additional Cost Functions

Shaghaf Alzorba, Mathematics, Martin-Luther-University, Richard-Paulick-Str.13, 1210, 06124, Halle, Sachsen-Anhalt, Germany, shaghaf7z@yahoo.com, *Christian Günther*, *Nicolae Popovici*

We study the decomposition of a vector optimization problem using the method of Pareto reducibility introduced by N. Popovici. For this method it is important to ask for conditions such that the set of efficient and weakly efficient solutions coincide. In the talk we study a single-facility location problem and we develope an implementable algorithm, which generates efficient solutions for such problems adding one or more other criteria. This algorithm is illustrated by a graphical user interface in MATLAB.

■ WD-40

Wednesday, 14:30-16:00
Y12-1

DEA applications IV

Stream: DEA and Performance Measurement
Invited session

Chair: *Lidia Angulo-Meza*, Production Engineering, Universidade Federal Fluminense, Av.Dos Trabalhadores 420 Vila Santa Cecilia, 27255125, Volta Redonda, Rio de Janeiro, Brazil, lidia_a_meza@pq.cnpq.br

1 - Technical Analysis and Scale Efficiency Through Time in Chilean Universities Through Window Analysis DEA

Gonzalo Eduardo Campos Hernández, Gestión de Operaciones, Universidad de Talca, Analisis Envolvente de Datos (DEA), Modelamiento Matematico, 8340518, Talca, Del Maule, Chile, gonzalo.campos.h@gmail.com, *Marcela Gonzalez-Araya*

Today the concern of most advanced countries to improve the efficiency and effectiveness of the Universities is evident. In Chile, this topic is not properly studied. This paper develops a new method that assesses the evolution of technical efficiency and scale of a Chilean university, through a time horizon (nine years). Three methods for selecting variables over time, which led to better discriminate the DMUs in the study period were created. Then DEA Window Analysis models, CCR and BCC, were applied, both with output, considering the efficiencies of scale and technological change (IPM).

2 - Evaluation of greek pubic university libraries efficiency using data envelopment analysis (dea)

Stella Sofianopoulou, Industrial Management & Technology, University of Piraeus, 80 Karaoli & Dimitriou street, 18534, Piraeus, Greece, sofianop@unipi.gr, *Lucine Mkrtsian*

This work seeks to measure the efficiency level of Greek public university libraries by applying Data Envelopment Analysis. Smaller or distant from the capital city universities have lower budgets, less students or staff. By this method we investigate whether these factors play a significant role in the efficiency of the libraries. Libraries efficiency scores are evaluated using Budget, Librarians, Books, Journals, Web DB and Users' as inputs and Circulation of Books, Users, Wed Site Visits as outputs. Among the 30 university libraries investigated 18 are rated as efficient.

3 - Efficiency measurement of economic higher education domains from Romanian Universities

Monica Mihaela Matei, Economic Informatics and Cybernetics, Bucharest University of Economic Studies, 6 Romana Square, 010374, Bucharest, Romania, matei.monicamihaela@gmail.com, *Crisan Albu*, *Tiberiu Spircu*, *Liliana Spircu*

Evaluation of the tertiary education system represents an essential pillar of the quality assurance process. The aim of this paper is to measure the efficiency of higher education domains from economic field in Romanian universities. In order to reach this goal we use partial frontier models known as order m and order alpha frontiers which were introduced in order to eliminate the drawbacks of the traditional nonparametric estimators of efficiency. In this framework the estimator of the frontier is built without enveloping all the observed data points.

4 - Distance learning evaluation using Data Envelopment Analysis and Dynamic clustering

Lidia Angulo-Meza, Production Engineering, Universidade Federal Fluminense, Av.Dos Trabalhadores 420 Vila Santa Cecilia, 27255125, Volta Redonda, Rio de Janeiro, Brazil, lidia_a_meza@pq.cnpq.br, *Silvio Gomes Júnior*, *João Carlos Soares de Mello*

We deal with a problem of educational evaluation of the CEDERJ distance learning centres in the Rio de Janeiro State. To perform this evaluation, we will use Data Envelopment Analysis (DEA). Since the DMUs are not homogenous, we need to group them into homogenous clusters. Instead of the classic static clusters we use the so-called dynamic clusters. Due to the fact that there are a few number of DMUs in each cluster, we use the Li and Reeves MCDEA model instead of the standard DEA model.

■ WD-41

Wednesday, 14:30-16:00
Y12-5

Energy and environmental modelling

Stream: Decision Making under Uncertainty and Environmental Applications
Invited session

Chair: *Olivier Bahn*, GERAD and MQG, HEC Montréal, 3000 Chemin de la Côte-Sainte-Catherine, H3T 2A7, Montréal, Qc, Canada, olivier.bahn@hec.ca

1 - The impact of adaptation on the transition towards clean energy systems

Olivier Bahn, GERAD and MQG, HEC Montréal, 3000 Chemin de la Côte-Sainte-Catherine, H3T 2A7, Montréal, Qc, Canada, olivier.bahn@hec.ca, *Kelly de Bruin*, *Camille Fertel*

Given that future climate changes appear now unavoidable to some extent, adaptation measures have recently gained a new political momentum. To analyse climate policies relying on adaptation, on may use integrated assessment models such Ada-BaHaMa, AD-DICE, AD-RICE and AD-WITCH. For this presentation, we have used the MERGE model, modified to account for the possibility to reduce gross damages through adaptation (AD-MERGE). We analyse with AD-MERGE how adaption impacts the use of mitigation options, looking at the market penetration of explicit clean energy technologies.

2 - A real options approach to assess climate change policies

Anca Pana, Department of Banking and Finance, University of Zurich, Plattenstrasse 32, CH-8032, Zürich, Switzerland, anca.pana@bf.uzh.ch, *Olivier Bahn*, *Marc Chesney*, *Jonathan Gheyssens*

This presentation assesses optimal investments in mitigation, adaptation, and geoengineering options to address climate changes. The Ada-BaHaMa model is used to describe economic and climate variables. We also use a real options approach to account for the high uncertainties surrounding geoengineering options. Our results point to the importance of considering risk when designing a climate policy mix: adaptation and mitigating measures dominate at the beginning of the decision horizon, while geoengineering is delayed until enough information regarding its net benefits is gathered.

3 - An Electronic Market Model for Secondary Markets
Ali Haydar Ozer, Department of Computer Engineering, Marmara University, Marmara Universitesi Goztepe Kampusu, Bilgisayar Muh. Bolumu MB 451 Goztepe Kadikoy, 34722, Istanbul, Turkey, haydar.ozer@marmara.edu.tr

A novel electronic market model designed for secondary markets is proposed. The model augments the double auction with a cover money mechanism which allows bidders to limit their budgets in the market. Furthermore, the model allows bidders to declare a list of substitutable items to be purchased and put a limit on the number of these items. These mechanisms provide better allocation of items and higher trading volume. Winner determination problem is formulated as an integer program, and complexity results are presented. Experimental results on a comprehensive test suite are demonstrated.

■ WD-42

Wednesday, 14:30-16:00
Y12-3

Policy Analytics 4

Stream: Policy Analytics
Invited session

Chair: *Marc Pirlot*, Mathematics and Operational Research, Université de Mons UMONS, Faculté Polytechnique, Rue de Houdain 9, B-7000, Mons, Belgium, marc.pirlot@fpms.ac.be

1 - A multicriteria population health index
Teresa Cipriano Rodrigues, Centre for Management Studies of Instituto Superior Técnico, Technical University of Lisbon, Avenida Rovisco Pais, 1, 1049-001, Lisbon, Portugal, Portugal, teresacrodrigues@ist.utl.pt, *Carlos Bana e Costa*, *Mónica Oliveira*, *Paula Santana*

Monitoring the status of population health requires the development of formal assessment tools, such as health indices. This study proposes a framework that combines concepts and methods from multicriteria value measurement with participatory methods to build a value-based population health index. The MACBETH approach is used to construct the population health index within a hierarchical additive model structure. Participatory methods involve both the use of a Delphi panel with a group of experts and decision conferencing with a strategic group.

2 - Contribution of TIMES-Canada and soft-links to the analytics of energy policies
Jean-Philippe Waaub, Geography, UQAM, CP 8888 succ. Centre-Ville, H3C 3P8, Montreal, Quebec, Canada, waaub.jean-philippe@uqam.ca, *Camille Fertel*, *Olivier Bahn*, *Kathleen Vaillancourt*

Policy Analytics aims to develop a decision aid tool-kit to support policy design, assessment, implementation or monitoring by taking into account the specificities related to policy cycles. TIMES-Canada is a long term energy and climate model. We show how it can contribute to policy design and assessment by providing strategic energy and GHG information. TIMES can be coupled with other operation research tools such as a Multicriteria or a Macro module. We also discuss complementarities with other decision aid tools used in Policy Analytics.

3 - Graph Centrality Measures and Conclave
Renato De Leone, School of Science and Technologies, Università di Camerino, via Madonna delle Carceri 9, 62032, Camerino, MC, Italy, renato.deleone@unicam.it, *Marco D Errico*, *Silvana Stefani*, *Anna Torriero*, *Maila Pietrini*

In this talk, we will apply some standard and more recent techniques for computing centrality measures for the graph in which the nodes are the Cardinals and existence and weights on the arcs are based on objective data (as, for example, age, nationality, member of Congregations, ...) for the Conclave that was held in March 2013. Computational results show that a small subset of cardinals are central according to one of the measures utilized.

4 - Data mining tecnics to assist in the inspection process in public sector
Adriana Clericuzi, Information Systems Departament, UFPB - Universidade Federal da Paraíba, CCAE - Campus IV - Departamento de Ciências Exatas - Rua da Mangueira, s/n, - Companhia de Tecidos Rio Tinto, 58297-000, Rio Tinto, PB, Brazil, adrianaclericuzi@dce.ufpb.br, *Tarcisio Grilo Jr.*

This research aims to apply data mining techniques in database Bidding and Contracts managed by the Court of the State of Paraíba (PB-TEC) in Brazil, allowing the generation of knowledge discovery hidden thus contributing to the process of decision making, oversight and procedural celerity within the public service. To the best comprehension it will bring to light the concepts of knowledge discovery in database. As a result we expect an increase in the productivity and also an increase in speed of lawsuit process from the public accounts analysis and public money fiscal control.

■ WD-43

Wednesday, 14:30-16:00
Y12-2

Collaborative Decision Making

Stream: Decision Support Systems
Invited session

Chair: *Pascale Zaraté*, Institut de Recherche en Informatique de Toulouse, Toulouse University, 118 route de NarBonne, 31062, Toulouse, France, zarate@irit.fr
Chair: *Jorge E. Hernández*, School of Management, University of Liverpool, Liverpool, United Kingdom, J.E.Hernandez@Liverpool.ac.uk

1 - Robustness Analysis in Multicriteria Disaggregation — Aggregation Approaches for Group Decision Making
Denis Yannacopoulos, Department of Business Administration, Technological Educational Institute of Piraeus, 12244, Egaleo, Greece, dgian@teipir.gr, *Athanasios Spyridakos*, *Nikos Tsotsolas*

A new process of feedbacks in the Disaggregation - Aggregation approaches for group decision making is presented. These feedbacks are based on the analysis of the assessed individual and collective Preference Models' (PM) robustness via 3d graphs and indexes, picturing their structure in a hyper - polyedron form. The target of this analysis is to identify interventions' regions in order to lead in an incensement of the PMs robustness, taking into consideration the Decision Makers' preferences. Also, the new module of RACES system, supporting the abovementioned processes is presented

2 - Strategic decision making during a disaster
Estelle Van Wyk, Industrial and Systems Engineering, University of Pretoria, Lynwood, Pretoria, South Africa, estelle.vanwyk@up.ac.za, *Venkata Yadavalli*

To address the complexity of the urgent need for relief supplies during and after a disaster, it is vital that relief supplies be pre-positioned to improve emergency response times. The location of pre-positioning facilities forms a critical part of the disaster operations life cycle. The facilities therefore need to be positioned in a strategic manner to ensure sufficient relief. This research proposes the application of stochastic modelling and Geographic Information System (GIS) technology for the location of emergency facilities within developing countries.

3 - Choosing the Best Anti-Virus in the World by Application of TOPSIS Method
Hesam Naie, Department of Industrial Management, Islamic Azad University (IAU), Iran, Islamic Republic Of, hesam.naie@yahoo.com

Decision making problem is the process of finding the best option from all of the feasible alternatives. Due to the fact that, the collected data for choosing an anti-virus are not concrete and substantial the way users demand including the risk attitude for a decision maker which is

somehow unknown. We present a new TOPSIS method for normalizing the collected data and ranking the alternatives, a MADM technique for ranking and selection of a number of externally determined alternatives through distance measures. For this research one of these criteria considered is Scanning Speed, and so on.

■ WD-44

Wednesday, 14:30-16:00
Y12-4

Traffic Routing and Congestion Games

Stream: Game Theoretical Network Models
Invited session

Chair: *Tobias Harks*, Quantitative Economics, Maastricht University, Maastricht, Netherlands, t.harks@maastrichtuniversity.nl

1 - Resource Aquisition Games

Britta Peis, Mathematics, TU Berlin, Strasse des 17.Juni 136, 10623, Berlin, Germany, peis@math.tu-berlin.de, *Tobias Harks*

We consider games in which the players jointly buy a subset of a given resource set E. A resource becomes only available if its entire load-dependent cost is paid by the players. A player's stratgey consists of the amount the player is willing to contribute towards the purchase of the resources. Her goal is to pay as little as possible by guaranteeing that at least one set of her predefined set family is available. We investigate existence and computability of Nash equilibria for such games. It turns out that matroids play a central role.

2 - Computing Network Tolls with Support Constraints

Tobias Harks, Quantitative Economics, Maastricht University, Maastricht, Netherlands, t.harks@maastrichtuniversity.nl, *Rolf Möhring*

Reducing traffic congestion via toll pricing has been a central topic in the operations research and transportation literature and, recently, it has been implemented in several cities all over the world. Since in practice it is not feasible to impose tolls on every edge of a given traffic network, we study the resulting mathematical problem of computing tolls on a predefined subset of edges of the network so as to minimize the total travel time of the induced equilibrium flow.

3 - On the Efficiency of Restricted Tolls in Network Routing Games

Guido Schäfer, Networks and Optimization, CWI, Science Park 123, 1098 XG, Amsterdam, Netherlands, g.schaefer@cwi.nl

Congestion in traffic networks has several negative effects as it causes environmental pollution, waste of resources, etc. In this context, road pricing is arguably one of the most effective regulation means. In this talk, we report on our studies about the computation of optimal tolls which are restricted to not exceed a predefined threshold for every edge. We show that optimal restricted tolls can be computed efficiently for parallel networks and affine latency functions. We also propose bounded marginal cost tolls and analyze their efficiency in general networks.

4 - Computing approximate pure Nash equilibria in congestion games

Ioannis Caragiannis, Department of Computer Engineering and Informatics, University of Patras, 26504, Rion, Greece, caragian@ceid.upatras.gr

Congestion games constitute an important class of games in which computing an exact or even approximate pure Nash equilibrium is in general PLS-hard. We present a simple polynomial-time algorithm that computes O(1)-approximate Nash equilibria in congestion games with polynomial latency functions of constant maximum degree. The algorithm essentially identifies a polynomially long sequence of best-response moves that lead to an approximate equilibrium. We also discuss extensions to weighted congestion games. Joint work with Angelo Fanelli, Nick Gravin, and Alexander Skopalik.

■ WD-45

Wednesday, 14:30-16:00
Y10-3

Decision making, auctions and monopoly models

Stream: Cooperative Game Theory
Invited session

Chair: *Mehmet Onur Olgun*, Industrial Engineering, Süleyman Demirel University, Turkey, onurolgun@sdu.edu.tr
Chair: *Sirma Zeynep Alparslan Gok*, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and Sciences, Suleyman Demirel University, Department of Mathematics, 32260, Isparta, Turkey, zeynepalparslan@yahoo.com

1 - Pre- or post-auction certification?

Laura Kohlleppel, university of cologne, Germany, kohlleppel@wiso.uni-koeln.de

We compare revenues from a first-price sealed-bid auction with bidder certification before and after the bidding. There are two countervailing effects: as certification is costly for bidders, there is less bidder participation under pre-auction certification which tends to reduce revenues compared to post-auction certification (exclusion effect). However, once bidders have paid the costs for pre-auction certification, these costs do not lead to lower revenues due to increased bid shading which is the case under post-auction certification (bid-shading effect).

2 - Optimization Model of a Monopoly Production Price Differentiation

Michal Fendek, Department of Operations Research and Econometrics, University of Economics Bratislava, Dolnozemská cesta 1/b, 85235, Bratislava, Slovakia, Slovakia, fendek@euba.sk, *Eleonora Fendekova*

In this article we discuss the general aspects of quantitative analysis of the monopoly price differentiation models and we will analyze in more detail the models of consumer's utility maximization in the conditions of price differentiation of the goods and a model of monopoly's profit maximization with price-differentiated production. We will analyze a role of consumer's behavior optimization and a problem of monopoly's profit optimization. For the optimization problems we will formulate the Kuhn-Tucker optimality conditions and we will study their economic interpretation options.

3 - Investments in r&d under monopolistic competition

Igor Bykadorov, Laboratory of Optimization Methods, Sobolev Institute of Mathematics SB RAS, 4 Acad. Koptyug avenue, 630090, Novosibirsk, Russian Federation, bykadorov.igor@mail.ru, *Sergey Kokovin*, *Evgeny Zhelobodko*

We study endogenous productivity in monopolistic competition with general utility/investment functions; a bigger investment yields smaller marginal cost. Then the equilibrium investments increase with the market size if and only if the utility generates increasing demand elasticity. However, this technological advantage of a bigger market is different from a welfare advantage. To fit social optimality conditions, a governmental taxation/subsidy should be non-linear. Supported by the grants of Russian government (No 11.G34.31.0059), EERC (No 11-5231), RFBR (No 12-06-00174-a).

■ WD-46

Wednesday, 14:30-16:00
Y10-1

Practical Applications of Game Theory

Stream: Game Theory and Combinatorial Optimization
Invited session

Chair: *Qi Qi*, Hong Kong UST, Hong Kong, kaylaqi@ust.hk
Chair: *Steffen Rebennack*, Economics and Business, Colorado School of Mines, Golden, CO, United States, srebenna@mines.edu

1 - Competition between suppliers with reservation and execution prices
Edward Anderson, University of Sydney Business School, University of Sydney, NSW 2006, Sydney, NSW, Australia, edward.anderson@sydney.edu.au, *Bo Chen*

We consider competing suppliers who each offer blocks of capacity quoting two different prices: a reservation price and an execution price. The buyer decides which blocks of capacity to reserve and pays the reservation prices. Then demand occurs according to a known distribution. Finally the buyer determines which of the reserved capacity to use, and pays the execution price for capacity that is required. Demand that exceeds the total amount of reserved capacity is lost. We describe the optimal buyer policy. We show that in the game between the suppliers, execution prices are set at cost.

2 - Games in Sports Games
Qi Qi, Hong Kong UST, Hong Kong, kaylaqi@ust.hk, *Xiaotie Deng*

We study the design of championship tournaments based on pairwise comparisons. While the competitive nature of sports has seen best effort central to success of sportsman and sportswoman, there have been incidences where players are believed to lose a match intentionally in order to advance and to win the championship eventually. We establish criteria that identify the existence of such strategic plays by mining historic data. We design game rules to eradicate such strategic behavior.

3 - Supply function equilibrium with benefits taxation
Andy Philpott, Engineering Science, The University of Auckland, 70 Symonds Street, 1022, Auckland, New Zealand, a.philpott@auckland.ac.nz, *Tony Downward*

We consider a transmission charging scheme in which beneficiaries of transmission investment projects contribute proportionally to their capital costs. An agent's benefits in a trading period under this scheme are calculated by increases in the agent's welfare when their offer curve is dispatched ceteris paribus in a market with the transmission asset as compared with a dispatch in a market without it. This gives payoffs that combine uniform and pay-as-bid mechanisms. We examine the implications of this scheme on agent behaviour using some simple supply function equilibrium models.

4 - Optimal Bidding Strategies for Price Making Hydro Electric Producers
Steffen Rebennack, Economics and Business, Colorado School of Mines, Golden, CO, United States, srebenna@mines.edu, *Greg Steeger*

Power generation companies desire to optimally schedule their energy production over time and their production is based on the bids they submit. This work particularly addresses bid-based markets with day-ahead price and/or quantity bidding. We utilize Lagrangian relaxation on the state variable (water balance) constraints to incorporate Nash equilibrium conditions into the framework of stochastic dual dynamic programming, determining optimal bidding strategies for multiple price maker hydro producers.

■ WD-47

Wednesday, 14:30-16:00
Y10-2

Pricing Strategies in Revenue Management

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Sasa Pekec*, Fuqua School of Business, Duke University, 100 Fuqua Drive, 27708-0120, Durham, NC, United States, pekec@duke.edu

1 - Strategic pricing when quoting reliable lead times to customers
Secil Savasaneril, Department of Industrial Engineering, Middle East Technical University, Dumlupinar Bulvari, 06800, Ankara, Turkey, ssecil@metu.edu.tr, *Harun Serin*

We study the pricing problem of a service center that quotes lead times to the customers. The service center may select among several pricing or lead time quotation schemes. However, the lead times must be reliable in that the quotes should reflect the true status of the system. Under such a setting, we characterize the optimal pricing strategies. Depending on the pricing scheme the prices are determined by stochastic dynamic programming or nonlinear programming. Through a numerical study, the impact of certain parameters on the strategy selection decisions of the service center is analyzed.

2 - Sales People and B2B Pricing
Itir Karaesmen, Kogod School of Business, American University, 4400 Massachusetts Av. NW, 20016, Washington, DC, United States, karaesme@american.edu, *Wedad Elmaghraby*, *Wolfgang Jank*

Analyzing the data provided by one of the largest grocery products distributors (GPD) in the United States, we investigate how salespeople use the information provided to them to set the prices; of particular interest to us is how salespeople use price recommendations coming from a decision support tool. Our research shows that salespeople's decisions are well-explained by a two-stage decision model.

3 - Optimal Pricing Mechanisms When Externalities are Valuable
Sasa Pekec, Fuqua School of Business, Duke University, 100 Fuqua Drive, 27708-0120, Durham, NC, United States, pekec@duke.edu, *Changrong Deng*

We study optimal allocation and pricing on a network of competing unit-demand buyers who have private information about the value of an item being sold. Buyers value externalities and place a premium on obtaining the item if no/some/all rivals obtain the item at the same time. The seller limited to offering posted prices should inflate the price in order to maximize revenues and capture the value buyers put on the allocative externalities. We use a revenue-maximizing mechanism design approach to describe optimal allocation and pricing schemes, and present an ascending auction implementation.

■ WD-48

Wednesday, 14:30-16:00
Y11-1

System Reliability and Failure

Stream: Financial Mathematics and OR
Invited session

Chair: *Michael Stutzer*, Finance, University of Colorado, 419 UCB, 80309, Boulder, CO, United States, michael.stutzer@colorado.edu

1 - Illiquidity and Insolvency: a Double Cascade Model of Financial Crises
Tom Hurd, Mathematics and Statistics, McMaster University, 1280 Main St W, L8S 4K1, Hamilton, Ontario, Canada, hurdt@mcmaster.ca

In current models of systemic risk illiquidity and insolvency are often treated as two distinct and separate phenomena. The main goal of this paper is to integrate these as two faces of the same coin in a mathematically tractable "deliberately simplified model" of financial networks. Three different possible behavioral states of a bank are identified, namely the normal state, the stressed state and the insolvent state. The overall level of stress and insolvency in the network leads to system-wide effects, such as the tightening of liquidity or the fire-sale of illiquid bank assets.

2 - Financial Network Contagion: An Introduction
Michael Stutzer, Finance, University of Colorado, 419 UCB, 80309, Boulder, CO, United States, michael.stutzer@colorado.edu

Recent events suggest the possibility of cascading bank failures due to the interconnectedness of interbank payments and mutual exposure to common external shocks. This talk is meant to motivate the subject, and briefly introduce the econometric and graph theoretic approaches.

3 - Modeling of reliability in multi-server computer
Saulius Minkevicius, Operations Research, Mathematics and Informatics Institute of VU, Akademijos g. 4, LT-08663, Vilnius, Lithuania, minkevicius.saulius@gmail.com

The performance in terms of reliability of computer multi-server networks motivates this paper. The probability limit theorem is derived on the virtual waiting time of job in open multi-server queuing networks in heavy traffic and applied to a reliability model for multi-server computer networks, where we relate the time of failure of a multi-server computer network to the system parameters.

■ WD-49

Wednesday, 14:30-16:00
Y11-2

Advances in Financial Modeling, Risk Management and Managerial Accounting

Stream: Data Mining in the Financial Sector
Invited session

Chair: *Yeliz Yolcu Okur*, Financial Mathematics, Middle East Technical University, Uygulamali Matematik Enstitüsü, S-Binasi, Ankara, Turkey, yyolcu@metu.edu.tr
Chair: *Peter Lakner*, IOMS, New York University, 44 West 4th St., Suite 8-61, 10012, New York, NY, United States, plakner@stern.nyu.edu

1 - Pricing American Options using the Malliavin Calculus
Mohamed Kharrat, Department of Mathematics, FS Sfax -Tunisia, Sfax, Sfax, Tunisia, mohamed.kharrat08@gmail.com, *Yacin Jerbi*

In this paper we elaborate a general expression of the conditional expectation related to pricing problem of the American options using the Malliavin derivative. This work is a generalization of paper of Bally and al. (2005) for the one dimensional case. Basing on the density function of the asset price, Bally et al. used the Malliavin calculus to evaluate the conditional expectation related to pricing American option problem, but in our work we use the Malliavin derivative to resolve the previous problem. Key words: Conditional expectation, Malliavin derivative, American option.

2 - Phillips Curve in condition of Czech Republic in 2000-2012
Ondrej Simpach, Department of Demography, University of Economics in Prague, W. Churchill sq. 4, 13067, Prague, Czech Republic, ondrej.simpach@vse.cz, *Marketa Arltova*, *Josef Arlt*

The aim of this paper is to assess the relationship between inflation and unemployment in the Czech Rep. based on the quarterly published time series for the period I/2000-III/2012 using co-integration analysis (VAR and ECM). We'll follow the approach by Phillips and Granger. It's clear that it's possible to confirm the negative relationship between the two time series in the period of economic crisis, which affected the Czech Rep. in the past. However, since their relationship isn't strong enough, it will be in the second part of the analysis extended by additional information.

3 - High Frequency Asymptotics for the Limit Order Book
Peter Lakner, IOMS, New York University, 44 West 4th St., Suite 8-61, 10012, New York, NY, United States, plakner@stern.nyu.edu, *Joshua Reed*, *Sasha Stoikov*

We study the one-sided limit order book for sell (or buy) orders and model it as a measure-valued process. Limit and market orders arrive to the book according to independent Poisson processes. Market orders remove from the book the order corresponding to the current best price. We consider the order book in a high frequency regime in which the rate of incoming limit and market orders is large and traders place their limit orders close to the current best price. We provide weak limits for the price process and the properly scaled measure-valued order book process.

4 - Fuzzy Difference Equations in Finance
Emine Can, Dept. of Physics, Kocaeli University, 41380, Kocaeli, Turkey, eminecan@kocaeli.edu.tr, *Afet GolayoĞlu Fatullayev*

Fuzzy difference equations initially introduced by Kandel and Byatt. An important effort to study such of equations has been made by Buckley. In this work we apply the method of fuzzy difference equations to study some problems in finance. As a source of different cases of finance equations we use the work by Chrysafis, Papadopolous, Papaschinopoulos. To illustrate the applicability of the method we give some numerical examples.

■ WD-50

Wednesday, 14:30-16:00
Y11-3

Energy Systems

Stream: Optimization under Uncertainty
Invited session

Chair: *Bruno Flach*, IBM Research, Brazil, Av. Pasteur, 138/146, Botafogo, 22296-903, Rio de Janeiro, RJ, Brazil, bflach@br.ibm.com
Chair: *Alexandre Street*, Electrical Engineering, PUC-Rio, Rua Marquês de São Vicente, 225, Edifício Cardeal Leme, sala 401 (Secretaria), 22451-900 , Rio de Janeiro, Rio de Janeiro, Brazil, street@ele.puc-rio.br

1 - A modern two-stage stochastic programming portfolio model for an oil refinery with financial risk management
Patrick ODriscoll, Birkbeck, University of London, WC1E 7HX, London, United Kingdom, podris01@mail.bbk.ac.uk

The proposal which we wish to make is for a two-stage stochastic programming model for a competitive oil refinery with stochastic oil and fuel prices. Most models for refineries are deterministic and do not consider the stochastic problem. This portfolio includes its own production, sales and costs of crude oil. The objective is to maximise the refiner's profits under raw material, product inventory and financial risk constraints. The expected value of perfect information calculation gives a value for the additional benefit that the decision maker receives in considering uncertainties.

2 - General Security Criterion and Demand Uncertainty in Energy and Reserve Scheduling Models: an Adjustable Robust Optimization Approach.
Alexandre Moreira, Electrical Engineering, Pontifícia Universidade Católica do Rio de Janeiro, Rua Marquês de São Vicente, 225/L401, Gávea, 22451-900, Rio de Janeiro, Rio de Janeiro, Brazil, mdsalexandre@yahoo.com.br, *Alexandre Street*, *José Manuel Arroyo*

In this presentation, adjustable robust optimization techniques are used to address the joint transmission and generation n-K security criterion and demand uncertainty in unit commitment (UC) problems. A joint energy and reserve scheduling model is used. Adjustable robust counterparts are formulated as trilevel programs and solved by Benders decomposition. To address nonlinearities due to demand uncertainty, a binary expansion approach is used. Results suggest that robust models provide a computational-efficient tool to account for uncertainties in UC models.

3 - A Hybrid Stochastic-Robust Portfolio Selection Model for Renewables in Brazil
Alexandre Street, Electrical Engineering, PUC-Rio, Rua Marquês de São Vicente, 225, Edifício Cardeal Leme, sala 401 (Secretaria), 22451-900 , Rio de Janeiro, Rio de Janeiro, Brazil, street@ele.puc-rio.br, *Bruno Fanzeres*, *Alexandre Moreira*, *Alvaro Veiga*, *Luiz-Augusto Barroso*

Due to its uncertain generation profile, renewable sources in Brazil are exposed to the so-called price-quantity risk, which occurs whenever the seller is long in contracts and must purchase at high spot prices the amount sold but not produced. In this environment, we propose a stochastic-robust portfolio model to set the best combination of complementary renewable units (wind and small hydro). In such model, for each scenario of energy production, a sublevel optimization problem assesses the set of spot prices that produces the worst-case annually revenue within a polyhedral uncertainty set.

4 - Transmission Network Investment with Probabilistic Security and Corrective Control

Rodrigo Moreno, Electrical and Electronic Engineering, Imperial College London, United Kingdom, r.moreno@imperial.ac.uk, *Danny Pudjianto*, *Goran Strbac*

This paper demonstrates that the growth in application of corrective actions to enhance network utilization will require a probabilistic treatment of network security for determining efficient levels of investment in network reinforcement. A Benders decomposition based two-stage probabilistic optimization model for the operational and investment problems is proposed. For selecting relevant contingencies (beyond N-1 criteria), a novel filtering technique for efficient elimination of redundant outages is presented and successfully tested.

■ WD-51

Wednesday, 14:30-16:00
Y11-4

Monte Carlo Methods in Finance

Stream: Financial Optimization
Invited session

Chair: *Denis Belomestny*, Universitat Duisburg-Essen, Altendorferstr. 11, D-45127, Essen, Germany, denis.belomestny@uni-due.de

1 - Multilevel Monte Carlo Methods for Pricing of American Options

Denis Belomestny, Universitat Duisburg-Essen, Altendorferstr. 11, D-45127, Essen, Germany, denis.belomestny@uni-due.de

In this talk we introduce several new Multilevel Monte Carlo approaches for pricing American type derivatives. We present the complexity analysis of the resulting algorithms and illustrate their efficiency in several benchmark option pricing examples.

2 - A Riskless Asset Strictly Enhances the Best Sharpe Ratio in a Multi-Period Setting

Li Zhongfei, Sun Yat-sen Business School, Sun Yat-sen University, 510275, Guangzhou, Guangdong, China, qiukili@hotmail.com

In this paper, we prove that the multi-period mean-variance efficient frontier generated by both risky and riskless assets is strictly separated from the one generated by only risky assets. We also prove that the inclusion of a riskless asset strictly enhances the best Sharpe ratio of the efficient frontier in the multi-period setting, and offer an explicit expression for the enhancement of the best Sharpe ratio. Such findings show that, in contrast to the single-period mean-variance model, the multi-period mean-variance model includes a number of different structures and properties.

3 - Multilevel policy iteration for pricing American options

Marcel Ladkau, WIAS, Mohrenstr. 39, 10117, Berlin, Germany, ladkau@wias-berlin.de, *Denis Belomestny*

In this talk we propose a multilevel simulation based approach for computing lower bounds of American options. By constructing a sequence of Monte Carlo based policy iterations due different levels of accuracy we construct a multilevel version of policy iteration with significantly improved complexity. In this context, we will present new convergence results regarding the bias and variance of simulation based Howard iteration and show that the multilevel complexity is superior to the standard one. This is joint work with Denis Belomestny and John Schoenmakers.

■ WD-52

Wednesday, 14:30-16:00
B13-1

Forecasting IV

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Sven F. Crone*, Department of Management Science, Lancaster University Management School, Bailrigg Campus, LA1 4YX, Lancaster, United Kingdom, s.crone@lancaster.ac.uk

1 - A bias and variance analysis for multi-step time series forecasting

Souhaib Ben Taieb, Machine Learning Group ULB, Boulevard Louis Schmidt 52, 1040 Etterbeek, 1040, Brussels, Brussels, Belgium, bsouhaib@gmail.com, *Amir F. Atiya*

We propose to study the behavior of bias and variance for multi-step forecasting strategies. The goal is to provide a study that analyzes the bias and variance components for multi-step forecasting, and determine how the forecast horizon factors into this relation.

Simulations using linear and nonlinear time series shows that the bias and variance components of each forecasting strategy can be affected by several factors such as the learning algorithm used for function estimation, the objective associated to the forecasting strategy, the size of the time series and the forecasting horizon.

2 - A forecasting support system for mobile devices

Foteini Skiada, Electrical and Computer Engineering, National Technical University of Athens, 9, Iroon Polytechniou Str, 15780, Zografou, Athens, Greece, foteini@fsu.gr, *Achilleas Raptis*, *Fotios Petropoulos*, *Vassilios Assimakopoulos*

The rise of mobile platforms has enabled the development of modern support systems that conveniently fit in smartphones. ForeDroid is an android application which offers data extrapolation via widely used forecasting techniques. Apart from classic approaches for data input, ForeDroid integrates an innovative 'click and forecast' feature, where a picture shot of a graph is digitized into time series and automatically forecasted. Numerical and graphical outputs can easily be shared through social media services. Performance assessment of the application has been realized by test users.

3 - Trend Strips: A New Tool for Analyzing Time Series

Regiane Máximo de Souza, Engenharia de Produção, Unesp, Brazil, regiane@feb.unesp.br, *Antônio Carlos Silva Filho*

Let X be a numerical time series for a given variable. In a previously published article, the authors proposed a new technique to analyze the patterns of evolution of X: the Trend Strips (TS). Trend Strips are sequences of "0" and "1" - 10011, for example - where the meaning of "1" is that the value of X in some position remained unchanged or increased relative to the value of a position before, while "0" means that the value has decreased. In this communication, we applied the TS for many deterministic systems (random, chaotic, periodic) and established their patterns of evolution.

4 - Improving Exponential Smoothing Model Selection for SAP APO DP — a case study in defining and selecting (few) Forecasting Profiles

Sven F. Crone, Department of Management Science, Lancaster University Management School, Bailrigg Campus, LA1 4YX, Lancaster, United Kingdom, s.crone@lancaster.ac.uk, *Nikolaos Kourentzes*

Research remains inconclusive on how to best select between exponential smoothing models automatically. In addition, the software SAP APO-DP offers the choice of selecting models and parameters automatically every time, or fixing models and parameters as forecasting profiles to be applied at future demand planning runs. This study assesses different approaches to identifying an optimum number of predetermined exponential smoothing forecasting profiles using clustering, and how best to select between profiles, on 326 empirical time series from fast moving consumer goods manufacturer Beiersdorf.

■ WD-53

Wednesday, 14:30-16:00
B13-2

Probabilistic Approach to Modeling Macroeconomic Uncertainties

Stream: Forecasting & Time Series Prediction II
Invited session

Chair: *Carlos Diaz*, Economics, University of Leicester, United Kingdom, cdv7@leicester.ac.uk

1 - Combining density forecasts

Stephen Hall, University of Leicester, United Kingdom, s.g.hall@le.ac.uk

This paper proposes a practical data-driven approach to the direct combination of density forecasts by taking a weighted linear combination of the competing density forecasts. The combination weights are chosen to minimize the 'distance', as measured by the Kullback—Leibler information criterion, between the forecasted and true but unknown density. We explain how this minimization both can and should be achieved but leave theoretical analysis to future research.

2 - Inflation and Inflation Uncertainty: A Dynamic Framework

Yeliz Yalcin, Gazi University, Turkey, yyeliz@gazi.edu.tr

This paper aims to investigate the direct relationship between inflation and inflation uncertainty. In this study Stochastic Volatility in Mean models are used to capture the shocks to inflation uncertainty within a dynamic framework. These models allow assessing the dynamic effects of innovations in inflation as well as inflation volatility on inflation and over time, by incorporating the unobserved volatility in the mean equation. Empirical findings, robust across various definitions of inflation and sub-periods, suggest that innovations in inflation volatility increases inflation.

3 - Defective Probabilistic Forecasts: Comforting the perplexed

Reason L. Machete, Department of Mathematics, University of Botswana, 00704, Gaborone, Botswana, Reason.Machete@mopipi.ub.bw

In operational forecasting, the goal of probabilistic forecasting may be unattainable due to model imperfection. Consequently, the resulting probabilistic forecasts will be defective. Considering macroeconomic forecasts for both the UK and the US, the types of defects that one can have are discussed. Both theoretical and empirical results are presented, which include ways to remedy these defects. One can have either pessimism or over-confidence in some way. Is it high time we realised that calibration is a mirage and should use alternative approaches to assess probabilistic forecasts?

4 - Inflation Fan Charts, Monetary Policy and Skew Normal Distributions

Carlos Diaz, Economics, University of Leicester, United Kingdom, cdv7@leicester.ac.uk, *Wojciech Charemza*, *Svetlana Makarova*

Issues related to classification, interpretation and estimation of inflationary uncertainties are addressed in the context of their application for constructing probability forecasts of inflation. The principal source of confusion in defining uncertainties is in ignoring the effect of feedback from the policy action undertaken on the basis of forecasts of inflation onto uncertainties. In order to resolve this problem a new class of skew normal distributions (weighted skew normal) is proposed and its properties derived. We show that it parameters can be interpreted in terms of monetary policy.

■ WD-54

Wednesday, 14:30-16:00
B14-1

Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks (COST TD1207) II

Stream: Energy, Environment and Climate
Invited session

Chair: *Martin Mevissen*, IBM Research Dublin, IBM Technology Campus, Damastown Industrial Park, Mulhuddart, 15, Dublin, Ireland, martmevi@ie.ibm.com
Chair: *Andrea Lodi*, D.E.I.S., University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, andrea.lodi@unibo.it
Chair: *Claudia D'Ambrosio*, LIX, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, dambrosio@lix.polytechnique.fr

1 - Bundle methods for energy problems: analyzing the impact of inexactness

Rosa Figueiredo, UA/ENSTA, Brazil, rosamaria.figueiredo@gmail.com, *Wim van Ackooij*, *Antonio Frangioni*, *Claudia Sagastizabal*

Lagrangian decomposition is crucial in many large-scale, difficult energy problems. The last generation of bundle methods is able to handle "inexact oracles", where subproblems are solved only approximately (and hence more efficiently), with an accuracy that varies along iterations under the control of the Bundle solver. We investigate the effect of inexactness on the speed of convergence of the dual and primal iterates, depending on various schemes for handling the levels of accuracy and on different variants of bundle methods.

2 - Optimal capacity expansion planning in energy systems

Christoph Thurner, Department of Mathematics, FAU Erlangen-Nürnberg, Discrete Optimization, Germany, christoph.thurner@math.uni-erlangen.de, *Alexander Martin*

Motivated by the nuclear phaseout plan of the German government we develop a model for the optimal expansion of power generation capacities in energy systems. The problem is decomposed into a master problem determining the capacities to be generated. This data is input for the unit commitment subproblem. For the latter we ensure service security for a given planning horizon. We present computational results on realistic problem instances. In addition, we discuss how to deal with difficulties caused by the uncertain feed in of renewable energy sources and the integration of storage capacities.

3 - MILP Formulation for Blackout Prevention by Deliberate Islanding of Power Networks

Andreas Grothey, School of Mathematics, University of Edinburgh, The King's Buildings, West Mains Road, EH9 3JY, Edinburgh, United Kingdom, A.Grothey@ed.ac.uk, *Waqquas Ahmed Bukhsh*, *Paul Trodden*, *Ken McKinnon*

We present an optimization-based approach to intentionally form islands in an electricity network. This is motivated by the need to have a robust method that can prevent faults cascading through a network and causing wide area blackouts. The decision is made of which transmission lines to disconnect in order to split the network while minimizing amount of load shed, or grouping coherent generators. The approach uses a mixed integer programming model with a new piecewise linear approximation to AC power flow. Resulting islands satisfy AC power flow laws, and have a healthy voltage profile.

4 - Approximate Robust Optimization with Application in Energy Systems

Andreas Bärmann, Department Mathematik, FAU Erlangen-Nürnberg, Germany, baermann@mathematik.tu-darmstadt.de, *Frauke Liers*, *Sebastian Pokutta*, *Christoph Thurner*

This talk is concerned with Robust Optimization for mixed-integer linear programs incorporating ellipsoidal uncertainty sets. We introduce a framework that linearizes the latter to maintain the linearity of the

problem. This is achieved via the Ben-Tal/Nemirovski-linearization of the second-order cone. Our general implementation of the method is applied to a problem arising in the context of planning the expansion of power generation capacities in energy systems. We present computational results on realistic instances for which the uncertainty lies in the feed-in of renewable energy sources.

■ WD-55

Wednesday, 14:30-16:00
B14-2

Mathematical and Data Models in Decision Making

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Marc Pirlot*, Mathematics and Operational Research, Université de Mons UMONS, Faculté Polytechnique, Rue de Houdain 9, B-7000, Mons, Belgium, marc.pirlot@fpms.ac.be
Chair: *Anastasia Motrenko*, Applied mathematics and management, MIPT, Moscow, Russian Federation, pastt.petrovna@gmail.com

1 - A re-characterization of the Kemeny distance

Burak Can, Dept. of Economics 1, Maastricht University, P.O. Box 616, 6200 MD, Maastricht, Netherlands, b.can@maastrichtuniversity.nl, *Ton Storcken*

The well-known swap distance (Kemeny (1959); Kendall (1938); Hamming (1950)) is analyzed. On weak preferences, this function was characterized by Kemeny (1959) with five conditions; metric, betweenness, neutrality, reducibility, and normalization. We show that the same result can be achieved without the reducibility condition, therefore, the original five conditions are not logically independent. We provide a new and logically independent characterization of the Kemeny distance and provide some insight to further analyze distance functions on preferences.

2 - The IUCN Red List threatened speices categorization algorithm

Mikhail Kuznetsov, Moscow Institute of Physics and Technology, Russian Federation, mikhail.kuznecov@phystech.edu, *Vadim Strijov*

The main purpose of the IUCN Red List is to categorize those plants and animals that are facing a high risk of extinction. Species are classified by the IUCN Red List into nine groups ordered by the the relative risk of extinction in the wild nature. Each species is described with the rank-scaled features given by the experts. The problem is to associate each species with one of the groups according to the data given by the experts. We consider the rank-scaled features as the cones in the space of objects and construct the solution as the nearest point to the superposition of this cones.

3 - A Choquet integral for the comparison of decisional maps

Valérie Brison, Mathematics and Operational Research, UMONS, Belgium, valerie.brison@umons.ac.be, *Marc Pirlot*

In a previous work, we proposed some models, all characterized by axioms, to help a decision maker to compare maps representing the state of a region at different stages of its evolution. In this work, we provide another model that enables to take into account one specific geographic aspect that may influence the decision maker's preference, namely the contiguity. More precisely, we specify interactions by means of a graph and we model these interactions by means of a Choquet integral, the parameters of which can be elicited.

4 - Noncompensatory scoring rules and threshold aggregation

Yuliya Veselova, Department of Higher Mathematics, National Research University Higher School of Economics, Russian Federation, yul-r@mail.ru

We consider the basic framework of social aggregation problem: each agent linearly orders the set of alternatives and their preferences are aggregated into a social preference. The threshold aggregation rule assumes that lower grades cannot be compensated by any number of higher grades (Noncompensatory Threshold and Contraction, NTC, axiom). We show that there is a class of generalized scoring rules that satisfy NTC axiom and fully characterize this set. We also prove that a generalized scoring rule is equivalent to the threshold aggregation rule if and only if it belongs to this class.

■ WD-56

Wednesday, 14:30-16:00
B15-3

Logistics: modeling and optimisation

Stream: OR Applications in Industry
Invited session

Chair: *Roberto Montemanni*, IDSIA - Dalle Molle Institute for Artificial Intelligence, SUPSI - University of Applied Sciences of Southern Switzerland, Galleria 2, CH-6928, Manno, Canton Ticino, Switzerland, roberto@idsia.ch
Chair: *Luca Maria Gambardella*, Istituto Dalle Molle di Studi sull'Intelligenza Artificiale, IDSIA, USI-SUPSI, University of Lugano - University of Applied Science and Arts of Southern Switzerland, DTI Department of Technology and Innovation, Galleria 2, 6928, Manno-Lugano, Switzerland, Switzerland, luca@idsia.ch

1 - Logistics Education Efficiency Analysis

Matthias Klumpp, Institut für Logistik & Dienstleistungsmanagement, FOM University of Applied Sciences, Leimkugelstraße 6, 45141, Essen, Germany, matthias.klumpp@fom-ild.de

The personal and business value of education investments is proven. This logistics education contribution tries to establish a link between individual advantages from further education in logistics and the corporate level by modelling a case study within DUISPORT based on a DEA, using education (accumulated learning hours) as input and transport performance (transshipment tons, transport tkm, turnover EUR) as outputs of individual team DMUs. An optimiziation will allow for corporate level outcome forecasting due to different logistics education investments.

2 - Dynamic Multi-Zone Dispatching in Noisy Data via Enhanced Intelligent Water Drop Algorithm for Thai Truck Load Trucking Problems

Pongchanun Luangpaiboon, Industrial Engineering, Thammasat University, Faculty of Engineering, Klong Luang, 12120, Pathumthani, Thailand, lpongch@engr.tu.ac.th

The multi-zone dispatching approach has been introduced to manage and control via the adjustment of the same point of products in and out to find the proper point of transportation. In fact, business conditions are constantly changing. The need of new quantity of orders, product lines, and technological advance or the dynamic and noisy natures of the multi-zone dispatching problems is proposed in terms of the re-arrangement penalty of the area in each zone. The objective of this research is to manage zones with minimal imbalance scenario via the enhanced intelligent water drop algorithm.

3 - Optimization approaches for the train load planning problem in seaport container terminals

Massimo Paolucci, DIBRIS, University of Genova, Via Opera Pia 13, 16145, Genova, Italy, Italy, massimo.paolucci@unige.it, *Daniela Ambrosino*, *Davide Anghinolfi*, *Silvia Siri*

The problem of defining loading plans for the trains departing from a seaport container terminal is faced. Import containers of different length, weight and priority must be assigned to trains, satisfying trains and wagons capacity constraints. The objectives are the minimization of re-handling operations in the stocking area and of non-productive movements of the overhead travelling crane, and the maximization of

the train utilization. A 01-LP model, solved by a general purpose MIP heuristic, and a heuristic approach are proposed. The results due to the proposed approaches are presented.

4 - Simulated Elevator Group Control Algorithm for Engineering Optimisations
Pasura Aungkulanon, Industrial Technology, Phranakhon Rajabhat University, 9 Changwattana Road, Bangkhen, 10220, Bangkok, Bangkok, Thailand, pasurachacha@hotmail.com, *Pongchanun Luangpaiboon*

In this paper, the novel simulated elevator group control algorithm isintroduced for determining the engineering optimisations. Eightnonlinear continuous mathematical functions in the context of noisyresponse surface, multi-response surfaces and economical machiningoperations problems were used to test the algorithm performance.

■ WD-57

Wednesday, 14:30-16:00
B15-4

Closed Loop Supply Chains

Stream: Environmental Issues in Operations Management
Invited session

Chair: *Seval Ene*, Industrial Engineering, Uludag University, Uludag University, Faculty of Engineering and Architecture, Gorukle Campuss, Bursa, Turkey, sevalene@uludag.edu.tr

1 - Modeling the Purchase Intention of Remanufactured Product Consumers
Beatriz Jiménez-Parra, Organización de Empresas, Universidad de Extremadura, Avda. de Elvas, s/n, 06006, Badajoz, Spain, bjimenez@unex.es, *Sergio Rubio*, *Azucena Vicente-Molina*

Many companies have begun to implement end-of-life strategies in response to worldwide concern about green issues while academic research on remanufacturing has focused on the analysis of activities from a supply side. However, little attention has been paid to the demand side of remanufactured products. The main objective of our study is to analyze the determinants of purchase intentions of remanufactured product consumers. The results provide firms interested in implementing green initiatives in their supply chain with useful information for their consideration of closed-loop supply chains.

2 - Sustainability in the supply chain
Maria Isabel Gomes, CMA - Universidade Nova de Lisboa, Monte da Caparica, 2829-516, Caparica, Portugal, mirg@fct.unl.pt, *Bruna Mota*, *Ana Paula Barbósa-Póvoa*

There is an ever growing need of sustainability. Closing the loop of forward and reverse supply chains can not only increase environmental performance but also the profit. Yet very few works consider simultaneously the three pillars of sustainability. The social pillar has been overlooked. A multiobjective model was developed to support such analysis: cost and environmental impact minimization, and social benefit. A social benefit indicator was developed favoring employment in less developed regions. The model is applied to the supply chain of a lead battery manufacturer and distributer.

3 - Collection of Recyclables from Cubes - a Case Study
Sanne Wøhlk, Department of Business Studies, Aarhus School of Business, Fuglesangs alle 4, DK-8210, Aarhus V, Denmark, sanw@asb.dk, *Morten Bie Bogh*, *Hardy Mikkelsen*

Collection of recyclable materials is an important part of reverse logistics. We consider a case study where paper and glass are collected from recycling cubes and transported to a treatment facility where it is processed for reuse. We analyze how outsourcing the planning and transportation of the service can result in conflicts of interest and cause unsustainable solutions. Finally, we suggest an alternative payment structure which can lead to a common goal, overall economic sustainability, and an improved financial situation for both the public company and the logistics provider.

4 - Closed-loop logistics network design
Seval Ene, Industrial Engineering, Uludag University, Uludag University, Faculty of Engineering and Architecture, Gorukle Campuss, Bursa, Turkey, sevalene@uludag.edu.tr, *Nursel Ozturk*

In this paper, closed-loop logistics network design problem, which is constituted of integration of forward flow of new products and reverse flow of returned products, is considered. This paper presents a mixed integer linear programming model for closed-loop logistics network design problem. The proposed model, which minimizes total cost of the network, determines facility locations and network flows between facilities. The model is also a strategic decision tool for firms to incorporate reverse flow. It can be adapted and enhanced to any product type.

■ WD-58

Wednesday, 14:30-16:00
B15-6

Recent Advances in Data Mining and Statistics, Supported by Continuous Optimization

Stream: Computational Statistics
Invited session

Chair: *Fatma Yerlikaya Ozkurt*, Scientific Computing, Institute of Applied Mathematics, Industrial Engineering Department, Middle East Technical University, 06800, Ankara, Turkey, fatmayerlikaya@gmail.com

1 - An Automated Box-Jenkins Modeling Forecasting Tool for Passenger Demand in Urban Rail Systems
Saeedeh Anvari, Industrial Engineering, Koc University, Eng212-Muhendislik Fakultesi, Koc University-Rumeli feneri Yolu, 34450, Istanbul, Turkey, sanvari@ku.edu.tr, *Metin Turkay*

An important factor in urban rail systems is the power consumption that can be significantly reduced by forecasting passenger demand and improving related operational issues. Most of the previous work is not adaptive to changes and difficult to implement in real life. Developing an accurate, adaptive and automated Box-Jenkins modeling tool to forecast passenger demand that can be used easily due to automation in structure and user friendly interface is a unique characteristic of this work. Parameters in the model can be customized to fit the characteristics of particular urban rail system.

2 - Different Approaches to Regression Analysis
Nuri Celik, Statistics, Bartin University, Turkey, nuri_celik_1905@hotmail.com.tr

Regression analysis deals with the dependence of one variable on other variables. We generally assume that the error terms in regression model are normally distributed. The estimators of the unknown model parameters are obtained by using the least square(LS) estimation method. However, when the normality assumption is not satisfied, LS estimators of the parameters and the test statistics based on them lose their efficiency. In this work, we introduce different approaches to regression analysis, we perform this alternative methods to real life data, finally we conclude the work with simulation.

3 - An Alternate for Practical Applications of Survival Analysis
Nezir Aydin, INDUSTRIAL ENGINEERING, YILDIZ TECHNICAL UNIVERSITY, Yildiz Teknik Universitesi Endustri Muhendisligi, Besiktas Kampusu, 34349, ISTANBUL, Turkey, neziraydin@yahoo.com, *Erkan Isikli*

Survival analysis (SA) is concerned with estimating the time observed until the occurrence of an event. Even though it is more flexible compared to OLS-based methods, one of its basic assumptions, the independence of the events, might be restrictive in real world applications. In this study, we present the results of an alternative way to deal with the obstacles caused by having violated this assumption using real and synthetic data and conclude that in such cases it is still possible to benefit from SA; however, the interpretation is not straightforward compared to traditional SA methods.

4 - A New Knot Selection Approach For Adaptive Regression Splines Based On A Nonlinear Mapping
Cem Iyigun, Industrial Engineering, Middle East Technical University, Turkey, iyigun@ie.metu.edu.tr, *Elcin Kartal Koc*, *Inci Batmaz*

Multivariate Adaptive Regression Splines (MARS) is a nonparametric regression method which is commonly used for prediction in several engineering problems . The method generates a fitting model adaptively by selecting knot points. For high dimensional datasets, the examination of large set of candidate knots becomes a computational burden. In this study, a novel knot selection procedure is proposed for selecting representative knot points using a mapping approach similar to self-organizing maps. The performance of the proposed approach is evaluated via artificial and real datasets.

■ WD-59

Wednesday, 14:30-16:00
B15-5

Foundations of Social Math: Uncovering the Hard Science in the Soft OR Debate

Stream: Soft OR / Systems and Multimethodology
Invited session

Chair: *Jared Lee Hanson*, Said Business School, Oxford University, PO Box 45180, 11512, Riyadh, Select, Saudi Arabia, jared.hanson@oba.co.uk

1 - The Neurobiological Hardware Common to All Thinking Agents
Kim Huhman, Behavioral Neuroscience, Georgia State University, PO Box 45180, 11512, Riyadh, NA, Saudi Arabia, info@themop.org, *Jared Lee Hanson*

Take a look down the microscope of neuroscience to see the real biomechanics of the human brain. Despite the complexity, "neuroanatomists have not found a hopelessly tangled, arbitrarily connected network, completely idiosyncratic to the brain of each individual, but instead a great deal of repeating structure within an individual brain and a great deal of homology across species." What we see is that the brain controls behavior and behavior in much the same way impacts the brain. This unified empirical context establishes universal constraints within all social systems.

2 - Evolutionary Cultural Anthropology–The Software of Human Cognition
Barry Hewlett, Cultural Anthropology, Washington State University - Vancouver, PO Box 45180, 11512, Riyadh, NA, Saudi Arabia, jared@yu.edu.sa, *Jared Lee Hanson*

Emergence and Self Organization in Linguistic and Cultural Systems. "In parallel with the current transformative revolutions in information processing and communication,...there is another revolution, a Kuhnian paradigm shift at the dawn of the 21st century much as physics underwent in the beginning of the 20th century when quantum mechanics was added to Newtonian physics. That revolution is in our understanding of how complex adaptive systems (CAS) gather, compute, store and communicate—from DNA to the human biopsychosocial levels—and in our use of this knowledge" (Jobson, 2011).

3 - Complexity, Chaos, and the Counter-intuitive Insights of Non-linear Systems
Ralph Abraham, Mathematics, University of California - Santa Cruz, PO Box 45180, 11512, Riyadh, NA, Saudi Arabia, jared.hanson@mail.sit.edu, *Jared Lee Hanson*

Given their common structural breakdown, we can describe all complex systems in fundamentally the same way. With the same underlying neurobiology, there is adequate reason to believe that the underlying processes of neural network formation and social decision making are generalizable despite variations in culture. The problem of misalignment between different complex, cultural systems stems from the different underlying rules of calculation arising from various cultural narratives. We can filter out this noise by anchoring to the empirics of neurobiology instead of to cultural frames.

4 - Basic Social Math: Closing the Linguistic Gap Between Rigorous Models and Empirical Systems
Jared Lee Hanson, Said Business School, Oxford University, PO Box 45180, 11512, Riyadh, Select, Saudi Arabia, jared.hanson@oba.co.uk

Taking fundamental steps beyond statistics, Social Math® seeks to bridge the philosophical divide between Hard and Soft OR. Proponents of "Hard" OR acknowledge the limits of "rigorous mathematical models" in solving many real-world, operational problems, but offer no solution. Ironically, it's the proponents of "Soft' OR who recognize the linguistic disconnect between "rigorous models" and the truly hard empirical systems they represent. This session explores how linguistic rigor can close the gap and unlock the full problem-solving power of math. Audience input & discussion encouraged!

■ WD-60

Wednesday, 14:30-16:00
B15-7

Learning: Methods and Algorithms II

Stream: Information and Intelligent Systems
Invited session

Chair: *Metin Turkay*, Department of Industrial Engineering, Koc University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, mturkay@ku.edu.tr
Chair: *Youssef Masmoudi*, University of Sfax, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef.masmoudi@gmail.com
Chair: *Fadime Uney-Yuksektepe*, Industrial Engineering, Istanbul Kultur University, E5 Karayolu Londra Asfalti Uzeri, Atakoy Kampusu, 34156, Istanbul, Turkey, f.yuksektepe@iku.edu.tr

1 - Towards a consolidation of worldwide journal rankings — A classification using random forests and aggregate rating via data envelopment analysis
Grigory Pishchulov, Faculty of Business, Economics and Social Sciences, TU Dortmund University, Martin-Schmeißer-Weg 12, 44227, Dortmund, Germany, grigory.pishchulov@udo.edu, *Heinz Tuselmann*, *Rudolf R. Sinkovics*

The question of how to assess research outputs published in journals is now a global concern for academics. Numerous journal ratings and rankings exist — featuring perceptual, citation-based, hybrid and, more recently, "meta" approaches intended to provide a balanced view by delivering a composite journal ranking. We extend this recent line of work by deploying a novel method that combines the random forests framework for missing data imputation and data envelopment analysis for the aggregation of rank data, and offering a comprehensive rating and ranking of business and management journals.

2 - An Adaptive Multivariate Supervised Learning Network to Fit the US Municipal Bond Term Structure
Gordon Dash, Finance and Decision Sciences, University of Rhode Island, 7 Lippitt Road, College of Business Administration, 02881, Kingston, RI, United States, ghdash@uri.edu, *Nina Kajiji*

A new multivariate neural network (K7-MRANN) is introduced to update and compare the results generated by contemporary models used to fit bond term structure. Using a unique near high-frequency municipal database, we produce a K7-MRANN fitted U.S. Municipal bond term structure and compare it to both the Nelson-Siegel linear model with fixed shape parameters and 1994 Svensson extension. Analytical and empirical findings demonstrate that the K7-MRANN method does not require a grid search, is not adversely affected by colinearity, large variances, and temporal instability.

■ WD-62

Wednesday, 14:30-16:00
R18-1

Emerging Applications of Finance in Economics and Environment.II

Stream: Emerging Applications of Finance in Economics and Environment
Invited session

Chair: *Omer Kayhan Seyhun*, Banking and Financial Institutions Department, Risk Centralization Division, Central Bank of Turkey, Istiklal Street No 10, Ulus, 06100, Ankara, Turkey, kayhan.seyhun@tcmb.gov.tr
Chair: *Kasirga Yildirak*, IAM, METU, 06531, Ankara, Turkey, kasirgayildirak@gmail.com.tr

1 - OR and finance

Alex Fleischer, Ilog Optimization Technical Sales, IBM Software Group, 9 rue de Verdun, 94, Gentilly, France, afleischer@fr.ibm.com

A strong concern shared by many mathematicians is that finance and its big bonuses have attracted many talents, however OR is not used as much as it should be even if it managed to provide huge ROIs in the financial sector. We'll discuss why and describe a few applications to support OR colleagues who intend to tackle finance related models. Details about some Classic Applications like Portfolio Optimization, Trade Matching and Timing and Asset-Liability Management will be provided.

2 - "The complexity of demand forecast in the age of macro-economic instability' — A statistical modeling solution

Saumik Barua, Analytics, Hewlett Packard Company, Global e:Business Op P/L No. 66/2, Ward No. 83, Bagmane Tech-Park Ground - 6th Floor, Wing A, Embassy Prime CV Raman Nagar, Bangalore, Karnataka, India, 560093, Bangalore, Karnataka, India, saumik.barua@hp.com, *Sandip Mukherjee*

The paper proposes a statistical modelling solution that drives the market sizing process in a company, enabling the business to have in-depth view of the market concerned. The objective is to identify the causality to the drivers of market demand to forecast market size through extensive correlation analysis of market demand to a wide range of macro-economic and industry variables at different lags, modelling of inherent drivers of the market concerned and development of time series models.

3 - Testing a Rating System's Calibration Quality when Defaults are dependent

Florian Resch, Oesterreichische Nationalbank, Austria, florian.resch@oenb.at, *Manuel Lingo*, *Gerhard Winkler*

Testing the accuracy of probability of default estimates is an integral element in the validation of credit rating systems. To this end, we describe a general framework for assessing whole rating systems under any assumed dependence structure for the individual obligors. We propose to benefit from the advantages of multiple comparisons and joint tests and merge these procedures to define a new, combined test. A scenario analysis using rating data of Moody's demonstrates that our newly proposed test enhances the statistical inference about the calibration quality of rating systems.

4 - Forecasting the tail density of financial time series: a mixture autoregressive model approach

Mary Akinyemi, Mathematics, University of Manchester, Apartment 36, THE GALLERY, 347, Moss Lane East,, M144LB, MANCHESTER, LANCASHIRE, United Kingdom, m.akinyemi@postgrad.manchester.ac.uk, *Georgi Boshnakov*

Forecasts play a very significant role in economics, finance, and other fields of application of time series analysis. Density forecasts have become more popular as real life scenarios require not only a forecast estimate but also the uncertainty associated with such a forecast. Applications of density forecasts span across various industries, including macroeconomics and finance. A very important area is risk management. Mixture autoregressive (MAR) models provide a flexible way to model various features of time series data and is very well suited for density forecasting.

■ WD-63

Wednesday, 14:30-16:00
R18-2

Logistics and Maritime IV

Stream: OR and Maritime Studies
Invited session

Chair: *Zhou Xu*, The Hong Kong Polytechnic University, Hong Kong, lgtzx@polyu.edu.hk

1 - Yard Template Planning under Uncertain Numbers of Loading Containers

Lu Zhen, Management Science & Engineering, Shanghai University, Shang Da Road 99, 200444, Shanghai, China, zhen_lu@yahoo.cn

A yard template determines the assignment of spaces (subblocks) in a yard for arriving vessels so as to minimize the utilization cost of subblocks and the transportation cost for moving containers in the yard. The fluctuation of the demand for freight transportation brings new challenges for making a robust yard template when facing uncertain maritime market. A model is proposed for yard template planning with considering random numbers of containers that will be loaded onto vessels that visit the port periodically.

2 - A Tree-splitting Approximation Algorithm for the k-depot Capacitated Vehicle Routing Problem

Liang Xu, Department of Logistics, The Southwestern University of Finance and Economics, China, arecxuliang1112@gmail.com

In this paper, we study the k-depot Capacitated Vehicle Routing Problem (k-depot CVRP). The aim of the k-depot CVRP is to determine k routes for the k vehicles located in distinct depots with each having a finite capacity of serving Q customers, so as to minimize the total length of the k routes. In this study, we develop an approximation algorithm for the k-depot CVRP, and we have proved that our proposed algorithm achieves the first constant approximation ratio for the k-depot CVRP.

3 - Joint Planning of Fleet Deployment, Speed Optimization and Cargo Allocation for Liner Shipping

Zhou Xu, The Hong Kong Polytechnic University, Hong Kong, lgtzx@polyu.edu.hk

In this study, we develop an aggregate planning model for the deployment of a fleet of container ships to liner shipping services that are rotated around different regions of the world. It takes into account a joint optimization of decisions on the numbers and speeds of ships deployed for each service, together with the cargo flows. We approximate the model by a mixed integer linear programming, and develop a branch-and-bound algorithm. Through numerical experiments, we have demonstrated the efficiency of the solution method, and compared the performance of various fleet deployment strategies.

4 - A bid-price control for slot allocation in liner shipping

Sebastian Zurheide, Institute for Operations Research and Information Systems, Hamburg University of Technology (TUHH), Schwarzenbergstrasse 95 D, 21073, Hamburg, Hamburg, Germany, zurheide@tu-harburg.de, *Kathrin Fischer*

In liner shipping, revenue management methods have gained in importance in the recent past. Therefore, the slot allocation problem for container bookings and different booking acceptance strategies are discussed in this work with respect to applicability and performance. Especially, a new bid-price strategy is compared to booking limit strategies. A simulation approach is used to evaluate the strategies for different scenarios. The simulation study reveals that especially the bid-price strategy can considerably improve the outcome for the company if transportation capacity is scarce.

■ WD-64

Wednesday, 14:30-16:00
R18-3

Health Care

Stream: Humanitarian Operations Research
Invited session

Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de
Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Active Relocation and Dispatching of Ambulance Department Heterogeneous Fleet
Ali Haghani, Civil and Environmental Engineering, University of Maryland at College Park, University of Maryland, College Park, Maryland, United States, haghani@umd.edu, *Elham Sharifi*, *Hadi Sadrsadat*

This research presents an integer programming model for Ambulance Management Centers. The model dynamically dispatches some vehicles to emergency incidents and relocates others to provide better coverage for the whole area. This model is event-based and will be solved whenever there is an event in the system. These events can be: occurrence of an emergency, change in the status of vehicles, change in the traffic data, and change in the likelihood of an emergency happening in the demand nodes. Two types of ambulances are considered in the system: Advanced Life Support, and Basic Life Support.

2 - Planning the weekly activities of doctors in a large teaching hospital
K Ramani, Indian Institute of Management, Vastrapur, 380015, Ahmedabad, Gujarat, India, ramani@iimahd.ernet.in

The weekly activities of doctors in a teaching hospital includes Undergraduate teaching, Postgraduate teaching, Outpatient consultations, inpatient care, academic meetings, research seminars, death audits, and administration. In this paper, we provide a weekly plan of activities of doctors in the Medicine Department (for illustration) of a large teaching hospital. A decision support system could provide flexibility to the management to schedule the weekly activities of its doctors, without compromising on service quality.

3 - Appointment Scheduling for Medical Diagnostic Facilities
Weifen Zhuang, School of Management, Xiamen University, Xiamen, Fujian, China, wfzhuang@xmu.edu.cn

This paper studies appointment scheduling for medical diagnostic facilities through a Markov Decision Processes (MDP) model. We derive structural properties of the value function and develop simple bounds to study asymptotics. Using the empirical data from the hospital, we conduct numerical studies to exam the asymptotics and evaluate the performance of heuristics.

■ WD-65

Wednesday, 14:30-16:00
R18-5

OR for Developing Countries, Humanitarian Applications

Stream: OR for Developing Countries, Humanitarian Applications (contributed)
Contributed session

Chair: *Harwin de Vries*, Econometric Institute, Erasmus University, Burgemeester Oudlaan 50, 3062 PA, Rotterdam, Netherlands, hdevries@ese.eur.nl
Chair: *Sevtap Kestel*, Actuarial Sciences, Applied Mathematics Institute, Middle East Technical University, Institute of Applied Mathematics, 06531, Ankara, Turkey, skestel@metu.edu.tr

1 - A Conceptual Framework for Facility Location Problem in Humanitarian Relief Logistics Systems
Alev Taskin Gumus, Industrial Engineering, Yildiz Technical University, YTU Dept. of Industrial Engineering, Yildiz-Besiktas, 34349, Istanbul, Turkey, ataskin@yildiz.edu.tr, *Erkan Celik*

Determination of facility numbers and locations, like medical, coordination and distribution centers, in humanitarian relief logistics systems is an important problem. It is important to implement relief activities in a more efficient and productive way during pre and/or post disaster humanitarian relief logistics operations. In this paper, a conceptual framework is presented considering facility location problem literature in humanitarian relief logistics systems.

2 - The Composition of government spending and economic growth in Latin American countries
Raul Chamorro-Narvaez, Economics, Universidad Nacional De Colombia, Carrera 30 No. 45-03, Bogota, Colombia, rachamorro@yahoo.com

The objective of this article is to determine the effects of different components of government spending on the per capita economic growth rate in a set of Latin American countries over the period 1975 — 2000. Government spending is disaggregated into eight functional categories. The empirical literature tends to reject the prediction of the neoclassical model of no role of fiscal policy in determining the growth rate.

3 - The Roadside Healthcare Facility Location Problem
Harwin de Vries, Econometric Institute, Erasmus University, Burgemeester Oudlaan 50, 3062 PA, Rotterdam, Netherlands, hdevries@ese.eur.nl, *J.j. van de Klundert*, *Albert Wagelmans*

Providing African truck drivers with adequate access to healthcare is an effective way to reduce the burden and the spread of HIV and other diseases. Therefore, NGO North Star Alliance builds a network of healthcare facilities along the major African trucking routes. We propose and analyze a MIP model to select locations for new facilities and to decide for these facilities which health services to provide. The objectives are to maximize the utilization of the facilities and to maximize the extent to which the truck drivers have continuous access to the needed health services.

4 - Determination of Optimum BPN Values and Macro-Texture Depths by the Help of Filled Function Technique
Emel Yuzer, Civil Engineering, Suleyman Demirel University, Turkey, emelyuzer07@hotmail.com, *Ekinhan Eriskin*, *Meltem Saplioglu*

Skid resistance plays an active role in accidents. Decrease of roughness of the road surface causes decline in the skid resistance of the road. This decrease affects driving safety negatively. Besides high values in the macro roughness cause accidents by distracting the driver. In the study macro-texture depths were measured in some places where had been most intensive traffic accidents in Isparta city. It is established a connection between the measurements and traffic accidents. This connection has been expressed by a mathematical equation and optimized with Filled Function technique.

■ WD-66

Wednesday, 14:30-16:00
R18-4

Sustainable Management for Resources, Conservation and Recycling V

Stream: Optimization for Sustainable Development
Invited session

Chair: *Sadia Samar Ali*, Operations Management, Fortune Institute of International Business , New Delhi - 110057, India, Plot No.5 Rao Tula Ram Marg, Opp Army R&R Hospital, Vasant Vihar, New Delhi - 110057, 201009, New Delhi, India, sadiasamarali@gmail.com

1 - Modeling decision processes of a green supply chain with regulation on energy saving level
Gang Xie, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Siyuan Building Room C510, No.55, Zhongguancun East Road, 100190, Beijing, China, gxie@amss.ac.cn

In this study, we analyze the impact of threshold value of energy saving level set by the policy maker on energy saving level and price set by green supply chains. Then, the decision of the policy maker and the coordination of a supply chain are investigated. The results suggest that both regulation and supply chain structure have significant impacts on energy savings and profits. From the observations, we can conclude vertical integration and coordination should be advocated if energy savings is urgent and regulation is implemented.

2 - An Evaluation of the World's Major Airlines' Technical and Environmental Performance
Amir Arjomandi, Economics, University of Wollongong, University of Wollongong, 2522, Wollongong, NSW, Australia, amira@uow.edu.au, *Juergen Seufert*

This study uses bootstrapped VRS-DEA models to examine environmental and technical efficiency of airlines. 48 world's major full-service (FSCs) and low-cost carriers (LCCs) are chosen from six different IATA regions. Our results show that a large number of the most technical efficient airlines are from the region China and North Asia while many of the most environmental efficient airlines belong to the region Europe and Russia. We also found that although the number of environmentally-oriented FSCs is increasing over the time, LCCs can still be seen as more environmentally-oriented airlines.

3 - Financial Feasibility Analysis for Project Selection
Pall Jensson, School of Science and Engineering, Reykjavik University, Menntavegi 1, 101, Reykjavik, Iceland, pallj@ru.is

The focus of project management has been on enhancing methods on how to run projects efficiently, on time and within budget. The pre-project effort has often been neglected. In recent years more emphasis has been directed to this pre-project effort and methods of feasibility analysis tools have developed. One of the key components in feasibility analysis is a financial analysis aimed at assessing the profitability of a project and thus supporting the project selection and justification. This paper discusses these models and how they are used in project selection and project justification

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■ WD-69

Wednesday, 14:30-16:00
R19-3

Public/Nonprofit Supply Chains

Stream: Stream of INFORMS Society for Public Programs, Service and Needs
Invited session

Chair: *Mohammad Moshtari*, University of Lugano, Switzerland, mohammad.moshtari@usi.ch

1 - Designing Intervention Strategy for Public-Interest Goods
Ece Zeliha Demirci, Industrial Engineering, Bilkent University, Bilkent University, Department of Industrial Engineering EA325, 06800, Ankara, Turkey, edemirci@bilkent.edu.tr, *Nesim Erkip*

The supply chain of a public-interest good (health-related products, energy efficient appliances, eco-consumables etc.) is generally subject to a central authority's intervention due to its remarkable societal value. The aim of the central authority is maximizing the social utility. In this study, we consider a system composed of a retailer and a central authority that regulates the system through direct investment and/or subsidies. Overall, we model the system via bi-level programming, characterize the optimal strategy and provide useful insights for the regulation of public-interest goods.

2 - Factors Influencing Collaboration Among International Humanitarian NGOs: An Empirical Analysis
Mohammad Moshtari, University of Lugano, Switzerland, mohammad.moshtari@usi.ch

This paper empirically investigates the factors influencing horizontal collaboration performance among international NGOs conducting humanitarian operations, providing a systematic view of the drivers and impediments to collaboration. Theories and concepts from interorganizational relationships constitute the study's theoretical foundation. Data are collected through a web-survey of International NGOs in 25 countries, and I use structural equation modeling to examine the proposed hypotheses.

3 - Locating vulnerable temporary depots prior to a natural disaster
Anastasia Nikolaeva, Industrial and Systems Engeneering, SUNY at Buffalo, 11 Georgian Ln., #7, 14221, Williamsville, NY, United States, aanikola@buffalo.edu, *Rajan Batta*, *Jun Zhuang*

This talk addresses the problem of temporary supply depot (SD) locations in anticipation of a natural disaster (e.g. hurricane). Vulnerability of SDs is mentioned in previous works. We develop this line of work by modeling the assignment of protection levels to SDs that will decrease their chance to be affected by the disaster. We also consider vulnerability of route segments involved in supply distribution between SDs and DPs (demand points) by applying some ideas from the Influence Maximization literature. Numerical examples will be presented to contrast with existing models.

■ WD-71

Wednesday, 14:30-16:00
R16-1

Health Care Management (Emergency Care/Services)

Stream: Health Care Management
Invited session

Chair: *John Fowler*, Industrial Engineering, Arizona State University, Tempe, AZ, United States, john.fowler@asu.edu

1 - Optimal Control Policies for Ambulance Diversion
Esma Gel, School of Computing, Informatics and Decision Systems Engineering, Arizona State University, 699 S. Mill Avenue, 85281, Tempe, AZ, United States, esma.gel@asu.edu, *Ahmet Hafizoglu*, *Adrian Ramirez Nafarrate*, *John Fowler*

We consider optimal ambulance diversion control policies with the objective of minimizing patients' waiting time higher than a recommended safety time threshold. We model the problem using a Markov decision process formulation, and characterize the structure of an optimal ambulance diversion policy. We compare the performance of the optimal policy with simple heuristics using a simulation model, and analyze the value of information in ambulance diversion decisions.

2 - DES modeling of an EMS call center
Geert-Jan Kommer, Dept for Public Health Forecasting, Dutch National Institute for Public Health and the Environment, PO Box 1, Ant. van Leeuwenhoeklaan 9, 3720 BA, Bilthoven, Netherlands, geertjan.kommer@rivm.nl

Each year, the Ambulance Care Dispatch Centres in the Netherlands handle more than a million calls. Ambulance organisations respond to more than 1.000,000 call-outs, 66% of which are urgent. These involve situations that may be life-threatening or may result in serious damage to health. The other 34% of call-outs involve planned transport. The ambulance care dispatch centres handle urgent calls from the national 112-emergency number and, via a different incoming line, requests from the police, general practitioners or other health care providers. Apart from handling the incoming calls, the di

3 - Estimating Locational Demand for Emergency Departments in Singapore
Mabel Chou, National University of Singapore, 1 Business Link, BIZ 1, #04-08, 117592, Singapore, Singapore, mabelchou@nus.edu.sg

The paper contributes to the determination and forecast of patient presentation volumes at individual emergency departments situated in a territory with a dense but highly mobile population, such as Singapore. This investigation enhances the administrative capability of planning and optimizing the national healthcare resources. We will make explicit the explanation of how many patients would arrive in a particular hospital ED, as opposed to the other hospitals, from a particular district given the population size and demographics of the district and the attributes of the hospital.

4 - Stochastic modeling of the emergency department
Safiye Sencer, Management Information Systems, Sakarya University, Esentepe Campus, Turkey, safiyesencer@yahoo.com

Abstract: Hospital's emergency department may face to unexpected patient arrives and operations in every time. In this paper, dynamic probabilistic patient movements and service capabilities illustrated with dynamic stochastic model. Modeled of the system covers the expected and unexpected patient arrives and operations. Model structure, state space, internal and external events, output costs, risks and value model defined and modeled with stochastic dynamic approach in detail.

■ WD-72

Wednesday, 14:30-16:00
R16-2

Data Mining in Biology and OR methods for NMR

Stream: Computational Biology, Bioinformatics and Medicine
Invited session

Chair: *Metin Turkay*, Department of Industrial Engineering, Koc University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, mturkay@ku.edu.tr
Chair: *Giuseppe Lancia*, Matematica e Informatica, University of Udine, Udine, Italy, lancia@dimi.uniud.it
Chair: *Giovanni Felici*, Istituto di Analisi dei Sistemi ed Informatica, Consiglio Nazionale delle Ricerche, Viale Manzoni 30, 00185, Roma, Italy, giovanni.felici@iasi.cnr.it
Chair: *Marta Szachniuk*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl

1 - On the role of alignment free distances in DNA reads assembly
Emanuel Weitschek, IASI-CNR, 00100, ROMA, Italy, emanuel.weitschek@gmail.com, *Giovanni Felici*, *Daniele Santoni*, *Maria De Cola*

In DNA sequence assembly a relevant issue is related with the trade-off between precision of the assembly process and its computational time. An important step in DNA assembly is the identification of a subset of read pairs that have a high probability of begin aligned sequentially in the sequence that is to be reconstructed. We propose alignment free distances to evaluate the similarity between two reads as a technique for filtering good read pairs to be assembled. The method is tested in its ability to emulate, with a proper level of precision, much more time consuming distance functions.

2 - Factorization machine learning framework in the sparse multi-view derived feature space from sites profile and coupling analysis between variables
Ya Nan Zhang, IBM China Research Lab, 6/F, Bldg.10, 399 Keyuan RoadZhangjiang Hi-Teck ParkPudong New District, 201203, Shanghai, China, zynsh@cn.ibm.com, *Feng Jin*, *Wen Jun Yin*, *Zhi Bo Zhu*, *Wei Wu*

Adenosine-5'-triphosphate (ATP) plays a critical role in the metabolism of life. So it is very necessary to perform extensive research on various aspect of protein-ATP binding site profile. In our study, not only multi-view sparse protein profile was derived, but specialized factorization machine framework was designed for depth analysis of protein-ATP binding sites profile also including variables coupling and sparsity of feature domain. Insightful results based strict evaluation criteria show better performance compared with existing learning framework.

3 - Optimal pathway reconstruction on NMR maps
Marta Szachniuk, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl, *Mikolaj Malaczynski*, *Erwin Pesch*, *Jacek Blazewicz*

We consider a problem of designating optimal routes crossing peaks on NMR maps, that originates from structural bioinformatics. Reconstruction of pathways tracing inter-nuclei NMR interactions allows to assign them to parent-atoms. This starts the procedure of computing parameters of the molecule structure what contributes to a reconstruction of its three-dimensional fold. Here, we describe BS-MLP method designed to automatically reconstruct pathways on 2D NMR maps of RNAs. We present the results of computational experiments and their evaluation due to the constraints provided by NMR experts.

4 - Making NVR-ACO a practical tool for NMR Protein Structure-Based Assignments
Mehmet Serkan Apaydin, Istanbul Sehir University, 34662, Istanbul, Turkey, apaydin@sehir.edu.tr, *Jeyhun Aslanov*, *Murodzhon Akhmedov*, *Bülent Çatay*

The key bottleneck of NMR protein structure determination is the assignment problem, which is about mapping the peaks to corresponding nuclei. We previously developed a suite of programs that solve this problem with the help of a template protein. In this talk we describe our progress in developing a novel scoring function, incorporating more information coming from the NMR data, and our web server that makes it easier to access the program.

■ WD-73

Wednesday, 14:30-16:00
R16-3

OR in Water Management II

Stream: OR in Water Management
Invited session

Chair: *Ulku Gurler*, Department of Industrial Engineering, Bilkent University, 6800, Ankara, Turkey, ulku@bilkent.edu.tr
Chair: *A. Burcu Altan-Sakarya*, Civil Engineering, Middle East Technical University, 06800, Ankara, Turkey, burcuas@metu.edu.tr

1 - Centralized and Decentralized Management of Conjunctive Use of Surface and Groundwater
Ulku Gurler, Department of Industrial Engineering, Bilkent University, 6800, Ankara, Turkey, ulku@bilkent.edu.tr, *Emre Berk*, *Yahya Saleh*

We investigate the conjunctive surface and groundwater use management problem with two identical users in a dynamic game-theoretic structure over a planning horizon of two periods. Under the decentralized management scheme, each user is allowed to use water individually making usage decisions in a non-cooperative fashion. Under the centralized scheme both users are allowed to use water with the supervision of a social planner. Optimal water usage is obtained in both problems. Numerical examples are also provided.

2 - Optimal estimation of the manning's surface roughness in river flows using hybrid psolver optimization algorithm
M. Tamer Ayvaz, Pamukkale University, Turkey, tayvaz@pau.edu.tr, *Omer Genc*

This study proposes a solution model for estimating the Manning's surface roughness in river flows by integrating the hydraulic simulation models to hybrid PSOLVER algorithm which integrates the particle swarm optimization (PSO) and spreadsheet "Solver' add-in. The applicability of the proposed model is demonstrated on East Fork River, WY, USA. Also, a sensitivity analysis is conducted for evaluating the model results for different sets of PSO solution parameters. Identification results are compared with the ones those obtained by using different optimization approaches in literature.

3 - Identification of best installed capacities for the turbines for hydropower plants
Elcin Kentel, Department of Civil Engineering, METU, Orta Dogu Teknik Universitesi, Universiteler Mahallesi, Dumlupinar Blv. No:1, 06800, Ankara, Turkey, ekentel@metu.edu.tr, *Halil Önder*

Conventionally, hydropower plants constructed in Turkey contain two turbines with equal capacities. However two-turbine combinations with different installed capacities result in different annual energy generations. The goal of this study is to identify best installed capacities for the turbines. As a case study Balkusan hdyropower plant constructed on Balkusan Creek, a branch of Ermenek River in Karaman Turkey is used.

4 - Fuzzy Logic and Genetic Algorithms for Multi Criteria Restoration of Water Resources
Angel Udias, Water Resources Unit, Joint Research Center, Italy, angelluis.udias@urjc.es, *Javier Cano*, *Lorenzo Lgalbiati@gencat.cat*

Sustainability of water resources has become a challenging problem worldwide. Realistic Multi Criteria Decision Making (MCDM) problems in water resources management face various sources of uncertainty. We investigate multicriteria restoration of water resources by using genetic algorithms and fuzzy logic. The overall performance of a wealth of alternatives is evaluated, reducing the uncertainty and ambiguity of the decision making process, and determining the satisfactory solution with respect to the environmental sustainability and cost-effectiveness criteria.

■ WD-74

Wednesday, 14:30-16:00
R16-4

Applications of Operations Research in Education

Stream: Applications of Operations Research in Education
Invited session

Chair: *Susana Fernandes*, Matemática, FCT Universidade do Algarve, Campus de Gambelas, 8005-139, Faro, Portugal, sufer72@gmail.com

1 - A Dynamic Nonlinear Model for Educational Systems: A Simulation Study for Primary Education
Roy Zúñiga, Operations Management, Incae Business School, Costa Rica, roy.zuniga@incae.edu, *Luis Lopez*

Abstract. This article aims to improve understanding of the causal processes driving the dynamic behavior of primary education systems using an inflow-outflow simulation model developed for the case of Nicaragua. The model includes complex systems structures such as feedbacks and nonlinear relationships between critical factors that are decisive in replicating observed data over time. It also outperforms alternative models that employ a simple linear perspective. We derive intriguing insights that strengthen the stance for adhering to a complex systems framework when attempting to advance the

2 - Uncovering the hidden world of O. R.; the secret science of system improvement
Geoff Royston, Independent (also , for 2012/13, The OR Society), South View, Copgrove Road, Burton Leonard, hg3 3sj, harrogate, north yorkshire, United Kingdom, geoff.royston@gmail.com

We have a tagline for O.R. - "the science of better'. It attempts to say quite a lot in a very few words - that O.R. is a disciplined approach to improving things. But, of course, it does not say anything more about the science, or about what is better, or in which way. Which begs the question: what would the corresponding "ology' be - what would constitute an articulated "science of better'? This paper seeks to provide such an articulation and then considers the quite profound consequences for the theory and practice of, and education and training in, O.R.

3 - Improving the Relevance and utility of Evaluation in Educational Development Processses: A Viable Systems Approach
Diane Hart, Business School, Manchester Metropolitan University, Aytoun Building, Aytoun Street, Manchester, United Kingdom, d.hart@mmu.ac.uk, *Alberto Paucar-Caceres*

This paper illustrates how Beer's Viable Systems Model (VSM) has been used to inform the design of evaluation. The context of the research is educational development work aimed at improving technology supported learning. Key concepts of VSM have been used to inform the design of evaluation, subsequently tested and improved using an action research approach across multiple case studies. The paper should be of interest to researchers exploring the use of systems theory for organising inquiry, in particular in the context of educational development work in higher education.

4 - Two-variable linear programming: a graphical tool
Susana Fernandes, Matemática, FCT Universidade do Algarve, Campus de Gambelas, 8005-139, Faro, Portugal, sufer72@gmail.com, *José Pereira*

This paper presents an interactive tool for graphical linear programming involving two variables. The tool is designed to solve any linear programming problem for two variables. Implemented using the algebra system Mathematica, this interactive tool allows the user to dynamically explore different objective functions and restriction sets, and also perform post-optimal analysis. All the functionalities of tool are represented graphically and updated in real time. These interactive, dynamic, and graphical features make it a powerful tool for teaching linear programming introductory courses.

Wednesday, 16:30-17:30

■ WE-01

Wednesday, 16:30-17:30
O1-1

IFORS Distinguished Lecturer - John D.C. Little

Stream: Invited Lectures - Plenary
Plenary session

Chair: *Nelson Maculan*, UFRJ-COPPE / PESC, Universidade Federal do Rio de Janeiro, 21941-972, Rio de Janeiro, RJ, Brazil, maculan@cos.ufrj.br

1 - IFORS Distinguished Lecture: Applications of Little's Law

John D C Little, MIT Sloan School, Mass. Inst. of Tech., Room E62-534, 100 Main St, 02142, Cambridge, MA, United States, jlittle@mit.edu

Queues are everywhere. We shall show pictures of them. Some queues contain people, others contain things, and still others elephants. Generically, we call them all items. Some pictures of queues are particularly interesting, or display obvious difficulties, or are funny. Little's Law (LL) is a property of queues. LL's simple equation contains three parameters. Expressed in words: (the average number of items in a queuing system (usually denoted, L) = the arrival rate of items to the system (denoted by the Greek letter, lambda) x (the average time an item spends in the system (denoted W). Thus, L = (lambda) W, is Little's Law.

You can tell that Little's Law must be useful because, although it is a simple mathematical theorem, over the years, it has acquired a distinctive name. I did not name it. On the other hand, I haven't objected to its name.

After showing pictures of various styles of queues, we shall prove Little's Law in a simple but important case. Not only do we prove it, we give a physical intuition as to why it is true. Note also that it is exactly true. That's the law.

LL has many applications, mostly unreported. This spring I ran a course with the title of this talk "Applications of Little's Law." I sought out several guests who had applied it themselves. My colleague, Richard Larson, told how he used LL to analyze the MIT appointment process with its input of assistant professors and output of faculty retirements. He sought and found policy implications. John Carrier, a consultant in the Boston area, has analyzed a medium sized furniture maker in Kentucky that was in financial trouble. He amazed me by finding values for LL parameters from the financial statements of the company. He used these to argue for cutting down the number of line items in the company's catalog, thereby saving setup costs, shortening product lead times, and overcoming the cost advantages of foreign competitors by providing faster service. Profits increased substantially. Mike George, a long time entrepreneur and advocate of building manufacturing operations centered on LL, sold his consulting firm, which did this, to Accenture for over $100 million. He has now bought two manufacturing companies to run himself. Not only has he already made them more profitable, but he also plans to collect operational data to test his scientific theories about ways to make LL-centered manufacturing more efficient.

Finally, I shall try to make generalizations about what makes Little's Law useful so that it can work for you.

Thursday, 8:30-10:00

■ HA-02

Thursday, 8:30-10:00
O1-2

Session to the Honour of Prof. Dr. A.N. Krylov and Prof. Dr. I.R. Prigogin: Methodologies in Complex Multidisciplinary Systems Dynamics

Stream: Dynamical Systems and Mathematical Modeling in OR
Invited session

Chair: *Lyudmila Kuzmina*, Theoretical mechanics, Kazan State Technical University - Kazan Aviation Institute - National Research University, Adamuck, 4-6, Kazan-15, 420015, Kazan-15, Russian Federation, Lyudmila.Kuzmina@ksu.ru

1 - Stability principle and problems of modelling in complex multiscale systems dynamics
Lyudmila Kuzmina, Theoretical mechanics, Kazan State Technical University - Kazan Aviation Institute - National Research University, Adamuck, 4-6, Kazan-15, 420015, Kazan-15, Russian Federation, Lyudmila.Kuzmina@ksu.ru

This work is aimed to analyze method development in nonlinear dynamics of multi-scale complex systems via A. M. Lyapunov methodology. The synthesis of stability theory methods with asymptotic approach is establishing the comparison principle for fundamental problem of complex multidisciplinary systems modeling. Non-traditional approach, based on Lyapunov theory, stability/singularity postulates, is generalizing the parametric stability concept on quasi-Tikhonov systems, with the substantiation of the approximate models/theories, is useful for Knowledge (Natural Science / Humanities).

2 - Nonlinear Dynamics for the prediction of Statistical Distributions: An Operational Research perspective
Ricardo Tomás Ferreyra, Matemáticas (Ingeniería), FCEFyN, Universidad Nacional de Córdoba, Avenida Velez Sarfield 1611., Calle Obispo Trejo 734. Piso 3. Departamento C., CP 5000, Capital, Córdoba-Argentina, Argentina, ricardotf45@hotmail.com

A semantic connection between nonlinear analysis, dynamical systems and statistical distributions is developed. This connection is applied to predict changes of the classical distributions which can be helpful to make decisions in any operational research framework. After nonlinear dynamic analysis, new statistical distributions for decision support are expected to be better than original ones. A practical case of interest for operational research is studied.

3 - Algorithmic Topology in Complex Multidisciplinary System Dynamics
Arturo Graziano Grappone, Medicine, Rome Second University, via Carlo Dossi 87, 00137, Rome, Lazio, Italy, a.grappone@mclink.it

Turing's machines have space-time development on open Euclidean space. Dubois' incursive and hyper-incursive anticipatory algorithms have space-time development on torus and hyper-sphere. Thus, in order to represent Dubois' algorithms too in computation theory, we can add to standard Turing's quadruples intermediate data entanglement operations. So, it is useful to define an 'algorithmic topology', i.e. algorithm analysis related to space-time development topology.

4 - Modeling Evolving Systems
Claudio Maccone, International Academy of Astronautics, Via Martorelli 43, 10155, Torino (Turin), Torino, Italy, clmaccon@libero.it

We present a mathematical model merging SETI, Evolution of Life on Earth and Human History: 1) Geometric Brownian Motion (GBM) represents Evolution as the stochastic increase of the number of species living on Earth over the last 3.5 billion years. 2) b-lognormals have their peaks on the exponential mean value curve of the GBM, representing Cladistics. 3) The b-lognormal entropy represents the "degree of progress". 4) This agrees with SETI, since the Statistical Drake Equation leads just to the lognormal distribution for the number of ET civilizations in the Galaxy.

■ HA-03

Thursday, 8:30-10:00
O1-3

Service Systems 1

Stream: Service Systems (contributed)
Contributed session

Chair: *Christos Vasilakis*, Clinical Operational Research Unit, University College London, 4 Taviton Street, WC1H 0BT, London, United Kingdom, c.vasilakis@ucl.ac.uk
Chair: *Boaz Golany*, Industrial Engineering & Management, Technion - Israel Institute of Technology, Technion City, 32000, Haifa, Israel, golany@ie.technion.ac.il

1 - Integrating Affective Computing in New Service Design
Devanathan Sudharshan, Gatton College of Business and Economics, University of Kentucky, S. Limestone, 40502, Lexington, KY, United States, sudharshan@uky.edu, *Rodoula Tsiotsou*, *Olivier Furrer*, *Ben Liu*

Suh's Axiomatic Design, Altshuller's TRIZ, and Bitner's Service Blueprinting are extant approaches in the science of design and innovation. However, the empowered role of consumers in service coproduction and value co-creation is changing the manner in which new services could be designed and developed. Using an affective computing approach, we propose a value-centered design model that would serve as a core structure to understand, develop, and guide further research in integrating emotion models into new service design. Our model offers both, theoretical and practical implications.

2 - Marginal Distribution of the Queues Lengths in the Longest Queue System
Rachel Ravid, Industrial Engineering and Management, Ort Braude College, Snunit 51 P.O.B 78, 21982, Karmiel, Israel, rachelr3@braude.ac.il, *David Perry*, *Onno Boxma*

We consider a repair facility consisting of one repairman and two arrival Poisson streams of failed items. The items are exchangeable in the sense that a failed item can be returned after repair to another customer. The customers are satisfied by repaired items according to the longest queue mechanism. That is, at a moment of service completion (a repair), the item is delivered to the base that has the largest number of failed items. The difference between the queues lengths and the marginal distribution of the queues lengths are analyzed.

3 - Development of a user-friendly computational cloud system in computer rooms
Ryuichiro Yamada, The Faculty of Engineering Science, Kansai University, Yamate-cho, 3-35, 3-chome, 564-8680, Suita, Osaka, Japan, k515093@kansai-u.ac.jp, *Hiroyuki Ebara*

Computers in universities can be more effectively used during their downtime through the use of software applications, portals and plug-ins to aid the user in automatically and effectively scheduling large jobs to run "in the cloud" during that downtime. In this paper, we use a job scheduler to perform calculations in such situations. We have developed software applications, portals, and plug-ins used for Netbeans and Eclipse. By implementing these, we can greatly reduce the burden on the user, and efficiently use the surplus computer resources of downtime.

■ HA-04

Thursday, 8:30-10:00
O4-4

Algorithms in Linear and Continuous Optimization

Stream: Convex Optimization
Invited session

Chair: *Robert Gower*, School of Mathematics and Maxwell Institute for Mathematical Sciences, Edinburgh University, United Kingdom, gowerrobert@gmail.com

1 - Third Order Methods using slices of the Tensor and AD developments

Robert Gower, School of Mathematics and Maxwell Institute for Mathematical Sciences, Edinburgh University, United Kingdom, gowerrobert@gmail.com, *Jacek Gondzio*

What can be gained by incorporating third-order information in the Newton direction? The third-order derivative is a third order tensor: a cube. Calculating, maintaining and operating on such an object becomes a fundamental deterrent as dimension grows. We investigate methods that incorporate a handful of tensor-vector products, each of which is a sparse matrix. Thus no three dimensional object is formed. Furthermore, we present a novel Automatic Differentiation method for calculating such slices of the tensor, at a cost comparable to state-of-the-art methods for obtaining sparse Hessians

2 - Solving Block Angular Linear Programs via Total Decentralization

M. Aslı Aydın, Department of Industrial Engineering, Boğaziçi University, Bebek, 34342, İstanbul, Turkey, aslim.aydin@boun.edu.tr, *Z. Caner Taşkın*

We propose a decomposition method for solving large-scale linear programs in Block Angular Structure. Existing decomposition methods allow for decentralization to a certain extent. However, there is always a master problem that contains coupling constraints to direct subproblems. The main contribution of this study is to propose a decomposition method that achieves total decentralization where complete removal of the master problem from the system is achieved while allowing minimal required information exchange among subproblems.

3 - Central path for the linear complementarity problem

Marianna E.-Nagy, Budapest University of Technology and Economics, Hungary, enagym@math.bme.hu

The linear complementarity problem (LCP) has a wide range of practical applications. It is well known that if the coefficient matrix of the problem is a sufficient matrix, then interior point algorithms (IPM) are able to solve the LCP. However, the LCP belongs to the class of NP-complete problems already if the coefficient matrix is not P_0. The difficulty is also indicated by the fact that the guideline of IPMs, namely the central path is not unique anymore in the latter case. Therefore we investigate the connection between the data of the LCP and the number of the central paths.

4 - A Family of Simple Algorithms for Linear Programming

Jair Silva, Mathematics Department, Federal University of Mato Grosso do Sul-UFMS, Street 13 of May, 1404, Block C, Apartment 33, 79004-420, Campo Grande, State of Mato Grosso do Sul, Brazil, j.silva@ufms.br, *Aurelio Oliveira*, *Carla Ghidini*, *Marta Velazco*

This paper presents a family of simple algorithms for linear programming. This family results from the generalization of the optimal pair adjustment algorithm, which in turn was based on the von Neumann's algorithm. The optimal pair adjustment algorithm was developed as an improvement to the convergence of the von Neumann's algorithm; thus, maintaining its attractive features. By generalizing this algorithm, these features were maintained. Significant improvements over the optimal pair adjustment algorithm were demonstrated through numerical experiments on a set of linear programming problems.

■ HA-05

Thursday, 8:30-10:00
O4-1

Recent Advances in Optimal Control Theory

Stream: Optimal Control
Invited session

Chair: *Julien Chabas*, Vienna University of Technology, Vienna, Austria, julien.chabas@student.tuwien.ac.at

1 - The problem of keeping the linear dynamic system in the state constraints

Klara Mizhidon, Applied Mathematics, East Siberia State University of Technology and Management, 40V Klyuchevskaya str., Ulan-Ude, Russian Federation, mizhidon@gmail.com, *Arsalan Mizhidon*

In this paper there is a problem of control for linear dynamic system under given perturbations. Here the main purpose of control is to keep the system in the state constraints. The constraints are imposed on control. Consider an auxiliary optimal control problem with quadratic performance measure and system matrices depending on weight coefficients. The choice of these coefficients provides satisfaction of the state constraints. We propose an approach to the construction of algorithmic support of problem solution and consider numerical example.

2 - Optimal control of a linear-quadratic problem with free initial condition

Mohand Ouamer Bibi, LAMOS Laboratory, Operations Research Department, University of Bejaia, 06000, Bejaia, Algeria, mobibi.dz@gmail.com, *Samia Medjdoub*

An optimization algorithm is constructed for a linear dynamical system with terminal quadratic functional, where the initial condition belongs to a polytope. The suggested method is based on the concept of generalized support control which allows to prove the optimality criterion. The proposed algorithm is constructed without quantization of the continuous dynamical system and possesses a finishing procedure that gives the required accuracy in the construction of optimal control. An illustrated example is provided.

3 - Dynamic Optimization Modeling Language - justification and key features

Tomasz Tarnawski, Department of Mechatronics, Warsaw Universtiy of Technology, Institute of Automatic Control and Robotics, ul. Sw. Andrzeja Boboli 8, 02-525, Warsaw, Poland, tarni@op.pl, *Radoslaw Pytlak*, *Bartosz Lipinski*

The proposed DOML format is meant as a universal and programming-language-independent format for specifying optimal control problems. It is based on Modelica language and its extension – Optimica (proposed by JModelica.org). DOML format is assumed to be sufficiently expressive so that admixing fragments of native code (C, Fortran) will no longer be necessary. Key novel features of the proposal are aimed at: - the ability of "chaining" of solvers, i.e. using solvers in a sequence so that a succeeding solver would use and) improve on the solution from a predecessor; - specifying PDE problems.

4 - Integrating behavioural and regulatory biases in optimal control of investments under uncertainty

Julien Chabas, Vienna University of Technology, Vienna, Austria, julien.chabas@student.tuwien.ac.at

Applying optimal control and switching to investment timing constitutes the core of real options theory. Nevertheless, interactions between actors of a market, as well as information diffusion, remain a challenge. In this presentation, we will focus on two interactions, studying their impact on investment policies by applying optimal control techniques. The first one is what the psychologists call "herding effect" and can be expected in oligopolies where smaller actors follow the trend set by bigger ones. The second effect is the cohabitation of regulated and market-driven technologies.

■ HA-06

Thursday, 8:30-10:00
O4-2

Generalized Differentiation and Optimization

Stream: Generalized Differentiation and Optimization
Invited session

Chair: *Laura Martein*, Department of Economics and Management, University of Pisa, via Ridolfi, 10, 56124, Pisa, Italy, lmartein@ec.unipi.it

1 - New global semiparametric sufficient efficiency conditions in multiobjective fractional programming with generalized (F, b, phi, rho, theta)-univex n-set functions)
Andreea Madalina Stancu Rusu, Institute of Mathematical Statistics and Applied Mathematics, The Romanian Academy, Calea 13 Septembrie, nr 13, RO-050711, Bucharest, Romania, andreea_madalina_s@yahoo.com, *Ioan Stancu-Minasian*

In this paper, we present new global semiparametric sufficient efficiency conditions under various generalized (F, b, phi, rho, theta)-univexity hypotheses for a multiobjective fractional subset programming problem. Until now, F, was assumed to be a sublinear function in the third argument. In our approach, we suppose that F is a convex function in the third argument.

2 - Nonsmooth minimax fractional programming involving generalized semilocally V-type I-preinvex and related functions
Hachem Slimani, Laboratory of Modeling and Optimization of Systems LAMOS, Computer Science Department, University of Bejaia, Algeria, 06000, Bejaia, Algeria, haslimani@gmail.com

We are concerned with a nonsmooth minimax fractional programming problem with inequality constraints. We consider each component of functions occurring in the problem semidifferentiable along its own direction instead of a same direction. Necessary and sufficient optimality conditions and duality results for a class of nonsmooth minimax fractional programming problems are obtained under nondifferentiable generalized semilocally V-type I-preinvex assumption imposed on objective and constraint functions.

3 - Simplex-like sequential methods for a class of generalized fractional functions
Laura Carosi, Department of Economics and Management, University of Pisa, Via Ridolfi, 10, 56124, Pisa, Italy, lcarosi@ec.unipi.it, *Laura Martein*, *Ezat Vali pour arab*

We deal with a class of generalized fractional programming problems having a polyhedral feasible region and as objective the ratio of an affine function and an affine to the power p>0. We aim to propose simplex-like sequential methods for finding the global maximum points. As the objective function may have local maximum points not global, we analyze the theoretical properties of the problem; in particular, we study the maximal domains of the pseudoconcavity of the function. Depending on whether or not the objective is pseudoconcave on the feasible set, we suggest different algorithms.

■ HA-07

Thursday, 8:30-10:00
O4-3

Nonlinear Optimization and Applications I

Stream: Nonlinear Programming
Invited session

Chair: *Simone Göttlich*, School of Business Informatics and Mathematics, University of Mannheim, A 5, 6, Mannheim, 68131, Germany, goettlich@uni-mannheim.de

1 - The influence of the barrier parameter update strategies in the Optimal Power Flow Solution
Edmea Cássia Baptista, Departamento de matemática, Faculdade de Ciências, Unesp-Univ. Estadual Paulista, Brazil, baptista@fc.unesp.br, *Ellen Cristina Ferreira*, *Edilaine Soler*

The Optimal Power Flow problem, studied at Electrical Engineering, is formulated as large-scale, non convex, constrained and non linear problem. Among the methods used for its solution, we highlight the Interior Point Methods. Many researchers report that the convergence of this method depends on the barrier parameter update strategies. In this paper, we propose to use the software package Knitro and analyze the influence of different barrier parameter update strategies in the Optimal Power Flow solution. Numerical results and conclusions are presented using the IEEE 30 and 118 bus systems.

2 - Dynamic Control of Infeasibility for Nonlinear Programming
Abel Siqueira, Universidade Estadual de Campinas - UNICAMP, Brazil, abel.s.siqueira@gmail.com

We propose a new composite-step algorithm for nonlinear programming, based on the Dynamic Control of Infeasibility (DCI) method for equality constraints, proposed by Bieschowsky and Gomes. In our algorithm, we use a tangent step to reduce the Lagrangian function and a normal step reduces the infeasibility. The steps are required to stay into what is called Trust Cylinders, that are cilynders around the feasible set with radii proportional to the projected gradient. We extend the DCI ideas to problems with inequalities. Our implementation compares favourably with the well-known method IPOPT.

3 - An Exact Algorithm for Nonconvex Quadratic Integer Minimization using Ellipsoidal Relaxations
Laura Palagi, Dipartimento di Ingegneria informatica automatica e gestionale, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, palagi@dis.uniroma1.it, *Christoph Buchheim*, *Marianna De Santis*, *Mauro Piacentini*

Minimizing a quadratic function over integer variables is an NP-hard problem in general. In our talk, we present a branch-and-bound approach that works for both convex and non-convex problems and that turns out to be particularly effective for problems with small variable domains. Dual bounds are computed by minimizing the objective function over the boundary of certain axis-parallel ellipsoids. After a suitable preprocessing, these dual bounds can be computed very efficiently, yielding a fast algorithm for ternary quadratic optimization.

4 - Explicit Optimal Predictive Control Solution for Longitudinal Equation of Motion of an Airplane
Ezzat Meshkinfam, SBU - Flight Mechanics and Control, velenjak, Iran, Islamic Republic Of, afm89.stud@gmail.com, *M. Navabi*

In this paper, explicit optimal predictive control solution utilizing quadratic programming method (where is called eMPC) is obtained for Longitudinal Equation of Motion of an Airplane. By using eMPC, online computation complexity and its time consuming are reduced and explicit solution of equations is obtained.

■ HA-08

Thursday, 8:30-10:00
O3-2

Tutorial - R. Vohra

Stream: Invited Lectures - Keynotes and Tutorials
Tutorial session

Chair: *Tamás Terlaky*, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

1 - Mechanism Design and Linear Programming
Rakesh Vohra, Department of Managerial Economics and Decision Sciences, Northwestern University, Kellogg School of Management, 2001 Sheridan Rd, 60208, Evanston, IL, United States, r-vohra@kellogg.northwestern.edu

Mechanism design is an analytical framework for thinking carefully about what a given institution can achieve when the information necessary to make decisions is dispersed and privately held. The range of questions to which the approach can be applied is striking. To achieve a given reduction in carbon emissions, should one rely on taxes or a cap and trade system? Is it better to sell an IPO via auction or the traditional book building approach? Mechanism design helps us understand how the answers to these questions depend on the details of the underlying environment. In turn this helps us understand which details matter and which don't.

Operationally, a mechanism design is an optimization problem where the parameters of the objective function are not known to the solver. Thus the challenge is to simultaneously elicit the relevant information and solve the resulting optimization problem. In this tutorial I will outline the use of linear programming techniques to solve such problems.

■ HA-09

Thursday, 8:30-10:00
O3-3

Sponsor - LOCALSOLVER

Stream: Sponsors
Sponsor session

Chair: *Giuseppe Bruno*, Dipartimento di Ingegneria Industriale, Università Federico II di Napoli, Piazzale Tecchio n.80, I80125, Napoli, IT, Italy, giuseppe.bruno@unina.it

1 - Toward a full mathematical programming solver based on local search
Frédéric Gardi, LocalSolver, 24 avenue Hoche, 75008, PARIS, France, fgardi@localsolver.com, *Julien Darlay*

We present LocalSolver (www.localsolver.com), model-and-run solver integrating pure local-search techniques. It can handle very large non-linear problems with millions of 0-1 decisions. LocalSolver offers simple APIs as well as an efficient modeling language for fast prototyping. It is used in real-life applications by several companies through the world, but the product remains free for academics. As example of its strength compared to classical MIP, CP, SAT softwares, LocalSolver was the sole general-purpose optimization solver to be qualified for the final tour of the Google ROADEF/EURO 2012 Challenge, thanks to a 100-line model. More recently, LocalSolver was chosen against the state-of-the-art MIP solvers of the market to solve an operational all-Japan food supply chain problem: 20 millions of variables with 3 millions of 0-1 decisions, handled in a few minutes of running time.

LocalSolver is based on the fast exploration of multiple variable neighborhoods to provide high-quality (hopefully optimal) feasible solutions quickly. Different kinds of neighborhoods are employed during the search: small (basic moves), medium (compound moves), large (tree-search moves). Smaller are the neighborhoods, faster is their evaluation through incremental computations. The selection of the neighborhood to explore is dynamically adapted during the search through learning to ensure the fastest convergence, while a simulated annealing heuristic with reheatings and restarts allows to escape local optima and to diversify widely the search. On the other hand, LocalSolver provides an optimality gap based on propagation and relaxation techniques.

Having reviewed these current technical features and detailed some benchmarks to assess the performance of LocalSolver, we will outline our current work to extend this technique for continuous or mixed-variable optimization. More generally, we will present the roadmap of the LocalSolver project toward an all-in-one math programming solver.

■ HA-10

Thursday, 8:30-10:00
G5-1

Management Challenges and Frameworks

Stream: Risk Management in Online Social Networks
Invited session

Chair: *Thomas Gottron*, Institute for Web Science and Technology, Universität Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, gottron@uni-koblenz.de

1 - Challenges in Managing Online Business Communities
Thomas Gottron, Institute for Web Science and Technology, Universität Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, gottron@uni-koblenz.de, *Michal Jacovi*, *Adrian Mocan*, *Steffen Staab*

Online business communities constitute rich ecosystems that enable an amorphous group of employees, customers or company partners to disseminate, exchange and curate content items, information and valuable knowledge. While the platform technologies for online business communities have been around for several decades, there still is a lack of metrics and tools for the analysis and management of the assets provided by these communities. In this talk, we will describe the analysis and management challenges arising in online business communities based on actual systems being run at IBM and at SAP.

2 - Effects of Content Positioning on Collections of Information Items in Collaborative Online Communities
Felix Schwagereit, Institute for Web Science and Technology, Universität Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, schwagereit@uni-koblenz.de, *Thomas Gottron*, *Steffen Staab*

The way users consume, generate, interact with and react to information on online community platform establishes a feedback loop. The presentation of the information has a strong impact on this feedback loop and is itself governed by policies implemented in the platforms. Changing a policy calls for a prior analysis of the potential impacts on the community at a macro level. In this talk we combine a model of the layout and positioning of content with a model of user activity, which captures essential parameters for creating collections of information items in online communities.

3 - Scalable Analytics to Enable Risk Management in Online Communities
Marcel Karnstedt, DERI, NUI Galway, Ireland, marcel.karnstedt@deri.org, *Conor Hayes*, *Harith Alani*, *Miriam Fernandez*

With the constantly growing ecosphere of online communities, their managers and operators require a rich set of tools to successfully understand, control and exploit them. According risk management requires to extract reusable, interpretable analytics in real time from the streams of dynamically, socially produced data. In this talk, we summarise our efforts on producing a suite of novel, highly scalable methods and tools to enable this, aligned along four non-disjoint dimensions: structural analysis, behavioural analysis, content/social-semantic analysis, and cross-community analysis.

4 - Ambiguous Networks
Marco Pelliccia, Economics, Mathematics and Statistics, Birkbeck College, University of London, Malet St, WC1E 7HX, London, United Kingdom, m.pelliccia@mail.bbk.ac.uk

We investigate the impact of network structures describing reciprocal influence-relationships between agents on their perceived ambiguity. We argue that, under specific assumptions, the potential complexity of the link-structures creates extra uncertainty or ambiguity over the "right" probability distribution to consider. This result affects the optimal equilibrium structures which arise in a dynamic game where the agents/nodes strategically rewire their links to minimize the perceived uncertainty.

■ HA-11

Thursday, 8:30-10:00
G5-3

Continuous Location

Stream: Location Analysis
Invited session

Chair: *Cem Iyigun*, Industrial Engineering, Middle East Technical University, Turkey, iyigun@ie.metu.edu.tr

1 - An approximation for the kth nearest distance and its application to location analysis
Masashi Miyagawa, Regional Social Management, University of Yamanashi, 4-4-37, Takeda, 400-8510, Kofu, Yamanashi, Japan, mmiyagawa@yamanashi.ac.jp

We provide an approximation for the distance to the kth nearest point. Distance is measured as Euclidean and rectilinear distances on a continuous plane. The accuracy of the approximation is assessed for regular and random point patterns. Comparing the approximation with road network distances shows that the approximation on a continuous plane can be used for estimating the kth nearest distance on actual road networks. As an application of the approximation to location analysis, we obtain the average distance to the nearest open facility when some of the existing facilities are closed.

2 - A column generation based heuristic for the solution of the single source capacitated multi-facility Weber problem
Onder Tombus, Maltepe University, 34000, Istanbul, Turkey, tombus@gmail.com, *Ayse Cilaci Tombus*

We propose a column generation based heuristic for the solution of the capacitated multi-facility Weber problem with single-source constraints.This problem is concerned with determining the locations of m facilities in the plane and allocating their limited capacities to n customers, where each customer is assigned to a single facility. The proposed algorithm is tested on set of test instances generated from the capacitated multi-facility Weber problem instances in the literature and is also extended to a distributed algorithm, assuming customers have computational capabilities.

3 - Heuristics for a continuous multi-facility location allocation problem with demand regions
Derya Dinler, Industrial Engineering, Middle East Technical University, Middle East Technical University, Industrial Engineering Department, 06800, İnönü Bulvarı, Ankara, Turkey, dinler@metu.edu.tr, *Mustafa Kemal Tural*, *Cem Iyigun*

The problem we consider can be stated as follows: given m demand regions in the plane, find the locations of p facilities and allocate regions to the facilities so as to minimize the sum of squares of the maximum (Euclidean) distances of the demand regions to the facility locations they are assigned to. Each demand region may consist of a finite or an infinite number of points. We do not allow fractional assignments. We propose three heuristics and compare them in terms of both solution quality and computational time.

4 - A Clustering Based Approach for Solving Planar Hub Location Problems
Derya Kilinc, Industrial Engineering, Middle East Technical University, 06800, Ankara, Turkey, dkilinc@metu.edu.tr, *Cem Iyigun*, *Sinan Gürel*

We consider the planar p-hub location problem where flow occurs by using at most two hubs, and direct travel is allowed. Points can be assigned to multiple hubs, using cost based assignment probabilities. In the literature mostly discrete hub location problems are studied, planar case is not studied extensively. We propose a solution approach based on a clustering method for solving the planar p-hub location problem. The approach is an iterative method that minimizes total cost. Convergence of the approach is shown for a single hub assignment case and our computational results are reported.

■ HA-12

Thursday, 8:30-10:00
G5-4

Recent Advances in Dynamics of Variational Inequalities I

Stream: Recent Advances in Dynamics of Variational Inequalities and Equilibrum Problems
Invited session

Chair: *Patrizia Daniele*, Department of Mathematics and Computer Science, University of Catania, Viale A. Doria, 6, 95125, Catania, Italy, daniele@dmi.unict.it

1 - Solving Generalized Nash Games with Shared Constraints through Evolutionary Variational Inequalities
Monica-Gabriela Cojocaru, Mathematics & Statistics, University of Guelph, Guelph, Ontario, Canada, mcojocar@uoguelph.ca

We show in this talk how a new parametrization technique can be introduced via the so-called evolutionary variational inequality (EVI) problems, such that by restricting the solution sets of such specialized EVI problems, together with complementarity conditions, we obtain a clear description of the solution set of a generalized Nash (GN) game with shared constraints. As a consequence, the stability of GN equilibria can be studied. We give examples of how the technique is used and show that it solves GN previously not solved by existing VI parametrization techniques.

2 - Optimal Strategy and Pricing on the CLSC with Buy-back and Remanufacturing
Zhaowei Miao, Management Science, Xiamen University, School of Management, Xiamen University, Fujian Province, PR China, 361005, Xiamen, Fujian, China, miaozhaowei@gmail.com, *Zhiqiang Xia*

In this paper, we investigate three reverse logistics strategies including NN (i.e., no buy-back or remanufacturing) strategy, BN strategy (i.e., buy-back without remanufacturing) and BR (i.e., buy-back with remanufacturing) strategy, and develop a decision mechanism for a monopoly OEM who may wonder which reverse logistics strategy should be selected, and how to determine the corresponding pricing regime for each strategy. Moreover, by analyzing all the solutions of these models, we provide an integrated decision mechanism and managerial insight for the monopoly OEM.

3 - A System Dynamics application to strategic marketing
Suzanne van Staveren, Management Research, Radboud University Nijmegen, van Oldenbarneveltstraat 30, 6512 AX, Nijmegen, Netherlands, savanstaveren@hotmail.com, *Rasa Cincyte*

Traditional marketing approaches are loosing their magic as more and more money gets lost on conventional solutions. Is it really the unexplainable or might some answers be hidden in the way marketing needs are evaluated in the first place? This project is a product of the cooperation of System Dynamics scholars and marketing experts. Several months of working together led through the transformation of an econometrics-based model for marketing to a System Dynamics-driven equivalent. While different in nature, this brought interesting insights for the understanding of strategic marketing.

4 - Decoding the dynamics of crime
Luis Lopez, Incae Business School, Apartado 960-4050, La Garita, 4050, Alajuela, Costa Rica, luis.lopez@incae.edu, *Roy Zúñiga*

Becker (1968) suggests that criminals respond rationally to committing crime. Hence the deterrence hypothesis: judicial policies can reduce crime by increasing its costs. Yet, countries undergo crime escalations despite implementing such suggestions. This paper explores this disparity by focusing on institutional failures in the implementation of deterrence policies. With a dataset of judicial figures the paper calibrates a System Dynamics model. Contrary to expectations, criminals are punished not exclusively on the basis of their behavior, but in terms of other institutional variables.

■ HA-13

Thursday, 8:30-10:00
G5-5

Sustainable mobility

Stream: Traffic
Invited session

Chair: *Philipp Stroehle*, Business Engineering and Management, Karlsruhe Institute of Technology, Englerstr. 14, 76131, Karlsruhe, Baden-Wuerttemberg, Germany, philipp.stroehle@kit.edu

1 - Sustainability evaluation of urban mobility projects using ideal-solution based multicriteria decision making techniques
Anjali Awasthi, CIISE, Concordia University, H3G 1MB, Montreal, Quebec, Canada, awasthi@ciise.concordia.ca, *Hichem Omrani*, *Philippe Gerber*

Modern cities are facing increased congestion, rising fuel costs, and lack of public space which is detrimental to the quality of life and environment. To control this situation, several sustainable mobility measures are being implemented in urban areas. E.g., use of public transport, energy efficient vehicles. The challenge before transport decision makers is how to select various measures. In this paper, we investigate the application of ideal-solution based MCDM techniques (TOPSIS, VIKOR, GRA) for sustainability evaluation of urban mobility projects. A numerical application is provided.

2 - Sustainable Urban Mobility in Porto Alegre: Models for a Host City for World Cup Football 2014
Everton da Silveira Farias, Management Science, Universidade Federal do Pampa - UNIPAMPA, Rua Bagé, 94 Apto 402, Petropolis - Porto Alegre, RS - BRAZIL, 90460080, Porto Alegre, Rio Grande do Sul, Brazil, everton.farias06@gmail.com, *Denis Borenstein*

This paper presents the main models for mobility and public transport to Porto Alegre, one of the host cities for the World Cup 2014. The models and works are analyzed, mostly recent articles from major publications such as: Operations Research, European Journal of Operations Research, Transportation Science, Transportation Research, Network, etc. The goal is to identify the main characteristics of these works, prioritizing sustainable energy models, to propose possible implementations in the Host City of the 2014 World Cup.

3 - Harnessing Consumer Flexibility in Car-sharing
Philipp Stroehle, Business Engineering and Management, Karlsruhe Institute of Technology, Englerstr. 14, 76131, Karlsruhe, Baden-Wuerttemberg, Germany, philipp.stroehle@kit.edu, *Christoph Flath*

We use empirical booking and driving data from a German car-sharing provider to analyze consumer behavior. We estimate the value of consumer flexibility with respect to time, location, vehicle class and combinations thereof in terms of reduced fleet size to the firm. We develop an online optimization heuristic that allows the firm to harness part of consumer flexibility while balancing fleet utilization and quality of service for the customers. Our results indicate that taking even a modest amount of consumer flexibility into account results in significantly higher fleet utilization.

■ HA-14

Thursday, 8:30-10:00
G5-6

Location and Routing problems II

Stream: Hybridisation of Heuristic for Global Optimisation
Invited session

Chair: *Noor Hasnah Moin*, Institute of Mathematical Sciences, University of Malaya, 50603, Kuala Lumpur, Malaysia, noor_hasnah@um.edu.my

1 - Title: The Continuous P-centre Location Problem : A hybrid approach
Abdalla Elshaikh, kent business school, university of kent, 74 Tenterden Drive, CT2 7BN, CANTERBURY, Kent, United Kingdom, ae201@kent.ac.uk, *Said Salhi*, *Gabor Nagy*

In this talk, variable neighbourhood search (VNS) and perturbation-based heuristic methods are developed for the p-centre location problem in the continuous space. Several simple but effective enhancements based on these 2 approaches are also proposed, followed by their hybridisation. These implementations are tested on several data sets with varying n and p. Competitive results are obtained when compared to the best known results including those reported optimal solutions.

2 - Two Nature Inspired Algorithms for Multivariant Telecentres Location Problem
Tatyana Levanova, Siberian Branch of Russian Academy of Sciencies, Omsk Branch of Sobolev Institute of Mathematics, 13 Pevtsov str., 644099, Omsk, Russian Federation, levanova@ofim.oscsbras.ru, *Alexander Kolokolov*, *Yury Pozdnyakov*

Telecommunication technologies play an important role in development of individual regions and countries as a whole. A discrete optimization model for location of a set of communication telecentres is considered in this paper. Each telecentre can be equipped with one of the types of stations. It is necessary to place the telecentres and choose the equipment so that a signal is provided cost-effectively to consumers. We suggest an Ant Colony Optimization and an Artificial Immune System algorithms for this problem. Computational experiment to compare these algorithms is carried out.

3 - Swarm Intelligence Approaches to A Reverse Logistics Network Design Problem: Seeker Optimization Algorithm versus Particle Swarm Optimization Algorithm
Kemal Subulan, Industrial Engineering, Dokuz Eylül University, Dokuz Eylül Üniversity, Engineering Faculty, Department of Industrial Engineering, Tınaztepe Campus, Buca/Izmir, Izmir, Turkey, kemal.subulan@deu.edu.tr, *Alper Saltabaş*, *Adil Baykasoğlu*

In this research, priority based-Seeker Optimization (SOA) & Particle Swarm Optimization (PSO) algorithms are proposed for solving Reverse Logistics (RL) network design due to the NP-hard nature of problem. While realizing the algorithms, unbalanced trasportation problems are decoded without adding any dummy nodes different from the literature. This improvement yields more efficient encoding/decoding procedure and also computational efficiency. Summary of the results show that SOA outperforms than PSO for complex RL network design problem in terms of both solution quality & computational time.

4 - A Scatter Search Algorithm for the Integrated Production and Inventory Routing Problem
Noor Hasnah Moin, Institute of Mathematical Sciences, University of Malaya, 50603, Kuala Lumpur, Malaysia, noor_hasnah@um.edu.my

We consider an integrated production,inventory and routing problem consisting of a single production plant which produces a single product that is delivered to customers by a set of homogeneous fleet of vehicles. We propose a scatter search algorithm comprising of three phases. We solve the allocation model and the solution are partitioned into clusters using giant tour procedure, savings and sweep algorithm to determine the delivery routes for each period in phase 2. The solution is further enhanced in phase 3 and the results are compared with lower and upper bound from Cplex sotfware.

■ HA-15

Thursday, 8:30-10:00
G5-2

Terminal Design

Stream: Container Terminal Operations
Invited session

Chair: *Carsten Boll*, Fachbereich 2, Hochschule Bremerhaven, An der Karlstadt 8, 27568, Bremerhaven, Bremen, Germany, cboll@hs-bremerhaven.de

1 - Container Port of the Future
Carsten Boll, Fachbereich 2, Hochschule Bremerhaven, An der Karlstadt 8, 27568, Bremerhaven, Bremen, Germany, cboll@hs-bremerhaven.de

An innovative concept for a container port has been designed for an annual throughput of 20 million TEU. The area available was 250 ha, the quay wall 2 x 2.5 km with 12 berths for ultra large container vessels. Simulation models helped provide evidence for the feasibility of • an annual throughput of 20 million at the quay (of which 80% transshipment containers and 20% local inbound/ outbound containers), • effective storing of standard, reefer, dangerous and empty containers, • equipment and transport network for internal moves, • reliability and sustainability.

2 - Evaluating approaches for the analysis of berthing capacities - A case study for a Panamanian Container Terminal
Leif Meier, Realtime Business Solutions - EMEA Office, Paul-Stritter-Weg 5, 22297, Hamburg, Germany, leif.meier@rbs-emea.com, *Rebeca Caceres Labarba*, *Holger Schuett*

Usually optimization models for container terminal berthing problems focus on minimizing transport distances or vessel waiting times considering quaylength as a given parameter. Trends in demand patterns are leading to insufficiencies in operations based on the given terminal setup. Varying berthing capacities is one option to be considered from a strategic level. But at which point it is necessary to review these parameters? Assuming the quaylength to be flexible, we evaluate berthing capacities based on two approaches, simulation capacity analysis and berth allocation optimization models.

3 - Effect of Handling Equipment Type on Optimizing Container Arrangement
Etsuko Nishimura, Graduate School of Maritime Sciences, Kobe University, Fukae-minami, Higashinada, 658-0022, Kobe, Japan, e-nisi@maritime.kobe-u.ac.jp, *Akio Imai*

Marine container terminals are operated by various types of handling equipment. The relevant terminal layout is suitable to the equipment type. We consider the effects of equipment type and layout on the container arrangement. The differences among equipment types are following: the service time depends on the path location for yard trailer or straddle carrier movement, and the total capacity of container storage is determined by the size and mobility for equipment. From the computational results, the service levels by RTG are better than those by RMG and Straddle Carrier in most cases.

4 - How to integrate rail in automated terminal operations?
Bernd Kortschak, Economics Logistics Transport, Univ. of Appl. Sc. Erfurt, 25 Altonaer -Straße, 99085, Erfurt, Thuringia, Germany, bernd.kortschak@wu.ac.at

Rail links in sea-terminals are often separated by extra truck haulage thus hindering the competitiveness of rail versus road. It will be shown how Rail can be incorporated in automated terminal operations. Earlier solutions are dealt with — like to put a quai-track underneath the gantry crane to get direct transfer of containers. The solution has to be found by including shuttle trains in the AGV regime of the terminal for better productivity and sufficient flexibility. The paper will outline which criteria to be dealt with to achieve that goal of better economic performance.

■ HA-16

Thursday, 8:30-10:00
G5-7

Metaheuristics for Routing Problems II

Stream: Routing Problems
Invited session

Chair: *Robert Manger*, Department of Mathematics, University of Zagreb, Bijenicka cesta 30, 10000, Zagreb, Croatia, manger@math.hr

1 - Testing TSP crossover operators within the VRP environment
Robert Manger, Department of Mathematics, University of Zagreb, Bijenicka cesta 30, 10000, Zagreb, Croatia, manger@math.hr, *Krunoslav Puljic*

The vehicle routing problem (VRP) has much in common with the traveling salesman problem (TSP). Therefore, it is expected that both problems can be solved by similar evolutionary algorithms. In this work we investigate how certain crossover operators originally designed for the TSP behave when they are applied to the VRP. The considered crossovers are tested on a set of well known benchmark VRP problem instances. The obtained testing results clearly show that the performance and relative ranking of the operators within the VRP environment is quite different than within the TSP environment.

2 - Parallel k-opt heuristic for node routing problems on graphics processing units
Briseida Sarasola, Computational Logistics Lab, Salzburg Research, Jakob-Haringer-Strasse 5/III, 5020, Salzburg, Austria, briseida.sarasola@salzburgresearch.at, *Erich Mraz*

Graphics processing units (GPUs) can be used to accelerate the execution of algorithms solving hard combinatorial problems. However, parallel algorithms running on GPUs must consider the requirements of the underlying hardware platform to boost performance. We present a parallel k-opt heuristic for the traveling salesman problem and extend it to be applied to the vehicle routing problem using three different solution representations. Our experiments show that problem features and implementation decisions may influence the results. We report speedups in range 10-30x, depending on the instance.

3 - A simulated annealing heuristic for the open vehicle routing problem with cross-docking
Vincent F. Yu, Department of Industrial Management, National Taiwan University of Science and Technology, 43, Sec. 4, Keelung Rd., 10607, Taipei, Taiwan, vincent@mail.ntust.edu.tw, *Hsiu-I Ting*

Cross-docking is an effective logistics strategy adopted by many companies. This study considers the open vehicle routing problem with cross-docking (OVRPCD). In the OVRPCD, vehicles provided by a third party logistics (3PL) company are used to perform two delivery routes and one pickup route. After finishing the second delivery route, the vehicles return to the 3PL company. We developed a mathematical model and implemented a simulated annealing (SA) heuristic for the problem. Computational results indicate that the proposed SA heuristic solves the OVRPCD effectively and efficiently.

4 - Battery exchange station location-routing problem with capacitated electronic vehicles
Jun Yang, Huazhong university of science & technology, China, jun_yang@mail.hust.edu.cn, *Hao Sun*

With the extensive use of electric vehicles (EVs), many logistic companies electrify their vehicle fleets to establish green logistic network. Because of limited range and capacity of EVs, we introduce the basic and extensive models of battery exchange station location-routing problem, which determines station locations and vehicles routing plan to minimize establishing cost and operational cost. As solution method, a hybrid heuristic that incorporates clustering, greedy method and adaptive large neighborhood search, is developed. Numerical results show that the heuristics perform well.

■ HA-17

Thursday, 8:30-10:00
G5-8

Liner shipping network design

Stream: Maritime Transportation
Invited session

Chair: *Fernando Alvarez*, Goteborggata 9, 0566, Oslo, Norway, jfa2@cornell.edu
Chair: *Berit Dangaard Brouer*, DTU Management Engineering, Technical University of Denmark - DTU, Bygning 426, 2800, Kongens Lyngby, Denmark, blof@man.dtu.dk

1 - Designing liner shipping networks
Judith Mulder, Erasmus University Rotterdam, Netherlands, mulder@ese.eur.nl, *Rommert Dekker*
We consider the combined fleet-design, ship-scheduling and cargo-routing problem with limited availability of ships. The goal is to design a liner shipping network that maximizes profit given demand and cost data. The network should consist of a set of routes, the allocation of ships to the routes, the speed of ships and the demand allocation over the routes. The problem is solved by first aggregating the ports into clusters, for which a network is generated. Next, the feeder network is designed and improved using heuristics. Finally, existing networks are changed in an improvement step.

2 - An algorithm for solving the time-constrained multicommodity flow problem with applications in liner shipping network design
Christian Vad Karsten, DTU Management Engineering, The Technical University of Denmark, Denmark, chrkr@dtu.dk, *David Pisinger*, *Stefan Ropke*
The liner shipping network design problem has proven to be hard to solve. However, well-designed route nets are paramount to liner shipping companies both in terms of competitiveness and environmental impact. Fast evaluations of the multicommodity flow subproblem is one of the bottlenecks when determining the optimal routing and fleet deployment in the network design problem. Additionally, most existing models do not consider the level of service. To accommodate that, we present an algorithm for solving the multicommodity flow subproblem with limits on commodity travel time.

3 - A branch-and-price approach to the network design problem in liner shipping
Kristian Thun, Department of industrial economics and technology management, Norwegian University of Science and Technology, Norway, kristian.thun@iot.ntnu.no, *Henrik Andersson*
In this presentation, we look at the network design problem in liner shipping. In much of the literature, particular characteristics of the problem are exploited to ease the solving of the problem. We present a new mathematical path flow model which makes no assumptions on geographical properties of the problem, frequency constraints or other particular requirements. We present results from our attempts at solving this problem through exact methods using a branch-and-price algorithm.

4 - A decision support tool for liner shipping network design
Berit Dangaard Brouer, DTU Management Engineering, Technical University of Denmark - DTU, Bygning 426, 2800, Kongens Lyngby, Denmark, blof@man.dtu.dk, *Guy Desaulniers*
The liner shipping network of global carriers is often incrementally changed in order to implement new business strategies and adapt to the current market situation in terms of cargo demands and fleet deployment opportunities. We present a decision support tool for liner shipping network design to suggest new network configurations to network planners. The decision support tool uses a matheuristic to adjust the existing network to the new market situation. The matheuristic applies an integer program per service based on estimation functions considering the entire network.

■ HA-18

Thursday, 8:30-10:00
G5-9

Stochastic Modeling and Simulation VII

Stream: Stochastic Modeling and Simulation in Engineering, Management and Science
Invited session

Chair: *Ta-Hsin Li*, Mathematical Sciences, IBM T. J. Watson Research Center, IBM T. J. Watson Research Center, 10598, Yorktown Heights, NY, United States, thl@us.ibm.com
Chair: *Alper Inkaya*, Middle East Technical University, Institute of Applied Mathematics, METU Üniversiteler Mah. Dumlupınar Blv. No:1, Çankaya, 06800, Ankara, Turkey, ainkaya@metu.edu.tr

1 - An Application of Queuing Models to Human Resource Management and Planning of an IT Service
Ta-Hsin Li, Mathematical Sciences, IBM T. J. Watson Research Center, IBM T. J. Watson Research Center, 10598, Yorktown Heights, NY, United States, thl@us.ibm.com
In Application Mamagement Services (AMS), technical support of an application software is provided to the client. Service requests are classified into a plural of categories depending on their properties and priorities. Processing of such requests is often governed by a service level agreement (SLA) which specify certain targets for the duration of various processing stages. An important challenge facing the service provider is the management and planning of human resources given the SLA constraints and the need to improve resource utilization and profitability.

2 - Simulation model of Mobile rack automated storage and retrieval system (M-AS/RS)
Amine Hakim Guezzen, Faculty of Technology, Universy of Tlemcen, BP 203 Chetouane, 13000, Tlemcen, Algeria, amine.guezzen@yahoo.fr, *Sari Zaki*, *Amina Ouhoud*
Our interest is concerned with the simulation of Mobile rack automated storage and retrieval system. The main contribution of the proposed work is the development of a simulation model generator using SIMAN Arena software. This generator can automatically build a model of any dimension. The comparison between the analytical results and the results of simulation for different configurations shows a good behavior of the model generator. These results have great importance for a good comprehension of these kinds of systems, choice of dimensions and the management of this type of installation.

3 - Modeling and simulation of multi aisle automated storage retrieval system with different configurations
Amina Ouhoud, 1Manufacturing engineering, tlemcen university, BP 230 Faculté des sciences de l'ingénieur, Algeria, ami_ouh@yahoo.fr, *Amine Hakim Guezzen*, *Sari Zaki*
In this work we are interested on modeling and simulation and comparison the results with analytical results of multi aisle automated storage retrieval system. This type of AS/RS comprises several aisles, all served by only one storage / retrieval (S/R) machine. To simulate this type of AS/RS, we have developed a special template in Rockwell software Arena, this template is used to generate any desired structure, and the animation associated with this model is to better understand how the system works and the movement of the machine storage / retrieval.

4 - Streamflow modeling using the combination of Wavelet Shrinkage with PAR models
Rafael Souza, Electrical Engineering, Pontifical Catholic University of Rio de Janeiro PUC-Rio, Rua Marquês de São Vicente 225, Gávea, 22451-041, Rio de Janeiro, Rio de Janeiro, Brazil, rafael.morais.souza@gmail.com, *Reinaldo Souza*
This paper aims to improve the methods used to forecast and to generate streamflow scenarios in the Brazilian electric sector. In other words, a modeling that combines Wavelet Shrinkage and Periodic Autoregressive Models (PAR(p)) is proposed to the Natural Inflow Energy. Therefore, the first step is to process the streamflow time series by Wavelet Shrinkage with the aim to reduce the data noise, and then, the second step is to fit the PAR(p) models like it is already used in this sector. The combination of methodologies achieves better results than only the PAR(p) modeling.

■ HA-19

Thursday, 8:30-10:00
G5-10

Transport Systems

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Feixiong Liao*, Urban planning group, TU/e, Vertigo 8.09, Den Dolech 2, 5600 MB, Eindhoven, Netherlands, f.liao@tue.nl

1 - Order acceptance for motorail transportation with uncertain capacity demand
Pascal Lutter, Fac. of Management and Economics, Ruhr-University Bochum, Chair of Operations Research and Accounting, 44780, Bochum, Germany, pascal.lutter@rub.de, *Brigitte Werners*

Motorail transportation covers the loading of various types of cars and motorbikes onto trains with limited capacity. Compared to container loading numerous specific technical requirements have to be respected. During the booking process, order acceptance decisions base on available and uncertain required capacity. A situation with capacity uncertainty at the decision point will be investigated. We present a decision support system with mixed-integer linear programming to handle interval uncertainties which is successfully used in practice to achieve optimal train capacity utilization.

2 - Train formation under uncertainty
Sara Gestrelius, SICS, 16429, KISTA, Sweden, sarag@sics.se, *Christina Büsing*, *Florian Dahms*, *Markus Bohlin*

Train marshalling is a process subject to a number of uncertainties. One particularly common case is the arrival of new cars that need to be added to outbound trains in the yard. It is desirable that plans can directly accomodate a certain number of extra cars, or that it is possible to change the plan so that extra cars can be added. We will present a mathematical model of this problem and show how to both solve it and balance the different objectives (minimising cost and maximizing robustness) against each other.

3 - Integrated Last-Mile Planning in Delhi Metro
Ashwani Kumar, Singapore-MIT Alliance for Research and Technology, Singapore, Singapore, A0080555@NUS.EDU.SG, *Kwong Meng Teo*

Efficient mass transit systems and non-mechanised transportation modes such as walking and cycling are widely recognized to be essential components to sustainable urban mobility in developing megacities. While the latter addresses elegantly the last mile challenges faced by commuters on mass transit, there is often a lack of such integrated multimodal planning. We observed this in our case study in Delhi, and present an integrated multimodal planning approach to managing last mile problems in mass transits in developing cities.

4 - Incorporating activity duration into multi-state supernetworks to activity-travel scheduling
Feixiong Liao, Urban planning group, TU/e, Vertigo 8.09, Den Dolech 2, 5600 MB, Eindhoven, Netherlands, f.liao@tue.nl, *Theo Arentze*, *Harry Timmermans*

Activity-travel scheduling problem can be reduced to finding the optimal path through the multi-state supernetworks. Activity duration choice is not captured in current time-dependent supernetwork models. This paper attempts to incorporate this choice dimension. Based on the supernetwork representation, activity transaction links are extended into time-space sub-networks to model the arrival time and duration simultaneously. Thus, transaction link costs can be explicitly defined with the two components. A bi-criteria label correcting algorithm is proposed to find the non-dominated schedules.

■ HA-20

Thursday, 8:30-10:00
G5-11

Network Design

Stream: Optimization in Public Transport
Invited session

Chair: *Ernesto Cipriani*, Dept. Civil Engineering, University of Roma TRE, Via Vito Volterra 62, 00146, Roma, Italy, eciprian@uniroma3.it

1 - Urban transit network design problems: a general model and some solution algorithms
Mariano Gallo, Dipartimento di Ingegneria, Università degli Studi del Sannio, Piazza Roma 21, 82100, Benevento, Italy, gallo@unisannio.it, *Luca D'Acierno*, *Bruno Montella*

In this paper we propose a general model and some solution algorithms for solving the Transit Network Design Problem in urban areas. The model is a constrained optimisation model where the decision variables are line routes and frequencies, the constraints regard feasible values for the frequencies, budget, line capacities and user assignment. The general model, that can be particularised in function of the aim of the design, can assume the transportation demand as rigid or elastic. In the paper some meta-heuristic algorithms are proposed for solving the problem and tested on a case study.

2 - Optimization of a railway line system
Pieter Fioole, PI, Netherlands Railways, stalpaertstraat 56, 3067 XS, Rotterdam, Netherlands, pieterjan.fioole@ns.nl, *Bart de Keizer*, *Joel van 't Wout*

The line system is the basis of the timetable for a railway company. It defines start- and end-point of trains, their routes, the stopping stations and the frequency trains will run. Based on an OD-matrix and the railway network, the aim is to provide good travel options for all passengers on one hand and to do this in a cost-efficiënt way for the railway company on the other hand. We propose a genetic algorithm approach to solve this problem. We will present the potential benefits of this model both in terms of service improvement and cost reduction.

3 - Bus transit network design with mixed traction technologies and different fast charging schemes
Federico Giubilei, Sapienza University of Rome, 00184, Rome, Italy, federico.giubilei@gmail.com, *Gaetano Fusco*, *Chiara Colombaroni*

The paper deals with the problem of transit system design for a mixed fleet of electric and internal combustion buses, considering different fast charging schemes: at depots, at termini, at stops. Choice of vehicle type optimizes total lifetime internal and external costs. Unlike many works in literature, this model assumes the set of routes as fixed. It introduces instead constraints related to battery autonomy, energy consumption and power transfer from the grid. A real-size numerical application will be carried out on a portion of the public transport network in Rome.

4 - Route frequency setting for feeder bus network design
Francesco Ciaffi, Dipartimento di Scienze dell'Ingegneria Civile, Università Roma Tre, Via Vito Volterra 62, 00146, Roma, Italy, fciaffi@uniroma3.it, *Ernesto Cipriani*, *Marco Petrelli*

This research deals with the evolution of an existing methodology for solving the feeder bus network design problem in a real size large urban area, based on two main phases: generation of two different and complementary sets of feasible routes using a heuristic algorithm and the optimal network calculation through a GA. Main novelties are represented by the introduction of a basin definition and a zone aggregation procedure, in order to define the main skeleton of network to be served, and the improvement of the route frequency setting procedure, included in the optimal solution calculation.

■ HA-21

Thursday, 8:30-10:00
G6-1

Stochastic Project Scheduling

Stream: Project Management and Scheduling
Invited session

Chair: *Walter Gutjahr*, Department of Statistics and Decision Support Systems, University of Vienna, Universitaetsstrasse 5/3, 1010, Vienna, Vienna, Austria, walter.gutjahr@univie.ac.at

1 - Robust proactive schedule for the stochastic RCPSP: A chance-constrained programming approach
Patricio Lamas, KU Leuven, Chile, patricio.lamasvilches@kuleuven.be, *Erik Demeulemeester*

The resource-constrained project scheduling problem (RCPSP) with stochastic activity durations involves the determination of a proactive schedule. Due to the non-deterministic activity durations, the real executed schedule may differ from the planned schedule. A desirable characteristic of a proactive schedule is to have small deviations between real and planned schedules. This characteristic has been named in the literature as solution robustness. We propose a chance-constrained programming model that considers the robustness level as a constraint.

2 - A comparison of solution procedures for the dynamic stochastic resource-constrained multi-project Scheduling problem
Rainer Kolisch, TUM School of Management, Technische Universitaet Muenchen, Arcisstr. 21, 80333, Muenchen, Germany, rainer.kolisch@wi.tum.de, *Thomas Fliedner*, *Philipp Melchiors*, *Walter Gutjahr*

We consider the dynamic stochastic resource-constrained multi-project scheduling problem where projects arrive stochastically over time. Each arriving project is of the type as considered in the stochastic resource-constrained project scheduling problem (SRCPSP). Activities are started based on a policy of priorities for all unscheduled tasks. Policies are updated at each project arrival and are chosen under the objective of minimizing the average expected flow time of the projects. We report on a computational study in which we compare several variants of a Genetic Algorithm.

3 - Risk aversion in stochastic multi-mode resource-constrained project scheduling
Walter Gutjahr, Department of Statistics and Decision Support Systems, University of Vienna, Universitaetsstrasse 5/3, 1010, Vienna, Vienna, Austria, walter.gutjahr@univie.ac.at

In project scheduling under uncertainty, project managers often adopt a risk-averse attitude, which makes an expected-value consideration inappropriate. Elsewhere, programs with stochastic dominance constraints have been used for modeling risk-averse decision making. We propose optimization models of this kind for single-objective and multi-objective stochastic multi-mode RCPSPs. In the latter case, multivariate stochastic dominance relations are required as ingredients. In particular, also a novel dominance relation derived from the possibility of trading under transaction costs is discussed.

4 - A strategy game to explain the dynamics in the public-private partnership competitive dialogue
Dennis De Clerck, Decision Sciences and Information Management, KU Leuven, Belgium, dennis.declerck@kuleuven.be, *Erik Demeulemeester*

Public private partnerships are cutting edge contractual arrangements in which a contractor engages in a long-term commitment with the government. The high pre-tender research cost could become an inhibitor for participants. A game-theoretical modeling approach gives insights into the interplay between different actors in the market and, together with a simulation experiment, it investigates whether good government intervention policies suffice to overcome the reluctance to avoid high upfront bidding costs.

■ HA-22

Thursday, 8:30-10:00
G6-2

Scheduling in Transport

Stream: Scheduling II
Invited session

Chair: *Alena Otto*, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de

1 - The scheduling problem in the railway network.
Maiia Laskova, The Institute of Control Sciences V. A. Trapeznikov Academy of Sciences, Moscow, Russia, Russian Federation, laskovaya_maya@mail.ru, *Alexander Lazarev*, *Elena Musatova*

We consider double-track railway network. There is one-side movement on the each ofthe railway line. We interested in the situation when the one of railway line was closed for technical reasons, or emergency. In this case this area becomes problematic because the trais will move in two directions. The problem is to determine the most effective order of trains in such problematic area.

2 - An Integer Programming Model and a Shortest Path Algorithm for an Intermodal Transportation Problem
Seyda Topaloglu, Department of Industrial Engineering, Dokuz Eylul University, 35160, Izmir, Turkey, seyda.topaloglu@deu.edu.tr, *Emrah B. Edis*, *Gonca Tuncel*, *Pinar Kilinc*

In this work, we first propose an integer programming model to find the lowest cost intermodal freight routes for a logistics company that uses transportation modes trucks, trains, and ships. The proposed model incorporates train and ship schedules and warehousing options before changing the transportation mode to ship or train. Then we develop an efficient shortest path algorithm that minimizes transportation cost and also includes transfer time constraint. The solution of the algorithm is shown on an intermodal network which is generated considering the current practices of the company.

3 - Straddle carrier routing at container ports
Sebastian Meiswinkel, University of Siegen, 57068, Siegen, Germany, sebastian.meiswinkel@uni-siegen.de, *Erwin Pesch*

We address a straddle carrier routing problem that arises at container ports. Containers are transported from a stacking area to quay cranes and vice versa. The problem is to route straddle carriers such that a dispatching order at the quay crane is respected and the vessels' turnaround time plus the straddle carriers' travel distance is minimized. The problem is formulated as a MIP based on a ATSP with precedence constraints. We use a modified 3-opt heuristic and improve the solutions with an ejection chain algorithm. We run several computational experiments based on real world data.

4 - Crane scheduling at rail-road transshipment yards
Alena Otto, University of Siegen, 57068, Siegen, Germany, alena.otto@uni-siegen.de, *Xiyu Li*, *Erwin Pesch*

The promotion of freight rail transport is important to reduce pollution and relieve congested roads. Due to low average speed and unreliability, rail transport is often not competitive. Inefficient operation of transshipment yards (TY) is a major cause of these issues. This work optimizes crane scheduling at rail-road TY. Our objective is to find non-interfering working areas for cranes and a sequence of container moves, so that makespan is minimized. We model the problem as mATSP with time windows and further constraints. An effective heuristic approach based on decomposition is proposed.

■ HA-23

Thursday, 8:30-10:00
G6-3

Handling divergent interests in scheduling

Stream: Scheduling under Resource Constraints
Invited session

Chair: *Mikhail Y. Kovalyov*, United Institute of Informatics Problems, National Academy of Sciences of Belarus, Surganova 6, 220012, Minsk, Belarus, kovalyov_my@yahoo.co.uk
Chair: *Ammar Oulamara*, University Lorraine - LCOMS, France, oulamara@univ-lorraine.fr
Chair: *Ameur Soukhal*, University of Tours, Computer Science Laboratory, 64, avenue Jean Portalis, 37200, Tours, France, ameur.soukhal@univ-tours.fr

1 - Batching jobs of two competing agents
Ameur Soukhal, University of Tours, Computer Science Laboratory, 64, avenue Jean Portalis, 37200, Tours, France, ameur.soukhal@univ-tours.fr, *Mikhail Y. Kovalyov*, *Ammar Oulamara*

Jobs of two agents are scheduled on a serial unbounded batching machine. Only jobs of the same agent are assigned to the same batch, and they complete simultaneously. A setup time precedes each batch. An agent minimizes a function of the completion times of its jobs. We provide algorithms and full complexity classification for problems with the following functions: makespan, total completion time, maximum lateness, maximum cost, and (weighted) number of late jobs. One of these functions is minimized for one agent, and the same or another function is bounded from above for another agent.

2 - Scheduling with Job-Dependent Resource Reproducibility
Alexander Kononov, Sobolev Institute of Mathematics, pr. Koptyuga 4, 630090, Novosibirsk, Russian Federation, alvenko@math.nsc.ru

We consider a scheduling environment under the new type of resource constraints. Each job acquires and consumes a certain amount of resource from the common pool, and reproduces and returns, at its completion, to the common pool another amount of resource which could be different that the job already consumed. The reproducibility varies among the jobs. Reproducible resources include both renewable and nonrenewable resources and differ from partially (non)renewable resources. We present new complexity and approximation results for scheduling problems with reproducible resource constraints.

3 - Two-agent scheduling in the relocation problem
Bertrand Lin, Institute of Information Management, National Chiao Tung University, 1001, Tahsueh Road, 30010, Hsinchu, Taiwan, bmtlin@mail.nctu.edu.tw, *Alexander Kononov*

A certain amount of a single-type resource is given for processing a set of jobs. Each job is characterized by resource requirement, resource yield and processing time. The jobs belong to two agents. We want to find a feasible schedule that attains the minimum sum of weighted maximum completion times of the agents. The problem can be shown to be NP-hard. We investigate several structural properties of optimal schedules. Several special cases are analyzed with development of solution algorithms.

4 - Pareto front analysis for the Interfering vs Competing job set problems
Faiza Sadi, University of Tours, Computer Science Laboratory, 64 avenue jean portalis, 37200, Tours, France, faiza.sadi@etu.univ-tours.fr, *Ameur Soukhal*

Consider multicriteria scheduling problems in which jobs of K agents should be scheduled on parallel machines. Each agent aims at minimizing a function depending only on the completion times of his jobs. These problems are called Competing job set problems. Adding a global agent that aims at minimizing a function depending on the completion times of all jobs, the problem is called interfering job set problems. We study relationships that exist between the Pareto fronts of these problems. Dynamic programming algorithms are derived for settings with some combinations of the objective functions.

■ HA-24

Thursday, 8:30-10:00
G6-4

University Timetabling

Stream: Timetabling and Rostering
Invited session

Chair: *Gert Woumans*, Management, IESEG School of Management, 3, Rue de la digue, 59000, Lille, France, g.woumans@ieseg.fr

1 - A Column Generation Approach to Solve the Examination-Timetabling Problem
Gert Woumans, Management, IESEG School of Management, 3, Rue de la digue, 59000, Lille, France, g.woumans@ieseg.fr, *Liesje De Boeck*, *Jeroen Belien*, *Stefan Creemers*

We propose two column generation models for solving the exam-timetabling problem (ETP). The first models uses complete exam schedules for every unique student group as columns, which are generated by an adapted knapsack problem as pricing problem (PP). The master program (MP) selects the schedules for every student group. The second model uses mask schedules as columns, which are generated by an adapted shortest path problem as PP. The MP selects mask schedules for every student group and schedules exams in the masks slots. The second model solved a real life instance at HU Brussel.

2 - A goal programming approach to bi-objective make-up exam timetabling problem
Safak Kiris, Industrial Engineering Department, Dumlupinar University, Central Campus, Tavsanli Yolu 10.km, KUTAHYA, Turkey, safakkiris@gmail.com, *Ozden Ustun*, *Ilker Ozan Koc*

In this paper, a goal programming approach is proposed to solve a bi-objective make-up exam timetabling problem. The objectives are minimizing the number of sessions and maximizing the paper spread, which is a measure of the amount of study time that each student has between examinations. Assignment, open session, open class and non-conflicting constraints are considered in the proposed model. In the goal programming approach, the aspiration levels and the weights of the goals are determined by the management. The proposed model is solved for a case study by using Lingo 11.0.

3 - Establishing timetabling optimization at RWTH Aachen University
Florian Dahms, Operations Research, RWTH Aachen, Templergraben 64, 52056, Aachen, Germany, dahms@or.rwth-aachen.de, *Gerald Lach*, *Marco Lübbecke*

In early 2012, the RWTH Aachen University decided to improve their utilization of educational resources (especially rooms) using state of the art methods. The presentation will consist of two parts. First: how the problem can be modeled and solved using methods from mathematical programming. Second: what kind of problems arise (and how to overcome them) when actually implementing such a system in university operations. These include (but are not limited to) collecting and managing data, as well as persuading and balancing the interests of different kinds of stake holders.

4 - An Integer Programming Formulation for University Exam Timetabling and A Case Study
Kezban Bulut, Department of Industrial Engineering, Kirikkale University, Kampus, 71451, Kirikkale, Turkey, kezbanbulut@yahoo.com, *Gulgun Kayakutlu*

Integer programming technique is an extension of linear programming. The exam-timetabling problem consists of assigning exams to timeslots. In this study, Kirikkale University Department of Industrial Engineering midterm exam scheduling problem is considered. This program consists of 23 lessons, 3 exam rooms and 3 teaching members and 25 time slots. The purpose of this paper is to find a suitable assignment of exams, teaching members and students to classrooms under several conditions. This problem is modeled by 0-1 integer programming, solved and sensitivity analysis is done.

■ HA-25

Thursday, 8:30-10:00
G9-1

Fuzzy Decision Making

Stream: Fuzzy Optimization - Systems, Networks and Applications
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de
Chair: *Bohdan Pukalskyi*, Students Science Association, National Technical University of Ukraine, Kovalskyi provulok 5, 03057, Kyiv, Ukraine, bogdanpukalskyy@gmail.com

1 - An Adaptive Neuro-Fuzzy Inference System for Measurement of Total Productive Maintenance Effectiveness in Manufacturing Systems
Ebru Turanoglu Bekar, Industrial Engineering, Izmir University, Department of Industrial Engineering Izmir University, Gursel Aksel Bulvari No:14 Uckuyular/IZMIR, 35350, Izmir, Turkey, ebruturanoglu@gmail.com, *Mehmet Cakmakci*

Overall Equipment Effectiveness (OEE) is a fundamental measurement method for Total Productive Maintenance (TPM) effectiveness. The aim of the study is to develop new parameters to increase the effectiveness of overall equipment dealing with uncertainties in a manner more like humans; one may incorporate an approach based on adaptive neuro-fuzzy inference system (ANFIS). While fuzzy logic provides an inference mechanism under uncertainty, computational neural networks offer exciting advantages, such as learning, adaptation, fault-tolerance, parallelism and generalization.

2 - Using the Fuzzy Analytic Hierarchy Process for Ranking Risk Events of a Wind Power Project
Jose Roberto Ribas, Departamento de Engenharia Industrial, Universidade Federal do Rio de Janeiro, Centro de Tecnologia, Bloco F, sala 101, Ilha do Fundao, 21941-909, Rio de Janeiro, RJ, Brazil, jroberto_ribas@hotmail.com, *Flavio Sohler*, *Mariana de Oliveira Avellar*

This study applies a Fuzzy Analytic Hierarchy Process for setting up a hierarchical risk event structure (difficulty of connecting to the grid; technical failures in the turbine generator sets; delay on schedule; cost overrun; difficulty to comply with regulatory constraints) related to vulnerability issues (unavailability of skilled work force; project complexity; inexperience with wind power projects; inefficient project management) of a wind power project under construction, located in the Brazilian Northeastern region. The key elements were identified by the owners engineering specialists.

3 - Holistic Discourse in the Net Cognitive Modeling
Alexander Raikov, Lab. Cognitive Modeling and Situation Control, Institute of Control Sciences RAS, Profsoyuznaya, 65, 117997, Moscow, Russia, Russian Federation, Alexander.N.Raikov@gmail.com

The demand of the cognitive modeling on the base of network expert procedures for decision support in governments and corporations is growing. It is difficult to build a holistic discourse of the network expert consciousness in this case. It is proposed to use the convergent control mechanism, quantum entanglement and complementarity principles, as well as the development of multilateral training of participants of the strategic conversations for getting the holistic discourse.

4 - Electricity Consumption Forecasting with GM(1,1) Systems and Fuzzy Time Series
Eda Boltürk, Industrial Engineering, Istanbul Commerce University, Turkey, ebolturk@ticaret.edu.tr

Electricity consumption forecasting is a vital issue in energy management. Fuzzy Logic is used in forecasting and it gives better results with low errors. On the other hand, there is a new branch known as Grey System. One of the issues in Grey System is prediction. Prediction is solved with Grey Model(n,m). Present paper only deals with GM(1,1). In this study, a company's electricity consumption is taken. Two methods are compared in order to find which method is better. An error formula, Mean Absolute Error, is used for comparing the methods.

■ HA-26

Thursday, 8:30-10:00
G9-7

Topics in knapsack problems

Stream: Combinatorial Optimization I
Invited session
Chair: *Michele Monaci*, D.E.I., University of Padua, Via Gradenigo 6/A, 35131, Padova, Italy, monaci@dei.unipd.it

1 - Online Knapsack Problems with Dynamic Capacity
Morten Tiedemann, Institute for Numerical and Applied Mathematics, Georg-August-University Goettingen, Lotzestr. 16-18, 37083, Goettingen, Niedersachsen, Germany, m.tiedemann@math.uni-goettingen.de, *Clemens Thielen*, *Stephan Westphal*

In this talk, an online version of the knapsack problem with dynamic capacity is considered. At each time period, a set of items, each with a specific weight and value, is revealed and without knowledge of future items it has to be decided which of these items to accept. Furthermore, the knapsack capacity is not fully available from the start, but increases by a certain amount in each time period. The goal is to maximize the overall value of the accepted items. We discuss several variants of the problem and present a competititve analysis of deterministic and randomized online algorithms.

2 - Semi-continuous knapsack polyhedron with multiple GUB constraints
Daniel Espinoza, Industrial Engineering, Universidad de Chile, Av. Republica 701, 837-0439, Santiago, RM, Chile, daespino@dii.uchile.cl, *Alejandro Angulo*

We consider a polyhedron were variables are either zero, or take values in a bounded set; these variables are linked by a knapsack constraint and several disjoint clique inequalities. In this talk, we present valid inequalities for this set, multi-dimensional sequence-independent lifting functions, separation heuristics and computational experiments performed on real-world unit-commitment instances. This works builds on previous works by the authors and also from lifting techniques developed by Zeng and Richard.

3 - A Greedy Heuristic For Multi-Dimensional 0-1 Minimum Knapsack Problem
Ipek Seyran Topan, Cankaya University, Netherlands, ipeks@cankaya.edu.tr, *Levent Kandiller*, *Haluk Aygunes*

Two dimensional 0-1 minimum knapsack problem is considered. A new easy lower bound and a greedy algorithm is proposed. The asymptotic behaviors of the LP-relaxation of the problem and the performance of the greedy algorithm are analyzed. LP-relaxation of the problem is found as asymptotic tight while the greedy algorithm is found as asymptotic optimum. It is seen that when the item size n increases, the gap between optimum solution and the greedy algorithm converges to zero. The algorithm is tested by using generated random problem sets.

4 - On the Robust Knapsack Problem
Michele Monaci, D.E.I., University of Padua, Via Gradenigo 6/A, 35131, Padova, Italy, monaci@dei.unipd.it, *Ulrich Pferschy*

We consider an uncertain variant of the knapsack problem that arises when the exact weight of each item is not exactly known in advance but belongs to a given interval, and the number of items whose weight differs from the nominal value is bounded by a constant. We analyze the solution worsening due to uncertainty and compute it from a worst-case perspective; then, we extend the analysis to the fractional version of the problem. Finally, we perform a worst-case analysis for lower and upper bounds on the optimal solution value.

■ HA-27

Thursday, 8:30-10:00
G9-8

COMEX - Exact and heuristic algorithms for hard problems

Stream: Combinatorial Optimization II
Invited session

Chair: *Yves Crama*, HEC - Management School, University of Liège, Rue Louvrex 14 (N1), 4000, Liege, Belgium, Y.Crama@ulg.ac.be

1 - Dantzig-Wolfe reformulation for the network pricing problem with connected toll arcs
Alessia Violin, Computer Science, Université Libre de Bruxelles, Boulevard du Triomphe, CP 210/01, 1050, Bruxelles, Belgium, aviolin@ulb.ac.be, *Bernard Fortz*, *Martine Labbé*

We consider a pricing problem on a network with connected toll arcs. We prove that this problem is APX-hard and we propose a Dantzig-Wolfe reformulation for it. The model is therefore solved with column generation and the gap between the optimal integer value and the linear relaxation optimal value is shown to be at least as good as the one from the mixed-integer formulation proposed in the literature. Numerical results on different sets of instances are reported, showing that in many cases the proposed model performs strictly better.

2 - An exact formulation for three-dimensional bin-packing with transportation constraints
Célia Paquay, HEC - Management School, University of Liège, Rue Louvrex 30, 4000, Liège, Belgium, cpaquay@ulg.ac.be, *Sabine Limbourg*, *Michaël Schyns*

Packing a set of items into a minimum number of bins is a daily process in many fields such as transport. This problem belongs to the bin packing problems (BPP), which represent a well-known topic in combinatorial optimization. BPP is here studied in three dimensions with specific constraints such as the even distribution of the weight or fragility. We have written an exact model for the 3D-BPP. Numerical experiments have been performed using a standard B&C library.

3 - Approximation algorithms for multi-dimensional vector assignment problems
Trivikram Dokka, Operations Reseach and Business Statistics, KATHOLIEKE UNIVERSITEIT LEUVEN, Naamsestraat 69, B-3000, Leuven, Belgium, trivikram.dokka@yahoo.co.uk, *Yves Crama*, *Frits Spieksma*

We study the behavior of two classes of heuristics: sequential and heaviest-first, for a multi-dimensional vector assignment problem. We show that when the cost function is monotone and submodular, sequential heuristics have finite performance ratio for every fixed dimension. We prove a better performance ratio for heaviest-first heuristics when the cost function is additive. We provide examples to illustrate tightness of our analysis. Furthermore, we show that the problem is APX-hard even for the case of binary vectors, but can be solved in polynomial time for binary vectors of fixed size.

4 - An algebra of boolean functions and their relation with heuristics
Patrick De Causmaecker, Computer Science/CODeS, Katholieke Universiteit Leuven, Campus Kortrijk, Etienne Sabbelaan 53, BE-8500, Kortrijk, Flanders, Belgium, Patrick.DeCausmaecker@kuleuven-kortrijk.be

We study the lattice of anti-monotonic boolean functions and present a number of new algebraic identities. In particular, the structure of the intervals in this lattice allow for a large number of partitions of the space. A result is a set of algorithms effectively computing the size of the space. The motivation for this study is to draw a framework for the systematic study of heuristics. We describe the framework and speculate about its potential.

■ HA-28

Thursday, 8:30-10:00
G9-2

Graph Searching

Stream: Graph Searching
Invited session

Chair: *Peter Großmann*, Faculty of Transportation and Traffic Sciences, TU Dresden, Hettner Str. 1, POT-106b, 01069, Dresden, Saxony, Germany, peter.grossmann@tu-dresden.de

1 - Fractional Combinatorial Two-Player Games
Nicolas Nisse, COATI, INRIA, I3S(CNRS/UNS), INRIA, 2004 routes des Lucioles, 06902, Sophia Antipolis, France, nicolas.nisse@inria.fr

We propose a fractional relaxation of two-player combinatorial games. Two players can move or/and add fractions of tokens on the nodes of a graph and a player wins if he is the first one to reach a configuration in some specified set. Both allowed moves and winning configurations are defined thanks to a polynomial number of linear inequalities. Our framework applies to many two-players games including the fractional variant of cops and robber games. We give some results and promising perspectives of this new framework. Joint work with F. Giroire, S. Pérennes, R.P. Soares.

2 - Watchers and Listeners: The Art of Detection
Bert Hartnell, Mathematics & Computing Science, Saint Mary's University, 923 Robie St., B3H 3C3, Halifax, Nova Scotia, Canada, Hartnell@smu.ca

The problems of where to locate a set of cameras to guard all nodes of a network (cameras can "see" an intruder on adjacent nodes and form a dominating set) or a set of sensors that can determine the distance to an intruder and determine its location (a metric basis) have been examined by a number of authors. We shall consider what to do if one has both types of detectors available. That is, how many of each type are needed and where should they be placed? (joint with A. Finbow and J. Young)

3 - On Extracting Minimally Infeasible Periodic Event Networks
Peter Großmann, Faculty of Transportation and Traffic Sciences, TU Dresden, Hettner Str. 1, POT-106b, 01069, Dresden, Saxony, Germany, peter.grossmann@tu-dresden.de, *Jens Opitz*

Calculating timetables in periodic event networks is an NP-complete problem. In case the network's restriction system is infeasible, the operator has a decisive problem since in huge and complex networks, it is difficult to manually find small infeasible subnetworks. Firstly, this work presents a novel approach to find smallest infeasible subnetworks (local conflicts) by encoding the instance into a propositional formula and afterwards, extracting a minimally unsatisfiable subformula (MUS) by an MUS extractor. Secondly, we provide a complexity classification of the local conflict extraction.

■ HA-29

Thursday, 8:30-10:00
G9-3

Advanced Models in Reliability and Finance

Stream: Stochastic Models in Reliability and Risk
Invited session

Chair: *Vanderlei Bueno*, Estatística, Universidade de São Paulo, Rua do Matão, 17, 05508090, São Paulo, São Paulo, Brazil, bueno@ime.usp.br

1 - Marked point signature processes
Vanderlei Bueno, Estatística, Universidade de São Paulo, Rua do Matão, 17, 05508090, São Paulo, São Paulo, Brazil, bueno@ime.usp.br

An alternative structural representation of a coherent system is through its signature, as in Samaniego (1985), which gives its distribution function as a mixture of the ordered components lifetimes. Observing the system at component leaves, as they appear in time, we introduce a marked point signature process and its compensator and discuss the following questions: (1) What is the reliability importance of the component j, for the system reliability at the i-th failure? (2) What are the effects of the component lifetime minimal repair in the ordered lifetimes and in the signature itself?

2 - Non-negative targets in the Target-Based approach to Multi-Attribute Utilities
Fabio Fantozzi, Mathematics, University of Rome "La Sapienza", Piazzale Aldo Moro 5, 00185, Roma, Italy, fantozzi@mat.uniroma1.it, *Fabio Spizzichino*

In the frame of decision analysis we consider Multi-Attribute Utilities arising in the Target-Based Approach. Such utilities can be written in terms of a random vector of targets and on a capacity that represents the utility associated to each subset of targets. Firstly we illustrate some connections between the concepts of capacity and Mobius transform. Then we analyze the expected utility associated to a risky vector of prospects under different conditions on the joint law with the targets. Finally we discuss some connections with concepts of survival analysis.

3 - Martingale dynamics of repairable systems
Ilkka Norros, VTT Technical Research Centre of Finland, Finland, ilkka.norros@vtt.fi

We first propose a class of Generalized Semi-Markov models for incorporating 'weakening-by-failures' type dynamic dependence of component failures, and studying the case of two components in greater detail. Next, we extend a martingale approach to multivariate lifetime distributions to the case of repairable components and prove that weakening-by-failures implies association in this framework. Third, we give natural sufficient conditions under which models of the abovementioned type possess the weakening-by-failures property, thus deriving in particular that they are associated.

4 - The Economic Impact of Oil on Industry Portfolios
Jaime Casassus, Instituto de Economia UC, Universidad Catolica de Chile, Av. Vicuna Mackenna 4860, Macul, 7820436, Santiago, Santiago, Chile, jcasassus@uc.cl

We build an equilibrium model to disentangle industry-specific from business cycle effects of oil on stock returns. We estimate the model for 13 industries, including the oil industry. Our results suggest that the value of all non-oil industries decreases with an oil price shock. This result is explained by the significant negative effect of oil on the growth opportunities of the industries. The high persistence of the real oil price shocks makes these effects to be long-lived.

■ HA-30

Thursday, 8:30-10:00
G9-10

Multi-index assignment and related structures

Stream: Graphs and Networks
Invited session

Chair: *Reinhardt Euler*, Informatique, Université de Brest, 20 av. Le Gorgeu, B P 817, 29285, Brest, France, reinhardt.euler@univ-brest.fr

1 - Choosability with few colors
Marc Demange, ESSEC Business School and LAMSADE UMR 7243, Paris, France, demange@essec.edu, *Dominique de Werra*

List-coloring is the restriction of the vertex coloring problem when a list of allowed colors is assigned to each vertex. The question is whether there is a coloring satisfying the list constraints. A graph G is said l-choosable if for every list assignment of l allowed colors at each vertex there is a list coloring. We consider the restrictive version, called [l,k]-choosability, for which only k colors do appear in lists. We investigate the complexity of deciding whether a graph is [l,k]-choosable for some classes of graphs including bipartite and planar graphs and for small values of k.

2 - Exploring the many-to-many Stable Matching polytope and transportation-related generalizations
Pavlos Eirinakis, Management Science & Technology, Athens University of Economics & Business, 76 Patision Str., 10434, ATHENS, Greece, peir@aueb.gr, *Dimitris Magos*, *Yiannis Mourtos*

The characterization of the many-to-many Stable Matching (MM) polytope is based on a specialization of the related matroid-kernel polytope. Based on the existing linear description of the MM polytope, we examine its basic polyhedral characteristics. More specifically, we establish the dimension of the MM polytope and utilize its existing linear representation to derive its minimal description in terms of its minimal equation system and facets. Further, we explore the applicability of our approach to transportation-related generalizations, as the ordinal transportation problem and stable flows.

3 - Separation algorithms for the alldifferent system and related problems
Dimitris Magos, Informatics, Technological Educational Institute of Athens, Greece, dmagos@teiath.gr, *Yiannis Mourtos*

The alldifferent system, i.e., a set of alldifferent constraints, offers a natural representation of several combinatorial optimization problems, including multi-index assignment and graph coloring. For the polytope defined as the convex hull of vectors satisfying such a system, all known facet-defining inequalities arise from subgraphs of the associated constraint graph. We propose polytime separation algorithms for several such inequalities, including those induced by odd-holes, wheels and paths, report preliminary computational results and discuss some implications for related problems.

4 - An integrated solver for the (k,s)-assignment problem
Stathis Plitsos, Management Science and Technology, Athens University of Economics and Business, 47A Evelpidon & 33 Lefkados str, 113 62, Athens, Greece, stathisp@aueb.gr, *Dimitris Magos*, *Yiannis Mourtos*

The (k,s)-assignment problem sets a unified framework for the polyhedral and computational study of families of assignment problems, including axial and planar ones. Considering that there is much to be gained by exploiting the complementary strengths of different approaches to optimization, we have developed an integrated solver for this problem, through the combination of heuristics, constraint propagation and cutting planes. Apart from offering comparative computational results for the problem itself, our code may easily support the development of further heuristics or integrated methods.

■ HA-31

Thursday, 8:30-10:00
G9-11

IFORS Invited Tutorial - C. Gonzaga

Stream: Invited Lectures - Keynotes and Tutorials
Tutorial session

Chair: *Sue Merchant*, Blue Link Consulting, 4,Shepherds Way, WD3 7NJ, Rickmansworth, Hertfordshire, United Kingdom, suemerchant@hotmail.com

1 - Interior Point Methods for Mathematical Programming
Clovis Gonzaga, Dept. of Mathematics, Federal Univ. of Santa Catarina, Cx. postal 5210, Florianópolis, SC, Brazil, 88040-970, Florianópolis, SC, Brazil, ccgonzaga1@gmail.com

Interior point methods have been used to treat constrained nonlinear programming problems for about fifty years. These algorithms generate sequences of points which satisfy strictly the inequality constraints, as opposed to simplex like methods, which typically evolve on the boundary of the feasible set. They were initially based on the use of barrier functions to deal with the inequalities, and were applied to nonlinear problems with a small number of variables. In 1985, Karmarkar showed how to use interior points to solve the Linear Programming problem in polynomial time, for the first time challenging the supremacy of the simplex method in practical applications. This started a revolution in mathematical programming, which coincided with the decrease in cost of computation, which made powerful workstations accessible to all researchers. Interior point methods were then implemented for linear programming, and its realm spread to linear complementarity problems, semi-definite programming, conical problems and back to nonlinear programming. The problem sizes for linear programming grew from a maximum of some thousands of variables in 1980 to the 2008 record of one billion variables with hundreds of millions of constraints.

In this talk we present the basic ideas of interior point methods and a brief survey of their evolution and state of the art.

■ HA-32

Thursday, 8:30-10:00
G8-1

Perishable Inventory Management

Stream: Supply Chain Optimization
Invited session

Chair: *Stefan Minner*, TUM School of Management, Technische Universität München, Arcisstrasse 21, 80333, Munich, Germany, stefan.minner@tum.de

1 - Order quantity variability of demand management policies in a perishable product supply chain
Sandra Transchel, Kuehne Logistics University, Hamburg, Germany, sandra.transchel@the-klu.org, *Stefan Minner*

We analyze order variability in perishable-product supply chains with respect to customer reactions to stockouts (backorder/lost sales) and inventory depletion policies (FIFO/LIFO). We show that under conditions where no bullwhip effect would occur in non-perishable product supply chains, perishable products may face either the bullwhip effect or a reverse bullwhip effect, i.e., order variability is less than demand variability. We further discuss incentive conflicts between retailers and suppliers with respect to stockout control and inventory depletion policy.

2 - Impact of lead time on the ordering perishables
René Haijema, Operations Research and Logistics, TI Food and Nutrition & Wageningen University, Hollandseweg 1, 6706 KN, Wageningen, Netherlands, rene.haijema@wur.nl

This paper investigates the impact of a fixed lead time (L periods) on the structure of order policies for perishables with a maximum shelf life of m periods. Therefore rules in the class of periodic review (S,s,q,Q) policies (see Haijema, IJPE, 2011) are optimized. It is shown that an order-up-to S rule is appropriate, when the lead time is zero. However, when the lead time is relatively long (L > m), a fixed order quantity performs much better. The (S,s,q,Q) policy contains both these rules, and thus performs at least as good. It performs much better when the lead time is moderate (1<L<m).

3 - A hybrid MILP and simulation approach for redesigning a fresh product network
Marlies de Keizer, LDI, Wageningen University, De Leeuwenborch, room 6022, Hollandseweg 1, 6706 KN, Wageningen, Netherlands, marlies.dekeizer@wur.nl, *René Haijema*, *Jacqueline Bloemhof*, *Jack van der Vorst*

We present a hybrid approach for redesigning a fresh product network, i.e., optimizing the locations of facilities and allocation of processes and inventory with respect to costs, product quality and responsiveness. As products are perishable and have a short life time, a redesign should be evaluated at a detailed level, taking both demand and supply uncertainty and product quality requirements into account. We iteratively solve an MILP model and run a simulation, to check and adjust the MILP constraints, until a feasible solution is found.

4 - New heuristic policies for managing perishable inventories
Stefan Minner, TUM School of Management, Technische Universität München, Arcisstrasse 21, 80333, Munich, Germany, stefan.minner@tum.de

The optimal replenishment policy for perishable items is complex and therefore can typically only be obtained by stochastic dynamic programming. Several simple policies have been proposed. The base-stock and the constant order policy are the two most well-known ones. Based on the observation that each one can outperform the other, we propose a new combined policy that applies a constant order size for a certain range of inventory states and modified base-stock policies otherwise. A numerical study illustrates the improvements of this combined compared to the two pure policies.

■ HA-33

Thursday, 8:30-10:00
G8-3

Lot-Sizing and Related Topics 6

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Bernardo Almada-Lobo*, Industrial Engineering and Management, Faculty of Engineering of Porto University, Rua Dr. Roberto Frias s/n DEIG, 4200-465, Porto, Portugal, almada.lobo@fe.up.pt

1 - Simulation-Optimization for Pulp and Paper Mill Production Planning under Uncertainty
Gonçalo Figueira, Industrial Engineering and Management, Faculty of Engineering of Porto University, 4200-465, Porto, Portugal, goncalo.figueira@fe.up.pt, *Maristela Santos*, *Bernardo Almada-Lobo*

Motivated by a real-world case study in the pulp and paper industry, we tackle the short-term production planning and scheduling in an integrated mill, under process variability and disturbances. Our approach combines a Variable Neighbourhood Search and an exact solver, for the optimization of discrete and continuous variables, respectively. We further integrate a discrete-event simulation model to consider uncertainty and give feedback during the optimization procedure. The feedback is used to enhance the underlying analytical model, rather than simply evaluating solutions.

2 - Formulations of the capacitated lot sizing problem with sequence dependent setups
Dirk Van Eikenhorst, Economics Informatics and Social science, Molde University College, Britvegen 2, 6410, Molde, Norway, erik.van.eikenhorst@himolde.no

In this study the formulation of the CLSP with sequence dependent setup costs without setup carryover is analysed. Different formulations of the problem are compared to show how optimal solutions for practical size problems can be achieved. Also several relaxation methods based on this model are compared, together with a variable neighbourhood search heuristic, to find good feasible solutions in a small time limit. The results show how mathematical modelling can be used to solve practical size instances of a very hard problem or give fast and good upper bounds to these instances.

3 - An Integrated model for non cyclical maintenance planning and production planning
Mehdi Bijari, Industrial Eng., Isfahan University of Technology, Bolvar Daneshgah Sanati, 84156, Isfahan, Iran, Islamic Republic Of, bijari@cc.iut.ac.ir
In many industries, product yield is heavily influenced by equipment condition. We formulate a model that use Markov chain for producing parameters need to process model of a single stage multi parallel machines production system. The model addresses simultaneous lot-sizing and scheduling problem. The objective is to determine the equipment maintenance schedule as well as the production plan. The objective is to maximize profit. A simulated annealing and a heuristic and meta- heuristic combined method have been used to solve the problem.

4 - Order quantities in a production line, and its influences on production output and lead-time
Anders Segerstedt, Luleå University of Technology, Industrial logistics, SE 97187, Luleå, Sweden, anders.segerstedt@ltu.se
A simulation study over a supply chain with five linked machines is performed with a fixed setup time stochastic operation times for every item in the order quantity. The main purpose is to test the influence of setup times and order quantities and its dependence of maximum allowed work-in process (WIP). — The results show that increased WIP means that the lead-time increase but also that its variation increases, independent of setup time and order quantity. A decrease in order quantities lead to that the production rate decreases but also that the lead time increases!

■ HA-34

Thursday, 8:30-10:00
G8-4

Inventory management: Different performance criteria

Stream: Supply Chain Planning
Invited session

Chair: *Patrick Beullens*, School of Mathematics, School of Management, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, Hampshire, United Kingdom, P.Beullens@soton.ac.uk

1 - A Reformulation for Static-Dynamic Uncertainty Strategy under Service Level Constraint
Huseyin Tunc, Mississippi State University, 39762, Starkville, MS, United States, ht100@msstate.edu, *Onur A. Kilic*, *Armagan Tarim*, *Burak Eksioglu*
We study a stochastic lot-sizing problem under the static-dynamic uncertainty strategy with service level constraint. First, we show that the problem can be formulated as a shortest path when the dependency between replenishment periods is relaxed. Then, by using this fact, we revisit the original MIP formulation of the problem and test the resulting model on an extensive numerical study. We show for the majority of instances that the LP relaxation of the model is feasible and thus gives the optimal solution. Furthermore, it provides a very tight lower bound whenever it is infeasible.

2 - An MRP-based simulation model for the safety stock placement problem with customer service targets under budget and capacity restrictions
Jan-Patrick Pater, Heinz Nixdorf Institute, University of Paderborn, Fürstenallee 11, 33102, Paderborn, Germany, ppater@hni.upb.de, *Christoph Laroque*, *Wilhelm Dangelmaier*
We propose a multi-objective simulation-based optimization approach to solve the safety stock placement problem in a MTO multi-echelon supply chain with MRP support. Maximization targets are guaranteed delivery performances towards individual customers under consideration of budget and capacity restrictions. An evolutionary algorithm generates valid safety stock solutions and a discrete, hybrid event-and-process based simulation measures the impact on the delivery performance. We will present the simulation model, which takes lead time uncertainty for planned orders into account, in detail.

3 - Cost minimisation or profit maximisation in the supply chain of a deteriorating item with partial backlogging?
Yousef Ghiami, School of Management, University of Southampton, Building 2, University Road,, Highfield, Southampton, SO17 1BJ, Southampton, United Kingdom, yg5g09@soton.ac.uk, *Patrick Beullens*
Minimising costs is equivalent if variable revenues are, somehow, still accounted for. Classic inventory models may not achieve this - their parameters suffer from an interpretability problem related to the time value of money. For a deteriorating item that can be partially backlogged, conditions are derived under which minimising the Net Present Value (NPV) of costs indeed maximises this activity's NPV. Classic parameters cannot be arbitrarily chosen unless one accepts the current status-quo in which the interpretability problem leads to arbitrariness of the optimality of any solution.

4 - The Capital Costs and Rewards of Inventories in the Supply Chain of Independent Firms
Patrick Beullens, School of Mathematics, School of Management, University of Southampton, Highfield Campus, SO17 1BJ, Southampton, Hampshire, United Kingdom, P.Beullens@soton.ac.uk, *Gerrit K. Janssens*, *Luk Van Wassenhove*
We present an axiomatic framework within which it is meaningful to speak about a global optimal result for a collective of independent firms concerned with the maximisation of future profits. Adopting the framework as a thought experiment can reveal model incoherence or incompleteness. At least 50 papers in supply chain management suffer from incoherence or incompleteness; the real number may well be much higher. We uncover and resolve the compatibility problems between seminal philosophical theories on inventories in the supply chain including Harris (1915) and Clark (1958).

■ HA-36

Thursday, 8:30-10:00
G7-1

Cutting and Packing 7

Stream: Cutting and Packing
Invited session

Chair: *Marat Mesyagutov*, Numerical Mathematics, Dresden University of Technology, Zellescher Weg 12-14 (C 319), 01069, Dresden, Germany, marat.mesyagutov@tu-dresden.de

1 - A hybrid algorithm of Particle Swarm Optimization and Genetic Algorithms for the non-guillotine two-dimensional single knapsack problem
Luis Miguel Escobar Falcón, Maestría en Ing. Eléctrica, Universidad Tecnológica de Pereira, La Julita., Cra. 10 #46-132 Maraya, Pereira, Risaralda, Colombia, luismescobarf@utp.edu.co, *David Álvarez*, *Eliana Mirledy Toro Ocampo*, *Rubén Augusto Romero Lázaro*
This study presents the unconstrained (un)weighted fixed and rotated (first and superior order) non-guillotine two-dimensional knapsack problem. A suitable encoding based on the slicing tree is presented. A hybrid algorithm of Particle Swarm Optimization (PSO) with Genetic Algorithms (GA) is developed. This algorithm uses the main characteristics of PSO and introduces the flight turbulence factor through the concept of mutation of GA. The computational results on large sets of instances show that the methodology has effectiveness and robustness to solve the two-dimensional knapsack problem.

2 - Applying packing algorithms within a manufacturing automation context in a concrete factory
Andrey Ermakov, Robotics and complex automation, Bauman Moscow State Technical University, 2nd Baumanskaya street, 5, 105005, Moscow, Moscow city, Russian Federation, ermakov-andrey@yandex.ru, *Anton Ryzhikov*, *Anton Firsov*

In a concrete product factory it is necessary to harmonize the workflow of a continuous production process, that prepares the required amount of a specified grade of concrete mix, with the placement and packaging of workpieces at the molding site for casting the mix, and with producing the given orders taking into account their due dates. The principles underlying the resolution of such problem are presented, together with a multi-criteria 2D packing algorithm, aiming the improvement of the overall performance of the production system without any capital investments.

3 - A New Branch-and-Cut Algorithm for the Orthogonal Strip Packing Problem
Marat Mesyagutov, Numerical Mathematics, Dresden University of Technology, Zellescher Weg 12-14 (C 319), 01069, Dresden, Germany, marat.mesyagutov@tu-dresden.de, *Guntram Scheithauer*, *Gleb Belov*

We consider the 2D strip packing problem (SPP-2). Given a set of rectangular items, SPP-2 is to find a packing of all items occupying the minimal height of the given semi-infinite strip. SPP-2 is considered without items rotation. We develop an integer linear programming model and propose non-overlapping constraints which are facet-defining for the convex hull of the integer solutions. Based on the proposed formulation we develop a new branch-and-cut algorithm. Numerical results as well as theoretical investigations are discussed.

■ HA-37

Thursday, 8:30-10:00
G7-4

Multicriteria Decision Making and Its Applications VI

Stream: Multicriteria Decision Making II
Invited session

Chair: *Constantin Zopounidis*, Dept. of Production Engineering and Management, Technical University of Crete, University Campus, 73100, Chania, Greece, kostas@dpem.tuc.gr
Chair: *Ayse Özmen*, Scientific Computing, Institute of Applied Mathematics, Middle East Technical University, Kazimkarabekir Mah. 2048. Sok No:5/5, Etimesgut, 06790, Ankara, Turkey, ayseozmen19@gmail.com

1 - Robust linear multi-objective optimization with uncertain weights
Cristian Palma, Facultad de Ingenieria, Universidad del Desarrollo, Avda Sanhueza 1750, Concepcion, Chile, cristianpalma@ingenieros.udd.cl

Defining the objective weights in a multi-objective optimization framework is a difficult task, especially when many actors are involved in the decision-making process. In the context of the weighted-sum approach, we present a robust formulation of a multi-objective linear optimization problem in which the objective weights are defined as ranges of possible values rather than fixed values. We compare traditional and robust decisions under simulated scenarios of objective weights, and show that robust decisions produce a more stable weighted-sum of objectives than traditional decisions.

2 - How robust is the elicitation of criteria weights through Simos' procedure?
Nikos Tsotsolas, Department of Informatics, University of Piraeus, 2, Feidiou Str, 15236, Penteli, Greece, ntsotsol@unipi.gr, *Eleftherios Siskos*, *Nikos Christodoulakis*

In multicriteria outranking methods the Simos' procedure is considered as a good alternative tool to assess the importance of criteria. Nevertheless the method's input data required does not lead to a single weighting vector. This work evaluates the robustness of estimated weights in original and revised Simos' method focusing on assessing several robustness measures using LP techniques. It also outlines robust outranking rules within ELECTRE method by means of: (1) a Hamiltonian search algorithm and (2) a random sampling technique. The proposed approach is followed by a numerical example.

3 - On the robustness of representative value functions in multicriteria classification problems
Constantin Zopounidis, Dept. of Production Engineering and Management, Technical University of Crete, University Campus, 73100, Chania, Greece, kostas@dpem.tuc.gr, *Michael Doumpos*

Recent research on robust decision aiding has focused on identifying a range of recommendations from preferential information and the selection of representative models compatible with preferential constraints. This study presents an experimental analysis on the relationship between the results of a single decision model (additive value function) and the ones from the full set of compatible models in classification problems. Different optimization formulations for selecting a representative model are tested and the implementation of robust models in a business educational platform is outlined.

■ HA-39

Thursday, 8:30-10:00
G7-3

Multi-Objective Optimization

Stream: Multi-Objective Optimization
Invited session

Chair: *Matteo Salani*, DTI/SUPSI - USI, IDSIA, 6928, Manno-Lugano, Switzerland, matteo.salani@idsia.ch

1 - Multi-Objective Optimization in Optimal Marketing Strategy
Asaf Shupo, Business Development and Marketing, TD Bank Group, 100 Wellington Street West 6th floor, M5K 1A2, Toronto, Ontario, Canada, asaf.shupo@td.com

This current research presents an approach of using multi-objective optimization in defining optimal marketing strategy in banking system. It optimizes simultaneously different goals of a cash campaign, specifying Pareto-optimal non dominated solutions. In our previous work multiple conflicting objectives were considered individually providing solutions which can be improved. This approach provides a range of Pareto optimal solutions none of which dominate the others and a proper solution considering the trade-off among the different goals.

2 - An enumerative cutting plane approach to integer linear vector optimization problems
Walter Habenicht, Business Administration, University of Hohenheim, Lst. Beschaffung und Produktion (580 B), 70593, Stuttgart, Germany, walter.habenicht@uni-hohenheim.de

We present an interactive approach to integer linear vector optimization problems that combines some special kind of enumeration with cutting planes.

3 - A New Algorithm for Generating All Non-dominated Solutions for Multiobjective Discrete Optimization Problems
Gokhan Kirlik, Graduate School of Sciences and Engineering, Koç University, Rumelifeneri Yolu, 34450, Sariyer, Istanbul, Turkey, gkirlik@ku.edu.tr, *Serpil Sayin*

In this study, a new algorithm is proposed to generate all non-dominated solutions for multiobjective discrete optimization problems with any number of objective functions. In this algorithm, the search is managed over (p-1)-dimensional rectangles where p represents the number of objectives in the problem and for each rectangle two-stage optimization problems are solved. The algorithm is compared with former studies on multiobjective knapsack and multiobjective assignment problem instances. The method is highly competitive in terms of solution time and the number of optimization models solved.

4 - Distributed optimization for demand-side management
Matteo Salani, DTI/SUPSI - USI, IDSIA, 6928, Manno-Lugano, Switzerland, matteo.salani@idsia.ch, *Alessandro Giusti*, *Gianni Di Caro*, *Rizzoli Andrea*, *Luca Maria Gambardella*

We consider demand-side management in a microgrid by means of decentralized controllers. We address two possibly conflicting objectives: minimization of energy costs and stabilization of the aggregate load profile. In this work we compare different levels of communication pervasiveness, we present a multi-objective optimization model and a realistic microsimulation environment accounting for the effects on the distribution network. Extensive experiments show that restricted communication is sufficient to stabilize the aggregate network load profile, with minimal bandwidth consumption.

■ HA-40

Thursday, 8:30-10:00
Y12-1

DEA Applications V

Stream: DEA and Performance Measurement
Invited session

Chair: *Christos Papahristodoulou*, School of Business, Engineering and Society, Mälardalen University, Högskoleplan 2, 722 28, Västerås, Sweden, Christos.Papahristodoulou@mdh.se

1 - Estimating Technical and Allocative Efficiency of Australian Schools
John Ruggiero, University of Dayton, 509 Miriam Hall, 45469-2251, Dayton, Ohio, United States, jruggiero1@udayton.edu, *Vincent Blackburn*, *Shae Brennan*

Data Envelopment Analysis models typically look at the measurement of technical efficiency due to a lack of resource price information. This ignores a large source of inefficiency attributed to using the wrong input mix. In this paper, we apply a public sector DEA model to measure both technical and allocative efficiency of Australian schools. The model properly conditions on the environment.

2 - Performance Evaluation of Regional Railways: Case of I.R. Iran Railway
Hamid Reza Ahadi, School of Railway Engineering, Iran University Science & Technology, School of Railway Engineering, Iran University of Science and Technology, Tehran, Iran, 0098, Tehran, Tehran, Iran, Islamic Republic Of, ahadi@iust.ac.ir, *Zahra Saghian*

National Iranian Railway includes 15 regional railway which operates under the supervision of Iranian railway headquarter. In this paper, we have applied Data Envelopment Analysis (DEA) technique to measure the efficiency of these 15 regional railways (DMUs). To achieve this goal we have applied several models with different outputs. We have also ranked the efficient regional railways by applying heuristic ranking techniques. The results show that the "Hormozgan" railway region in Iran has the highest operational efficiency and can be set as a benchmark for other regional railways in Iran.

3 - Evaluating the performance of UEFA Champions League scorers
Christos Papahristodoulou, School of Business, Engineering and Society, Mälardalen University, Högskoleplan 2, 722 28, Västerås, Sweden, Christos.Papahristodoulou@mdh.se

The ranking of football players has always engaged media and supporters worldwide. The different views on ranking are due to two reasons. First, leagues are heterogeneous with various qualities. Second, fans often rely on different performance measures and statistics. Despite the fact that team and player bias will never disappear, this paper aims to objectively evaluate the efficiency of 42 top scorers who have played in the UEFA Champions League (UCL) over a period of six years, based on official match-play "multi-input and output" statistics, using input- and output oriented DEA models.

4 - Evaluation of undergraduate courses using a non-radial Data Envelopment Analysis model
Silvio Gomes Júnior, Coordenação de Engenharia de Produção, UEZO-Fundação Centro Universitário Estadual da Zona Oeste, Avenida Manuel Caldeira de Alvarenga, 1203, Campo Grande, 23070-200, Rio de Janeiro, Rio de Janeiro, Brazil, silviofgj@gmail.com, *João Carlos Soares de Mello*, *Lidia Angulo-Meza*, *Andre Gomes*, *Gilson Lima*

This work aims to evaluate quantitatively the undergraduate courses of a Private Higher Education Institution (IES), located in the Rio de Janeiro State using Data Envelopment Analysis (DEA) methodology with weight restrictions. We use a single benchmark for each DMU, the closest efficient DMU. A new efficiency index is calculated taking into account this single benchmark and the non-radial efficiency index based on vector properties. The weight restrictions are included via non-observed DMUs in order to allow the use of the hereabove mentioned non-radial index.

■ HA-41

Thursday, 8:30-10:00
Y12-5

Markov Decision Processes and Stochastic Games

Stream: Decision Making under Uncertainty and Environmental Applications
Invited session

Chair: *Eugene Feinberg*, Department of Applied Mathematics, Stony Brook University, and Statistics, 11794-3600, Stony Brook, NY, United States, eugene.feinberg@sunysb.edu

1 - Parameterized Penalties in the Dual Representation of Markov Decision Processes
Fan Ye, University of Illinois at Urbana-Champaign, 61801, Champaign, United States, fanye2@illinois.edu, *Enlu Zhou*

Duality in Markov decision processes (MDPs) has been studied recently by several researchers with the goal to derive dual bounds on the value function. We propose the idea of using parameterized penalty functions in the dual representation of MDPs, which allows us to integrate different types of penalty functions and guarantees a tighter dual bound with more penalties used. To complement and diversify the existing penalties developed in the literature, we also introduce a new class of penalties that can be used for a broad class of problems and are also easy to implement in practice.

2 - Stationary Markov Perfect Equilibria in Risk-Sensitive Stochastic Overlapping Generations Models
Anna Jaskiewicz, Wroclaw University of Technology, 50-370, Wroclaw, Poland, anna.jaskiewicz@pwr.wroc.pl, *Andrzej Nowak*

In this paper, we study intergenerational stochastic games that can be viewed as a special class of overlapping generations models under uncertainty. Making use of the Dvoretzky-Wald-Wolfowitz theorem from the statistical decision theory, we obtain new results on stationary Markov perfect equilibria for the aforementioned games, with a general state space, satisfying rather mild continuity and compactness conditions. A novel feature of our approach is the fact that we consider risk-sensitive generations.

3 - Robust Markov perfect equilibria in a dynamic choice model with quasi-hyperbolic discounting
Andrzej Nowak, University of Zielona Gora,, 65-246, Zielona Gora, Poland, a.nowak@wmie.uz.zgora.pl, *Anna Jaskiewicz*

A stochastic dynamic choice model with the transition probability depending on an unknown parameter is specified and analysed. The main feature in our model is an application of the quasi-hyperbolic discounting concept to describe the situation in which agent's preferences may hinge on time. This requirement, in turn, leads to a non-cooperative infinite horizon stochastic game played by a countably many selves representing him during the play. As a result, we provide two existence theorems for a robust Markov perfect equilibrium and discuss its properties.

4 - Optimality Conditions for Total-Cost Partially Observable Markov Decision Processes
Eugene Feinberg, Department of Applied Mathematics, Stony Brook University, and Statistics, 11794-3600, Stony Brook, NY, United States, eugene.feinberg@sunysb.edu, *Pavlo Kasyanov*, *Michael Zgurovsky*

This talk describes sufficient conditions for the existence of optimal policies for total-cost Partially Observable Markov Decision Processes (POMDPs). It is well-known that a POMDP can be reduced to a Completely Observable Markov Decision Process (COMDP) with the state space being the sets of believe probabilities for the POMDP. Thus, a policy is optimal in POMDP if and only if it corresponds to an optimal policy in the COMDP. Here we provide sufficient conditions for the existence of optimal policies for COMDP and therefore for POMDP.

■ HA-42

Thursday, 8:30-10:00
Y12-3

Simulation Based Decision Support

Stream: Simulation Based Decision Support
Invited session

Chair: *Mirjana Kljajic Borstnar*, Laboratory for Decision Processes and Knowledge-based systems, University of Maribor, Faculty of Organizational Sciences, Kidriceva 55a, 1000, Ljubljana, Slovenia, Slovenia, mirjana.kljajic@fov.uni-mb.si

1 - Nursing Recommendation Support System
Peter Benedik, SRC Infonet d.o.o., Cesta talcev 39, 4000, Kranj, Slovenia, Peter.Benedik@gmail.com, *Uros Rajkovic*, *Olga Sustersic*, *Vladislav Rajkovic*

This paper describes a recommendation system designed, to help focus a nurse's attention on those resources/solutions that are likely to be most relevant to their particular situation/problem in nursing domain. System is based on multi-relational property graph representing a flexible modelling construct. Graph allows modelling a nursing domain (ontology) and the indices that partition domain into an efficient, searchable space where the solution to a problem is seen as abstractly defined traversals through its vertices and edges.

2 - The school informatisation assessment model based on the hierarchical multiple attribute decision-making approach
Borut Čampelj, Ministry of Education, Science, Culture and Sport, Slovenia, borut.campelj@gmail.com, *Vladislav Rajkovic*, *Eva Jereb*, *Nives Kreuh*

Based on the theoretical and practical background, we developed and piloted multi-attribute hierarchical model of school informatisation. The model is divided into three subcategories: the school and environment, teachers and online communities, and students and environment. Piloted schools evaluated this model as an excellent tool for further planning and monitoring their informatisation. The development project linked theory and practice of self-evaluation process, the impact on future planning and implementation with the theory of decision-making skills.

3 - Simulation of Interregional Risk Management
Viveca Asproth, Dept of Information Technology and media, Mid Sweden University, Akademigatan 1, 83125, Östersund, Sweden, viveca.asproth@miun.se

Timely and adequate training, learning, and preparation tools are of great importance in any security management system. The idea of modeling and simulation with subsequent learning from the outcomes is here applied on inter regional security work. In this setting, multi-actors have to both cooperate and make coordinated decisions with just partial information about each other. The remedy proposed here builds on experimental prototyping opening up for stepwise and interactive group learning.

4 - Development of methodology for automatically positioning electronic publications into "universal decimal classification" system
Matjaz Kragelj, Department of library informatics, National and University Library, Turjaska 1, 1000, Ljubljana, Slovenia, matjaz.kragelj@nuk.uni.lj.si, *Mirjana Kljajic Borstnar*

The problem of publications classification to a Universal Decimal Classification (UDC) is described in the paper. Scientific publications recorded in the Slovenian library catalogue OPAC are defined by one or more classifiers in the UDC system. Most publications accessible through Digital Library of Slovenia, particularly older publications in the field of culture, lack such a record, and if recorded they are usually classified within the higher aggregation level (Slovene literature). We present a model for automated classification of publication into the UDC using machine learning methods.

■ HA-43

Thursday, 8:30-10:00
Y12-2

Decision-Making using Social Networks and Web Resources

Stream: Decision Support Systems
Invited session

Chair: *Shaofeng Liu*, School of Management, University of Plymouth, PL4 8AA, Plymouth, United Kingdom, shaofeng.liu@plymouth.ac.uk
Chair: *Jorge E. Hernández*, School of Management, University of Liverpool, Liverpool, United Kingdom, J.E.Hernandez@Liverpool.ac.uk

1 - Using Social Network Analysis to Measure Influence and Rank of Efficient Ports
Byunghak Leem, Business Administration, Pusan University of Foreign Studies, 55-1 Uam-dong, Nam-gu, Busan, Korea, 608-738, Busan, Korea, Republic Of, bhleem@pufs.ac.kr

Data envelopment analysis is known as a useful tool which produces many efficient decision-making units. Traditional DEA provides relative efficient scores and reference sets, but does not influence and rank for efficient DMUs. This paper suggests a method that provides influence and ranking information using PageRank centrality of Social Network analysis based on reference sets and their lambda value. The social network structure expresses the DMU as a node, reference sets as link, and lambda as connection strength or weight.

2 - Pricing and Order Decisions with Customer Returns in Online Retailing
Zhong Yao, School of Economics and Management, Beihang University, 83# Xueyuan Road, Haidian District, 100083, Beijing, China, iszhyao@buaa.edu.cn

Customers return products is very common in online retailing and it significantly impacts on the seller's operations decisions. In this paper, we investigate an online retailer who simultaneously determines the retail price and order quantity while experiencing customer returns. The retailer's price depends on a stochastic demand with a multiplicative mode. We analytically derive results for optimal prices and order quantities under certainty demand in both single and multi-period situations and demonstrate the unique solution existence in single period stochastic situation.

3 - A decision support system for timetabling in education: a web based exam scheduling application
Burcu Yilmaz Kaya, Department of Industrial Engineering, Gazi University Engineering Faculty, Gazi University Faculty of Engineering Industrial Engineering Department, Eti Quarter Yukselis St. Maltepe, 06570 , Ankara, Turkey, burcuyilmaz@gazi.edu.tr, *Gökhan Kaya*, *Metin Dagdeviren*

In this study, we designed a DSS to constitute a final exams schedule in Gazi University,Turkey, with C# .net 4.5 Framework, in two platforms; web and Windows form.SQL Server Express 2008 is used as database

in our application.With the algorithm that proposed DSS uses, conflicting requests of the lecturers are regulated, and a final exams schedule considering both the benefit of the students and the demands of the lecturers,is constituted, according to the criteria and weights, hard constraints and soft constraints, determined by DMT.We conclude the study by a presentation of our proposed DSS.

■ HA-44

Thursday, 8:30-10:00
Y12-4

Mathematical Methods for Decision Support in Energy and Industrial Sectors

Stream: Mathematical Methods for Decision Support
Invited session

Chair: *Elisabetta Allevi*, Department of Economics and Management, University of Brescia, Contrada Santa Chiara, 50, 25122, Brescia, Italy, allevi@eco.unibs.it
Chair: *Adriana Gnudi*, Mathematics, Statistics, Computer science and Applications, University of Bergamo, Via dei Caniana, 2, 24127, Bergamo, Italy, adriana.gnudi@unibg.it

1 - Evaluating the effects of different wind policies on the European electricity market
Giorgia Oggioni, Department of Economics and Management, University of Brescia, Italy, Contrada Santa Chiara, 50, 25122, Brescia, Italy, Italy, oggioni@eco.unibs.it, *Frederic Murphy*, *Yves Smeers*

This paper investigates the impact of a Nodal Pricing system and the European Market Coupling organization under two main wind policies ("no wind spill" and "with wind spill") on different economic agents of the power system. The effects of these two wind policies are measured by considering cases with different wind penetration levels, given capacities and endogenous investments, as well as with and without EU-ETS. Our simulations show that Nodal Pricing is more efficient than Market Coupling independently of the contextual assumptions that characterize the several cases analysed.

2 - Strategic gaming analysis for cement industry: a bilevel approach
Rossana Riccardi, Economics and Management, University of Brescia, Contrada Santa Chiara, 50, 25122, Brescia, Italy, riccardi@eco.unibs.it, *Elisabetta Allevi*, *Antonio J. Conejo*, *Giorgia Oggioni*

This paper investigates the equilibria reached by strategic producers in the cement sector through a technological representation of the market. We present a bilevel model with equilibrium constraints (MPEC) where each producer maximizes its profits and complementarity constraints describe market clearing. The upper-level problem is constrained by a collection of lower-level market clearing problems representing clinker and cement trading, and whose individual objective functions correspond to social welfare.

3 - A spatial equilibrium problem: impact of the environmental regulations on the steel industry
Francesca Bonenti, Department of Economics and Management, University of Brescia, Contrada Santa Chiara 50, 25122, Brescia, Italy, Italy, francesca.bonenti@eco.unibs.it, *Rossana Riccardi*, *Claudia Avanzi*, *Elisabetta Allevi*, *Adriana Gnudi*

In this work, a spatial equilibrium problem is formulated for analyzing the impact of the application of the EU-ETS on the energy and industrial sectors, such as the steel industry that has historically seen Europe as one of its major producers. The developed model allows us to simultaneously represent the interactions of several market players and to endogenously determine output and CO2 allowance prices. In addition, the proposed models support the evaluation of the CO2 emission costs on the basis of Directive 2009/29/EC, the "20-20-20" targets, and the Energy Roadmap 2050.

4 - Relation between electric energy consumption and socioeconomic indexes using an approach of DEA: study of the Brazilian industrial parks.
Daniela Hereid, Optimization and Intelligence Management Laboratory, University of the State of Ceara, Brazil, danihereid@gmail.com

Electricity is essential for the development of a country and yours ecologically friendly consumption reflects the level of social consciousness and public policies adopted by the nation. This study proposes to identify an Energy Efficiency Index of Brazilian states considered industrial parks. DEA CCR oriented to inputs model was chosen in order to analyze the efficiency of those parks aiming to optimize the relation energy consumption and socioeconomic indexes. It is hoped the encouragement of the efficient consumption without compromising the quality of life and economic growth.

■ HA-45

Thursday, 8:30-10:00
Y10-3

On economic modeling and multicriteria games

Stream: Cooperative Game Theory
Invited session

Chair: *Ahmet Sahiner*, Mathematics, Suleyman Demirel University, Department of Mathematics, Suleyman Demirel University, East Campus, 32260, ISPARTA, Turkey, ahmetsahiner@sdu.edu.tr

1 - From Multicriteria game to Ordinal game.
Naouel Yousfi, Operational Research, Laboratory of Modelling and Optimization of Systems, Algeria, yousfi_na@hotmail.com, *Mohammed Said Radjef*

This paper deals with the non cooperative multicriteria two person games. Using the outranking methods, we transform the finite multicriteria game to an ordinal game. We propose to find a Non-cooperative equilibrium and we develop an algorithm to find these equilibria if they exist. Finally, we illustrate the results on a numerical example.

2 - The effect of spillovers on the stability of joint research lab: Approach by game theory
Razika Sait, Laboratory of Modeling and Optimization of Systems (LAMOS), University of Bejaia, Algeria, Béjaia, Algeria, razika.sait@gmail.com, *Abdelhakim Hammoudi*, *Mohammed Said Radjef*, *Mira Birem*, *Soraya Ait Aissa*

In this paper, we study the impact that has Research and Development (R&D) spillover on the stability of coalition that arise endogenously between N firms. For this, we consider a three stage game model. At the first, the N firms decide simultaneously whether or not to conduct R&D in a joint research lab in order to reduce the costs of compliance with sanitary standards. At the second one, this coalition and the no-member firms engage in a noncooperative game where they decide their levels of R&D investment. At the third stage, the N firms remain noncooperative rivals in the product market.

3 - A general axiomatics for power indicies without anonimity axiom
Mikhail Batsyn, Laboratory of Algorithms and Technologies for Networks Analysis, National Research University Higher School of Economics, 136 Rodionova Street, 603093, Nizhny Novgorod, Russian Federation, mbatsyn@hse.ru, *Valery Kalyagin*

We propose a new axiomatics for power indices in the simple game model. It is based on two axioms: additivity axiom and dictator axiom and does not need anonymity axiom. An important property is established: a power index of a player can be represented as a sum of contributions of the coalitions in which he is a pivotal member. These coalition contributions do not depend on the payoff function. We illustrate our axiomatics on power indices taking into account player preferences. We also show that our axiomatics together with anonymity axiom is equivalent to semivalue axiomatics.

■ HA-46

Thursday, 8:30-10:00
Y10-1

Game Theory and Social Networks I

Stream: Game Theory and Social Networks
Invited session

Chair: *Juan Tejada*, Estadística e Investigación Operativa I, Complutense Unversity of Madrid, Universidad Complutense de Madrid, Plaza de Ciencias, 3, 28040, Madrid, Spain, jtejada@mat.ucm.es

1 - Computational complexity of the average covering tree value

Ayumi Igarashi, University of Tsukuba, Japan, igarashi80@sk.tsukuba.ac.jp

Khmelnitskaya et al. have recently proposed the average covering tree value as a new solution concept for cooperative transferable utility games with directed graph structure. In this talk we will discuss the computational complexity of the average covering tree value. We will show that exact computation of the average covering tree value is #P-complete even if the characteristic function is 0,1-valued. We prove this by a reduction from counting the number of all linear extensions of an arbitrary partial order, which has been shown by Brightwell et al. to be a #P-complete counting problem.

2 - Generating random networks by linear programming approaches

Stefano Nasini, Dept. of Statistics and Operations Research, Universitat Politecnica de Catalunya, 08034, Barcelona, Spain, stefano.nasini@upc.edu, *Jordi Castro*

Social networks is a recent area of research motivated by the empirical study of real-world networks, such as social relations, neuronal connections, etc.. As closed-form probabilistic models are often not available, the ability of randomly generating networks verifying particular constraints might be useful. The purpose is to develop optimization-based procedures to randomly generate networks with structural constraints. Polynomial-time methods are built. Computational results show that these methods are a general framework for the efficient simulation of random networks.

3 - Clustering networks by a new edge betweenness measure from a cooperative game theoretical approach. A new definition of modularity.

Daniel Gomez Gonzalez, Estadistica e Investigacion Operativa III, Complutense University, Av Puerta de Hierrro, 28040, Madrid, Spain, dagomez@estad.ucm.es, *Javier Castro*

In this work, it is defined a new shortest path betweenness measure in which for its calculation, the communication between each pair of nodes is weighed by the importance of the nodes that make this communication. The weights or importance associated to each pair of nodes is calculated as the Shapley of a new game. Also we give some definitions about the concept of groups in community detection.

4 - Intolerance and asymmetry in a Moran process in structured and unstructured populations.

Juan Tejada, Estadística e Investigación Operativa I, Complutense Unversity of Madrid, Universidad Complutense de Madrid, Plaza de Ciencias, 3, 28040, Madrid, Spain, jtejada@mat.ucm.es, *Ana Batanero*, *Daniel Vélez*

We study a modification of the Moran process taking into account the possibility of a certain degree of intolerance or aggressiveness of the mutant and resident strategies in the selection and reproduction steps. In particular, we compute the probability and expected time to fixation in unstructured and network structured populations. We consider the cases of symmetric and asymmetric behavior of both populations. A process of weak selection is also tackled.

■ HA-47

Thursday, 8:30-10:00
Y10-2

Revenue Management in Manufacturing and Retail

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Hendrik Guhlich*, Area Operations Management, University of Mannheim, Germany, guhlich@bwl.uni-mannheim.de

1 - Yield Management in the production and Distribution of Seasonal Appliances

Yassin Rady, Mechanical Engineering, American University in Cairo, 5, Abdel Monem Rady St., 1157 Sheraton, Cairo, Cairo, Egypt, yrady@aucegypt.edu, *Abdelghani Elimam*, *Loutfi Louis*

In this paper we deal with fluctuations in capacity utilization in multi stages manufacturing plants. A mixed integer model was developed to determine products quantities sold at various rate classes, and the incentive levels offered to customers at each rate class. The model is generic and aims at maximizing the net earnings. This developed model was applied to refrigerators assembly plant. Results showed that the model was useful in maximizing net earnings through achieving improved capacity utilization and motivating higher demand during low demand months.

2 - The effect of Data Modelling Choices on a Retail Price Optimization System — A Simulation Study

Timo P. Kunz, Management Science, Lancaster University Management School, Office C94, LA1 4YX, Lancaster, United Kingdom, t.p.kunz@lancaster.ac.uk, *Sven F. Crone*, *Joern Meissner*

We study the impact of data pruning and data aggregation on a retail price optimization system. We use simulated transactional retail data, generated following empirically valid parameter bounds, to calibrate a two-stage demand model, combining a linear formulation for category sales with a fractional logit market share model. We numerically assess the demand model estimation bias introduced under different experimental conditions and the consequences for the optimization problem, the optimal price set, and the optimal profit.

3 - Demand Distribution of the News Vendor Problem for Retailing with Applications to Duopoly

Hiroaki Sandoh, Graduate School of Economics, Osaka University, 3-1, Machikaneyama-cho, 560-0043, Toyonaka, Osaka, Japan, sandoh@econ.osaka-u.ac.jp, *Takeshi Koide*, *Jun Kiniwa*

We propose a mathematical model which provides a demand distribution at a retailer's store up to time t. We consider a monopoly assuming that each individual customer resides uniformly over the Hotelling unit interval and a single retailer's store is located at 0. It is also assumed that each customer departs from her residence following an identical departure time distribution to purchase a single product. The resulting demand distribution up to time t is given by the Normal distribution. We also apply the proposed model to the duopoly.

4 - Revenue management for assemble-to-order manufacturing

Hendrik Guhlich, Area Operations Management, University of Mannheim, Germany, guhlich@bwl.uni-mannheim.de, *Raik Stolletz*, *Moritz Fleischmann*

In this talk, we consider the order acceptance and due date promising decisions in an assemble-to-order production system. We take a revenue management approach. Both the availability of intermediate material and the assembly capacity are limited. In addition, the actual assembly date of an order is still subject to change after the acceptance decision. So, this decision has to be taken without complete knowledge of the actual used resources. We develop a novel bid-price approach that addresses these factors and present a numerical study to demonstrate the performance of our method.

■ HA-48

Thursday, 8:30-10:00
Y11-1

Simulation in Management Accounting and Management Control 1

Stream: Simulation in Management Accounting and Management Control
Invited session

Chair: *Friederike Wall*, Dept. for Controlling and Strategic Management, Alpen-Adria-Universitaet Klagenfurt, Universitätsstraße 65-67, 9020, Klagenfurt, Austria, friederike.wall@uni-klu.ac.at

1 - A Simulation Based Methodology for Measuring Production Planning Performance

Erkan Can Gursoy, Industrial Engineering, Yildiz Technical University, Barbaros Street, 34349, istanbul, besiktas, Turkey, ecgursoy@yildiz.edu.tr, *Ceyda Güngör Şen*, *Fatma Paşa*

The aim of this study is to present a simulation-based methodology for measuring performance of the production planning process that becomes more complex in today's highly competitive environment. Through a detailed literature review and interviews with experts, key performance indicators (KPIs) for production planning are determined, and a hierarchical structure of these KPIs is formed. Thereafter, a simulation-based methodology that incorporates both the importance and target values of these KPIs is presented.

2 - The Role of Actual Values in Management Accounting Systems

Friederike Wall, Dept. for Controlling and Strategic Management, Alpen-Adria-Universitaet Klagenfurt, Universitätsstraße 65-67, 9020, Klagenfurt, Austria, friederike.wall@uni-klu.ac.at

The paper analyzes the effectiveness of reducing errors in management accounting systems by using measured values. Different basic design options of management accounting systems in various organizational contexts are analyzed applying an agent-based simulation. Results broadly, but not universally support intuition that more accurate accounting information lead to more effective adaptation processes. Moreover, results indicate that the effectiveness of improved management accounting system subtly interferes with the complexity of interactions and the coordination mode in the organization.

3 - Simulation of Bribes and the Consequences of Leniency Policy. Results from an Experimental Study.

Ulrike Leopold-Wildburger, Statistics and Operations Research, Karl-Franzens-University, Universitätsstraße 15/E3, 8010, Graz, Austria, ulrike.leopold@uni-graz.at

Within the context of the present work an experimental study is conducted which executes negotiations between the agent and bidders. In these contract awards the opportunity for bribes is simulated. The following issues are analyzed: The willingness to be dishonest respectively to accept bribes, the effect of different detection probabilities and the possibility of leniency policy. The new idea is the simulation of bribes and as a further step the consequences of leniency policy. We run an experiment, introduce honesty factors, classify participants and report some interesting results.

4 - Modifying selfish decision rules to improve for social performance criteria

Dinard van der Laan, Econometrics & OR, Vrije University Amsterdam, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, d.a.vander.laan@vu.nl

For many problems in which limited resources are used it is well known that selfish (user optimal) decision rules are suboptimal with respect to optimizing some social performance criterion. On the other hand it is usually relatively easy to obtain and apply user optimal decision rules. Methods are considered to obtain decision rules which are also easy to obtain and implement, but which can perform considerably better than selfish rules. The main idea for improvement is to modify a selfish decision rule by combining it with non-selfish heuristic(s).

■ HA-49

Thursday, 8:30-10:00
Y11-2

Multicriteria performance of funds and banks

Stream: Operational Research and Quantitative Models in Banking
Invited session

Chair: *Mila Bravo*, UNIVERSITAT POLITÈCNICA DE VALÈNCIA, 03801, ALCOY, Spain, mibrasel@epsa.upv.es
Chair: *Enrique Ballestero*, Escuela Politecnica Superior de Alcoy, Technical University of Valencia, 03801, Alcoy (Alicante), Spain, eballe@esp.upv.es

1 - Measuring performance of mutual funds offered by banks: An actual case by multiple criteria decision making analysis.

Sonia Zendehzaban, Universidad Carlos III, Spain, pasonda@hotmail.com, *David Pla-Santamaria*

A compromise (CP) measure of fund performance is proposed to advise bank's customers on advantageous investments from their preferences. Customers' profiles are defined by preference weights. Advantages are: (a) the CP measure can be extended to a wide set of investment criteria, while most traditional measures are limited to profitability and risk; (b) using CP avoids troubles such as negativity in the ratio values. A case study with actual information provided by a Spanish bank is numerically developed.

2 - Multicriteria performance of banks from European stress tests: The Spanish case in 2012

Mila Bravo, UNIVERSITAT POLITÈCNICA DE VALÈNCIA, 03801, ALCOY, Spain, mibrasel@epsa.upv.es, *Antonio Benito*

Using update information, 17 Spanish banks are ranked from 23 financial criteria. Basic data on stress tests and expectations over 2012-2014 are published by The Bank of Spain, these being elaborated by an international financial consultant. The ranking relies on Moderately Pessimism Decision Making with veto. An advantage is objectivity of the ranking, which does not depend on particular judges, values and preferences of the analyst. Potential users are bank managers and government executives. The step by step process and results are numerically developed and tabulated.

3 - Multicriteria quality performance of oil paintings in bank collections.

Enrique Ballestero, Escuela Politecnica Superior de Alcoy, Technical University of Valencia, 03801, Alcoy (Alicante), Spain, eballe@esp.upv.es, *Paloma Pareja*

Oil painting reproductions are ranked by Moderately Pessimism Decision Making from their artistic characteristics. Quality criteria are drawing, color, theme originality, and eventually, others. A methodological advantage is objectivity of the ranking, which does not depend on particular judges and values of the analyst. Potential users are bank executives managing bank art collections. An actual case is numerically developed and illustrated by comparing photographs picturing original paintings and reproductions.

4 - Socially responsible mutual funds offered by banks: A multicriteria measure of intensity.

Ana Garcia-bernabeu, Economia y Ciencias Sociales, Universitat Politècnica de València, Plaza Ferrandiz y Carbonell, s/n, 03801, ALCOY, Spain, angarber@esp.upv.es, *Blanca Pérez-Gladish*, *Paz Mendez-rodriguez*, *Alexei Gaivoronski*

This paper deals with socially responsible investment (SRI) concerning mutual funds managed by banks, which are engaged with environmental and social policies. A multicriteria measure of SRI levels in funds is proposed, which relies on screening intensity. This allows bank's clients to select investments from their preferences for criteria such as environment issues, labor policies, and others. An empirical study is performed on 110 United States large cap equity mutual funds for various investors' profiles.

■ HA-50

Thursday, 8:30-10:00
Y11-3

Water resource management

Stream: Optimization under Uncertainty
Invited session

Chair: *Enza Messina*, DISCo - Department of Informatics, Systems and Communication, Università degli Studi di Milano Bicocca, viale Sarca 336, 20126, Milano, Italy, messina@disco.unimib.it

1 - An uncertainty perspective in hydrodynamic modelling of deltaic fluvial floods
Ioana Popescu, UNESCO-IHE Institute for Water Education, 2601, Delft, Netherlands, i.popescu@unesco-ihe.org, *Dimitri Solomatine*, *Pham Dang Tri Van*

Annual fluvial floods have caused significant impacts on livelihood of local residents living in the low-lying Vietnamese Mekong Delta (VMD). In order to eliminate the adverse impacts of future fluvial floods, it is important to project their behaviours and trends of changes, as well as to identify the inherent uncertainties of flooding simulations. This paper aimes to project the future floods in the VMD (in 2050) and to specify the inherent uncertainties of the applied hydrodynamic model (ISIS-1D v.3.3) according to projected boundary conditions.

2 - Data Analytics for Leakage Management in Water Distribution Networks
Antonio Candelieri, University of Milano Bicocca, 20126, Milan, Italy, antonio.candelieri@unimib.it, *Francesco Archetti*, *Enza Messina*

Worldwide growing water demand has been forcing utilities, in an era of tight budgets, to improve the way they manage their infrastructural assets. This paper presents how the critical leakage management process may be improved by applying Data Analytics strategies. The basis of the approach is that location and severity of a leak can be estimated through simulation and analysis of changes in flow and pressure. The interoperability with GIS and monitoring systems can support water authorities in order to to identify the most probably leaky pipes facilitating prompt and targeted interventions.

■ HA-51

Thursday, 8:30-10:00
Y11-4

Duality in Stochastic Control

Stream: Financial Optimization
Invited session

Chair: *Enlu Zhou*, University of Illinois at Urbana-Champaign, 61802, Urbana, IL, United States, enluzhou@illinois.edu

1 - An Iterative Dual Approach to Stochastic Control with Information Relaxation
Wei Yu, Systems Engineering and Engineering Management, the Chinese University of Hong Kong, Room814, ERB, CUHK, Shatin, N.T., Hong Kong, Hong Kong, wyu@se.cuhk.edu.hk, *Nan Chen*

We use the information relaxation technique to develop a value-and-policy iterative method to solve discrete time stochastic control problems. Both value and policy converges to the optimal ones within finite iterations.

2 - Subgradient Bounds for Convex Dynamic Programs
David Brown, Duke University, United States, dbbrown@duke.edu, *James Smith*

We study the use of information relaxations and penalty functions to compute bounds on the performance of an optimal policy for convex stochastic dynamic programs. We develop two types of penalty functions, both formed from subgradients of approximate value functions. We investigate properties of the resulting bounds and show that the approach can, in theory, lead to tight bounds. Finally, we demonstrate these methods on some challenging applications, including inventory control with lost sales and long lead times.

3 - Pathwise Optimization for Linear Convex Systems
Vivek Farias, MIT, 02142, Cambridge, United States, vivekf@mit.edu, *Vijay Desai*, *Ciamac Moallemi*

Building on so-called martingale duality approaches for stochastic control, we present a broad class of martingale penalties for linear systems with convex costs, and show that finding the 'optimal' penalty within this class is tractable.

4 - Information Relaxation and Duality in Controlled Markov Diffusions
Enlu Zhou, University of Illinois at Urbana-Champaign, 61802, Urbana, IL, United States, enluzhou@illinois.edu, *Fan Ye*

Information relaxation and duality in Markov decision processes (MDPs) has been studied recently by several researchers with the goal to derive dual bounds on the value function. We extend this dual formulation to controlled Markov diffusions, a continuous-time counterpart of MDP. We establish the weak duality, strong duality and complementary slackness results, and explore the structure of the optimal penalties. We demonstrate the use of the dual representation for controlled Markov diffusions in a classic dynamic portfolio choice problem.

■ HA-52

Thursday, 8:30-10:00
B13-1

Forecasting with Neural Networks & Computational Intelligence I

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Nikolaos Kourentzes*, Management Science, Lancaster University Management School, United Kingdom, n.kourentzes@lancaster.ac.uk

1 - Gb—SOM: a new tool for monitoring markets and visualizing financial information
Marina Resta, Department of Economics, University of Genova, via Vivaldi 5, 16126, Genova, Italy, resta@economia.unige.it

This work introduces Gb—SOM, a tool that combines Self Organizing Maps (SOM) and graphs. We employed it to explore markets at various (in)stability levels, training SOM with quoted stocks log—returns. We then defined graphs from SOMs leader units, originating various graph topologies. We first observed the markets in the period: December 2011—December 2012. We then moved to compare yearly Gb—SOMs over a ten years long period. In both cases we concluded that Gb—SOM makes possible to emphasize relations among enterprises, and to check for the emergence of critical patterns.

2 - Nonlinear combination of volatility forecasts based on ANFIS
Johanna Marcela Orozco Castañeda, Departamento de Ciencias de la Computación y de la Decisión, Universidad Nacional de Colombia, Cra 80 65-223, Bloque M8A, Of. 409, Medellín, Antioquia, Colombia, jmorozcoc@unal.edu.co, *Juan David Velásquez Henao*

Forecast combination models have been used to improve forecast accuracy. The key idea behind this approach is the diversification of the forecast models. In financial time series, volatility forecast is a difficult task due to it is an unobserved variable and must be estimated. In this work a new nonlinear ensemble model to forecast the volatility of

returns is proposed, conformed by a set of GARCH models fitted to a time series using different loss functions and an ANFIS as a combiner. The results show that, the ensemble predict with major accuracy the volatility than the individual models.

3 - Forecasting US Business Cycles Using Optimized Neuro-Fuzzy with Genetic Algorithm (Ga-Anfis) and Smooth Transition Regression (STR)
Ali Habibnia, Department of Statistics, London School of Economics (LSE), Columbia House, Houghton Street, WC2A 2AE, London, London, United Kingdom, a.habibnia@lse.ac.uk

This study present a precise hybrid model to forecast business cycles. In the first step, predictability and nonlinearity and chaoticity of time series data, have been examined by Largest Lyapunov Exponent and BDS test. Then business cycles has been modeled in two methods to compare, the first one is an optimised Adaptive Neuro-Fuzzy Inference System by Genetics Algorithm GA-ANFIS. Financial and economic indicators and their lags have been used as the inputs and GA employed to systematise input selection process. The second model which is recognised appropriate is smooth transition regression.

4 - Neural Network input variable selection for large high frequency time series datasets
Nikolaos Kourentzes, Management Science, Lancaster University Management School, United Kingdom, n.kourentzes@lancaster.ac.uk

Large time series datasets, often high frequency, are becoming more common, posing new challenges and opportunities for predictive modelling. Computationally intensive methods, like Neural Networks (NNs), can take advantage of the abundant sample. However, such data introduce a series of problems on model specification, in particular for the selecting the input variables. Methodologies in the literature either do not scale up to large datasets, or do not reveal existing nonlinearities, hindering the use of NNs. We propose a methodology to identify NN inputs for large high frequency datasets.

■ HA-53

Thursday, 8:30-10:00
B13-2

OR and Climate Change

Stream: OR and Climate Change
Invited session

Chair: *Marian Leimbach*, P.O. Box 60 12 03, 14412, Potsdam, Germany, leimbach@pik-potsdam.de

1 - First-mover advantage of defecting coalitions in international climate negotiations
Jan Kersting, Fraunhofer Institute for Systems and Innovation Research ISI, Breslauer Str. 48, 76139, Karlsruhe, Germany, jan.kersting@isi.fraunhofer.de

We apply cooperative game theory to the international climate negotiations. Chander and Tulkens (1997) showed that by using the "gamma-core' concept, stable allocations can be obtained for a large class of abatement cost and damage functions. We show that this optimistic result is not true if a defecting coalition can commit to an emission level that is calculated by taking the best-response functions of all other players into account. Certain parameter restrictions are checked by applying the game-theoretic setup to abatement cost data from a computable general equilibrium model.

2 - OR involvement in Decision Making conditioned to Climate Change: an overview
Costas Pappis, University of Piraeus, 80 Karaoli & Dimitriou str., 18534, Piraeus, Attica, Greece, pappis@unipi.gr, *Thomas Dasaklis*

Climate Change implications for society, economy and the environment contribute significantly and increasingly to the uncertainty and complications characterizing decision making in modern world. Operational Research may provide tools for effectively treating relevant problems that arise. Subject of this presentation is an overview and classification of the existing literature regarding OR involvement in shaping decisions in complex systems prone to climate change. Trends and challenges for future research are also presented.

3 - Solution algorithms of large-scale Integrated Assessment models on climate change
Marian Leimbach, P.O. Box 60 12 03, 14412, Potsdam, Germany, leimbach@pik-potsdam.de

A large part of Integrated Assessment models are formulated as optimization models that embed energy system modules, climate modules and land use modules around a welfare maximizing economic model. Complexity and non-linearity provide a big challenge for the solution algorithm of such models. In this paper we present and compare a Negishi algorithm that provides a globally optimal solution and a Nash algorithm that provides a market solution for a multi-region IA model. A correction term that implies reaction on expected price changes helps the Nash algorithm to converge.

■ HA-54

Thursday, 8:30-10:00
B14-1

Solutions for energy transition

Stream: Long Term Planning in Energy, Environment and Climate
Invited session

Chair: *Sandrine Selosse*, Centre for Applied Mathematics, MINES ParisTech, Rue Claude Daunesse, 06904, Sophia Antipolis, France, sandrine.selosse@mines-paristech.fr

1 - Distributional impacts of energy efficiency policies on households
Jean-Michel Cayla, EDF/Mines ParisTech, Paris, France, jeanmichel.cayla@gmail.com

Studies on impacts of policy tools rarely consider distributional impacts on final consumers. Our analysis relies on the TIMES-Households model which is a bottom-up optimization model from the MARKAL/TIMES family of energy models that allows for a very significant disaggregation of demand and technological processes. We are also able to take differences in energy consumption behavior into account. We then show the impact on household budget of an ambitious policy of 38% reduction target of primary energy consumption in residential building stock by 2020 adopted by the French government.

2 - Bio-based chemicals and bioenergy production: long-term prospective analysis using a TIMES approach
Paul Hugues, Centre for Applied Mathematics, MINES ParisTech, Rue Claude Daunesse, BP 207, 06904, Sophia Antipolis, France, paul.hugues@mines-paristech.fr, *Edi Assoumou*, *Nadia Maïzi*

Bio-based chemistry and bioenergy are both synergetic — considering integrated biorefinery facilities — and competing for the same biomass feedstock. To consider the closely linked future development of these two sectors in the French context, we use a TIMES approach. It consists in describing techno-economically the full production chain and minimizing the total discounted cost. The aim of this paper is to analyze their relative development under different policy incentives and biomass supply scenario.

3 - Multicriteria analysis for choosing an electricity technology mix in mexico's long term planning considering sustainable development.
Carlos Enrique Escobar-Toledo, Chemical Engineering. Faculty of Chemistry., National University of Mexico (UNAM), Building D - 310, Circuito Institutos, Ciudad Universitaria, 04510, Mexico City, DF, Mexico, carloset@servidor.unam.mx, *Lol-chen Alegria*, *Bertrand Mareschal*

This paper concerns a planning approach about economic and environmental evaluation scenarios to 2040 based on the potential for diminishing GHG in the Mexican energy system. It summarizes a case study including alternate sources of primary energy for power generation in a future horizon period based on sustainable development. Results consider electricity production for each new technology set using multicriteria analysis and integer programming of multiple scenarios to choose the technology mix to satisfy future demand. Results are also analyzed considering sensitivity analysis.

4 - InfiniDrive : Implementing an optimal charge for the integration of a captive electric fleet

Raphaël Poulain, CMA MinesParisTech, 06560, Sophia Antipolis, France, raphael.poulain@mines-paristech.fr, *Jean-Paul Marmorat*, *Marc Bordier*

In order to lower carbon emission of its fleet, the french mailing distributor company "La Poste' is about to acquire 10 000 thousands EV for internal use. One of the main challenges is to integrate this fleet on the grid under constraint as the respect of the grid performance and the optimization of the operational cost. Thus "La Poste' created InfiniDrive, a consortium including several entities as G2Mobility (EV charge terminal) and universities CMA-Mines de Paris, LORIA-Mines de Nancy. The presentation will introduce both the main stake and the mains results of the project.

■ HA-55

Thursday, 8:30-10:00
B14-2

Process Development and Decision Making

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Alexander Belenky*, Mathematics for Economics, National Research University Higher School of Economics and MIT, 20 Myasnitskaya Street, 101000, Moscow, Russian Federation, abelenky@mit.edu
Chair: *Anastasia Motrenko*, Applied mathematics and management, MIPT, Moscow, Russian Federation, pastt.petrovna@gmail.com

1 - Validity verification of an e-customer purchasing behavior pattern model

Yun Long Gao, Web Applied Technology, The Kyoto College of Graduate Studies for Informatics, 7 Monzen-cho Tanaka Sakyo-ku Kyoto, 6068226, Kyoto, Kyoto, Japan, xiaoya0102@hotmail.com, *Hong Seung Ko*, *Jia Lu*, *Shu Yan Miao*, *Liang Tang*, *Wu Fan*

Ko.et.al proposed the e-customer purchasing behavior pattern model for retaining most valuable customers in online, and verified the validity of pattern model by correlation analysis and the causality analysis. However, we consider that the cohort analysis is a proper tool for verifying the effectiveness of specific group pattern model than the correlation analysis and the causality analysis. Therefore, we analyze quantitatively and verify the e-customer purchasing behavior pattern model qualitatively by the cohort analysis.

2 - Innovation orientation and firm performance

Majda Bastic, Faculty of Economics and Business, University of Maribor, Razlagova 14, 2000, Maribor, Slovenia, majda.bastic@uni-mb.si

This paper develops the concept of innovation orientation and empirically examines the relationship between innovation orientation and firm performance. It is assumed in a theoretical model that organizational strategy and open-to-new-ideas culture support development of specific innovation processes and competencies in the areas of resource allocation, technology, employees, and markets. These competencies lead to innovation outcomes that, in turn, affect firm performance. The theoretical model is tested on the sample of 220 Slovene firms using structural equation modelling.

3 - A case study for multicriteria analysis of capesize bulk carrier

Cansu Aksu, Industrial Engineering, Balikesir University, Eng. & Arch. Faculty, Cagis Campus, 10145, Balikesir, Turkey, cansuaksu@gmail.com, *Ramazan Yaman*, *Kivanc Ali Anil*, *Roman Statnikov*, *Gulsen Yaman*

Engineering optimization problems have multicriteria. Right parameters is essential to solve them. Generating the design parameters of vessels is appropriate to this kind of problem structure and desing is the main concern of this study. It includes the process of establishing the basic design parameters of capesize bulk carrier exemplified on a model. Parameter Space Investigation(PSI) Method which states and solves multicriteria engineering problem correctly is used in this study. The PSI method is implemented in MOVI (Multicriteria Optimization and Vector Identification) software.

4 - The Production Function of the Transitive Economy - Case of Slovakia

Karol Szomolányi, University of Economics in Bratislava, Dolnozemská cesta 1, 852 35, Bratislava, Slovakia, szomolan@euba.sk, *Martin Lukáčik*, *Adriana Lukáčiková*

We estimate the production function parameters. The first order condition of the firm optimal behaviour states the equality between wage rate and marginal product of the labour. The CES production function generates the logarithmic relation between average and marginal products of the labour. The Cobb-Douglas production function generates the linear relation between average and marginal products of the labour. We estimate the specifications generated by these models. Using described approach we find that production function in Slovakia is Cobb-Douglas and the average labour share is 0.333.

■ HA-56

Thursday, 8:30-10:00
B15-3

Network design, location, and transportation

Stream: OR Applications in Industry
Invited session

Chair: *Geir Hasle*, Applied Mathematics, SINTEF ICT, P.O. Box 124 Blindern, NO-0314, Oslo, Norway, geir.hasle@sintef.no

1 - Strategic analysis of the dairy transportation problem

Nadia Lahrichi, Mathematics and industrial engineering, CIRRELT, École Polytechnique, CP6079 succ centre-ville, H3C3A7, Montreal, Qc, Canada, nadia.lahrichi@polymtl.ca

The dairy transportation problem consists of determining the best routes to be performed for collecting milk from farms and delivering to processing plants. We study the particular case of the province of Quebec. Several issues are highlighted in the actual process of designing contracts such as using historical data. We propose an approach based on scenario analysis which consists of revising both the steps and the information used to construct the routes. We develop a generalized tabu search algorithm that integrates the different characteristics of the dairy transportation problem.

2 - Models and Algorithms for Tactical Logistics Network Optimization

Alexander Richter, TU-Berlin, Germany, arichter@math.tu-berlin.de, *Tobias Harks*, *Felix G. König*, *Jannik Matuschke*, *Jens Schulz*

Tactical logistics planning aims at laying the groundwork for cost-efficient day-to-day operation by deciding on transport modes, routes, and delivery frequencies between facilities in the network. We propose a transportation model for tactical logistics network optimization that integrates routing and storage decisions by modeling delivery frequencies and complex tariff schemes uniformly using a cyclic time-expansion. We evaluate our heuristics on case studies from our partner 4flow AG, a market leader in logistics and supply chain management consulting, and assess high solution quality.

3 - An optimization approach for district heating strategic network design
Chiara Bordin, DEI, University of Bologna, Viale risorgimento 2, bologna, italia, Italy, chiara.bordin2@unibo.it, *Daniele Vigo*

A mathematical model developed for supporting district heating system optimal planning is presented: the objective is the connection of an optimal set of new users to the existing thermal grid, minimizing costs and drop of pressures along the pipes. Network design is made considering steady conditions and imposing the flow rate of water at plants. Model constraints are inserted to control flow rate values, pressures values, water direction along the pipes and nodes degree in order to generate realistic networks. The model was integrated with a decision support tool which uses GIS technology.

4 - A multi-period infrastructure planning system for several application domains
Simon Dunstall, Mathematics, Informatics and Statistics, CSIRO, Private Bag 33, 3169, South Clayton, Victoria, Australia, Simon.Dunstall@csiro.au, *Melanie Ayre*, *Tarek Elgindy*, *Andreas Ernst*, *Rodolfo Garcia-Flores*, *Antonio Gomez-Iglesias*, *Kim Levy*, *Martin Savelsbergh*, *Gaurav Singh*, *Stuart Woodman*

We address the development and application of a multi-period infrastructure planning system for electricity transmission and generation, ports planning, minerals bulk freight and food supply chains. The decision-making in this planning system is based on solving very large mixed integer linear programming problems and presenting data in novel ways. The planning system features a GIS-based user interface, database, heuristics and LP/MIP solvers. We describe the system, its application to real infrastructure planning problems, and approaches to solving the large integer programs.

■ HA-57

Thursday, 8:30-10:00
B15-4

Sustainable Food Chains

Stream: Environmental Issues in Operations Management
Invited session

Chair: *Jacqueline Bloemhof*, Operations Research and Logistics, Wageningen University, Hollandseweg 1, 6700 EW, Wageningen, Netherlands, jacqueline.bloemhof@wur.nl

1 - A two-phase framework to design the sustainable agri-food supply chain
Hamid Allaoui, University of Artois, 62030, ARRAS, France, hamid.allaoui@univ-artois.fr, *Jacqueline Bloemhof*, *Gilles Goncalves*, *Yuhan Guo*, *Jack van der Vorst*

The purpose of this paper is twofold. First, it introduces a literature review on OR methods for designing sustainable supply chain. Second, it presents a two-phase famework to optimize the sustainable agri-food supply chain. The approach allows putting forward two distinct strategies: Performing an initial evaluation of the potential roles of supply chain with a number of indicators integrated by AHP and OWA methods, and applying a mathematical model with multiple objective functions optimized by a Pareto method. The triple bottom lines of sustainability are considered in this approach.

2 - How to improve sustainability performance of food supply chains
Jacqueline Bloemhof, Operations Research and Logistics, Wageningen University, Hollandseweg 1, 6700 EW, Wageningen, Netherlands, jacqueline.bloemhof@wur.nl, *Mehmet Soysal*, *Jack van der Vorst*

In this paper we present a stepwise approach to assess, evaluate and improve the sustainability of food chains. In general, Life Cycle Assessment can be used to score key performance indicators for environmental pollution. These indicators need to be completed with social and economic indicators to assess overall sustainability performance. Innovative improvement options might have a positive influence on some indicators but a negative influence on others, needing trade-off decisions. We apply this approach for the soy and beef chains from Latin America to Europe.

3 - Multi-criteria cold warehouse location selection
Sahika Koyun, Yildiz Technical University, Fulya Mah. Ozluce Sk. Semiha Apt. 16/14 Sisli, 34349, Istanbul, Turkey, skoyun@yildiz.edu.tr, *Vildan Ozkir*

The decision of locating warehouses is strategically important for supply chains. The consequences of locating warehouses have impacts on numerious further operational and logistical decisions. In some cases, the content of product, ie. fast moving consumer goods /perishable foods, has significant effects on the process of site selection. Different from ordinary warehouse selection, there are additional factors effecting the site selection. New criteria for locating cold warehouses are needed to design effective cold supply chains. In this study, we utilize MCDM methods to locate cold warehous

4 - Planning the distribution and transportation of food from farm to local restaurants and canteens in a short distribution channel
Maria da Conceicao Fonseca, Departamento de Estatistica e Investigação Operacional, Universidade de Lisboa, Faculdade de Ciencias and Centro de Investigação Operacional, Bloco C/6 Campo Grande, Cidade Universitária, 1749-016, Lisboa, Portugal, mdfonseca@fc.ul.pt, *Isabel Martins*, *Ricardo Magalhães*, *Bruno Oliveira*

The aim of this work is to optimize the distribution and transportation of agricultural products from farmers directly to restaurants and canteens in the region of Setubal, Portugal. We propose to solve both problems together, on a daily basis, as a special case of the general pickup and delivery problem (GPDP). Although the transportation requests specify the set of destinations and the quantities demanded, in general the origins and the quantities delivered are not known beforehand. Computational results of a modified mixed integer programming model for the GPDP are given.

■ HA-58

Thursday, 8:30-10:00
B15-6

Recent Advances in Data Mining and Remote Sensing

Stream: Computational Statistics
Invited session

Chair: *Semih Kuter*, Department of Forest Engineering, Cankiri Karatekin University, Cankiri Karatekin Universitesi, Orman Fakultesi, 18200, Cankiri, Turkey, semihkuter@yahoo.com

1 - Use of a Density Based Spatial Clustering Method (DBSCAN) in Singular Spectrum Analysis of Time Series
Reinaldo Souza, Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro, Rua Marquês de São Vicente, 22453-900, Rio de Janeiro, RJ, Brazil, reinaldo@ele.puc-rio.br, *Keila Mara Cassiano*, *José Francisco Pessanha*

This work proposes using DBSCAN (Density Based Spatial Clustering of Applications with Noise) to separate the noise components of eigentriples in the grouping stage of the Singular Spectrum Analysis (SSA) of Time Series. DBSCAN is a modern and expert method at identify noise through regions of lower density. This work shows better efficiency of DBSCAN over the others methods already used in this stage of SSA, because it allows considerable reduction of noise and provides better forecasting. The result is supported by experimental evaluations realized for simulated series of Box-Jenkins models

2 - Incorporating the modern techniques of continuous optimization within spatial analysis
Semih Kuter, Department of Forest Engineering, Cankiri Karatekin University, Cankiri Karatekin Universitesi, Orman Fakultesi, 18200, Cankiri, Turkey, semihkuter@yahoo.com, *Gerhard-Wilhelm Weber*, *Zuhal Akyurek*, *Ayse Özmen*

Remotely sensed data is often associated with uncertainties due to atmospheric effects. Instead of radiative transfer-based methods, a different approach is represented for the regional atmospheric correction of satellite images by employing modern techniques of continuous optimization and conic quadratic programming. Models obtained through conic multivariate adaptive regression splines are applied on a set of satellite images. The results are compared with the ones obtained by both multivariate adaptive regression splines and a radiative transfer-based method.

3 - Fitting Mixed Effects Logistic Regression Model for Binomial Data as a Special Case of Generalized Linear Mixed Models (GLMMs)
Neslihan İyit, Statistics Department, Selcuk University, Faculty of Science Faculty, Konya, Turkey, niyit@selcuk.edu.tr

In mixed effects logistic regression model, subjects are specified as random effects and it is assumed that there is heterogeneity between the subjects and this heterogeneity can be modeled by a probability distribution which means that the regression coefficients called subject-specific parameters vary from subject to subject. In this study, when the response variable is binary, logistic regression model with a fixed and random effect from GLMM approach which is called mixed effects logistic regression model will be examined on a repeated measurements data set.

■ HA-59

Thursday, 8:30-10:00
B15-5

Soft OR and Multimethodology III

Stream: Soft OR / Systems and Multimethodology
Invited session

Chair: *Giles Hindle*, Mangement Systems, Hull University Business School, University of Hull, Cottingham Road, HU6 7RX, Hull, United Kingdom, giles.hindle@hull.ac.uk

1 - Evaluating the impacts of a multi-methodology intervention: understanding group negotiation dynamics
Felipe Henao, Faculty of Management Science and Economy, Universidad Icesi, Universidad Icesi, Calle 18 # 122 - 135, Pance, 760031, Cali, Valle del cauca, Colombia, jfhenao@icesi.edu.co, *L. Alberto Franco*

Multimethodology has been increasingly employed to cope with complex situations. Mainstream literature has paid particular attention to debating feasibility and sharing lessons from particular combinations of methodologies. However, there is still little understanding of how MM should be evaluated and analysed. We attempt to address this gap by presenting a detailed evaluation approach for a MM intervention, which enabled us to identify impacts of different nature on our client team. We build a theoretical interpretation of such impacts and discuss implications for both MM theory and practice.

2 - Integrating visions and negotiating interests to improve organisational efforts: Use of soft systems methodology in a family business in Catalonia, Spain
Alberto Paucar-Caceres, Business School, Manchester Metropolitan University, All Saints Campus, Oxford Road, M15 6BH, Manchester, United Kingdom, a.paucar@mmu.ac.uk, *Joan Roma*, *David Sierra*, *Diane Hart*

The papers reports on a systemic reflexion to integrate different visions and interests amongst the stakeholders in a small family business in Catalonia, Spain. The paper draws on the innovative work of Transnovaction® developed by the INNOVA Institute (Barcelona), through a series of workshops aimed to equip middle managers with the systemic tools of Soft Systems Methodology (SSM. We sketch the context and report on the initial SSM stages. The paper should interest systems practitioners, consultants and managers interested in to use systemic tools to make sense of businesses' visions.

3 - Action Research using Soft Systems Methodology: Developing a Taxonomy of Modelling Strategies
Giles Hindle, Mangement Systems, Hull University Business School, University of Hull, Cottingham Road, HU6 7RX, Hull, United Kingdom, giles.hindle@hull.ac.uk

Soft Systems Methodology (SSM) is an approach to tackling ill-structured problems which employs a modelling language based upon the concept of a Purposeful Activity System. Drawing on both the author's own Action Research programme and a review of the existing literature, a taxonomy of modelling strategies for SSM is presented. The taxonomy includes descriptive baseline modelling, creative design modelling, abstract theoretical modelling, change oriented planning modelling and research oriented modelling. Reference is also made to a variety of application areas and intervention modes.

4 - Paired-problem analysis: a co-creative problem structuring technique
Christopher Durugbo, Management, University of Bristol, Social Sciences Complex,, 8 Woodland Road, Clifton, BS8 1TN, Bristol, United Kingdom, United Kingdom, christopher.durugbo@bristol.ac.uk, *Xiaojun Wang*

Co-creation is a pro-active strategy for enabling firms to create value through co-opting consumer competences. This strategy offers avenues to structure problems in more concurrent and collaborative ways. Along these lines, this research proposes the paired-problem analysis approach that leverages the expertise of stakeholders by splitting problems into yin-yang dyads that offer paired configurations for a more balanced view of problems. The approach involves three main stages: 'nominal factoring' that creates paired groups, 'converse thinking' that generates problem statements and s

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■ HA-60

Thursday, 8:30-10:00
B15-7

Knowledge Organizations

Stream: Knowledge, Information & Technology
Invited session

Chair: *A. D. Amar*, Management Department, Seton Hall University, School of Business, 400 South Orange Ave., 07079, South Orange, NJ, United States, amaramar@shu.edu

1 - Knowledge Leadership: A Process Model
Uttarayan Bagchi, Information, Risk, & Operations Management, The Univ of Texas at Austin, 78712, Austin, Texas, United States, Uttarayan.Bagchi@mccombs.utexas.edu, *Amitava Dutta*, *Jack Hayya*

Knowledge exploitation entails more leadership than management. This is so because there seems to be an irreducible incompatibility between knowledge and what is usually understood as management. One might say that when it comes to knowledge, the reach of management exceeds its grasp. Knowledge and leadership on the other hand are commensurable constructs. They are conceptually compatible. However that may be, if we are to use leadership to exploit knowledge, we need more than conceptual compatibility. We need a process. And that is what we attempt to outline in this talk.

2 - Separation and Innovation
Ajay Das, Management, Baruch College, Box B9-240, One Bernard Baruch Way, 10010, New York, NY, United States, ajay.das@baruch.cuny.edu

We develop theory on the impact of separation between 'thought' establishments such as R&D centers, and 'process' establishments such as manufacturing plants. Specifically, we consider the impact of such

separation on innovation performance. Separation is conceptualized as a multi-dimensional construct with physical, cultural, and other dimensions. We theorize that separation affects different forms of innovation activity and outcomes in different manner.

3 - Career Ambition and Performance among Knowledge Workers
Hong Bui, Bournemouth University, BH12 5BB, Poole, United Kingdom, hbui@bournemouth.ac.uk, *Davide Secchi*

This study develops a framework of career ambition in relationships with its antecedents and performance. Motivation and situation theories are applied in this study. Using a sample of 973 employee- and supervisor-ratings of knowledge workers in the public sector, the study shows that teamwork, socially-based decision making, professionalism and competence are antecedents of career ambition. Interestingly, the findings challenge the normal assumption that career ambition shows no significantly positive impact on performance or even negative impact in one subsample.

4 - Issues in Success or Failure in Knowledge Management Systems
A. D. Amar, Management Department, Seton Hall University, School of Business, 400 South Orange Ave., 07079, South Orange, NJ, United States, amaramar@shu.edu, *Elayne Coakes*, *Maria L. Granados*

Taking a sociotechnical viewpoint of Knowledge Management System (KMS), we consider implementation issues such as stakeholder disenfranchisement, lack of communication, and the low involvement of key personnel. We provide guidelines derived from Clegg's Principles for enhancing KMS designs. Our data come from a large comprehensive global survey conducted from 2007 to 2011 of 1034 participants from varied organizations from 76 countries. In addition to multiple technology and usability issues, we find human and organisational barriers and recommend that users are included in the design team.

■ HA-62

Thursday, 8:30-10:00
R18-1

Emerging Applications of Finance in Economics and Environment III

Stream: Emerging Applications of Finance in Economics and Environment
Invited session

Chair: *Omer Kayhan Seyhun*, Banking and Financial Institutions Department, Risk Centralization Division, Central Bank of Turkey, Istiklal Street No 10, Ulus, 06100, Ankara, Turkey, kayhan.seyhun@tcmb.gov.tr
Chair: *Kasirga Yildirak*, IAM, METU, 06531, Ankara, Turkey, kasirgayildirak@gmail.com.tr

1 - The Efficiency of Carbon Markets
Omer Kayhan Seyhun, Banking and Financial Institutions Department, Risk Centralization Division, Central Bank of Turkey, Istiklal Street No 10, Ulus, 06100, Ankara, Turkey, kayhan.seyhun@tcmb.gov.tr

This paper examines the efficiency of carbon markets. In particular, the paper searches for the performance of carbon markets in different ways. Carbon markets are expected to be sensitive to quotas established by international institutions and other factors. On the other hand, carbon markets have other objects like social policy function for developing countries when hosting the carbon based projects. It is expected that forming efficient carbon markets will help to increase awareness for the global warming for all countries and reduce the cost of environmental risks.

2 - Influence of Carbon Trading System on Road Freight Transport Company
Li Chen, Department of Information System and Operations, Vienna University of Economics and Business, Nordbergstrasse 15, 1090, Vienna, Austria, chenli313@gmail.com

Carbon trading system is considered to be a useful measurement for carbon reduction in transport sector. This study uses cost-benefit model to analyze the influence of carbon trading on road freight companies based on the order of unit transport profit, carbon credit price and over emission penalty. A numerical analysis and case study are given under the scenario of Chinese freight market with reduction target from Direction of Low Carbon Transportation System. The results of the study are crucial for the implementation of such a policy in the near future from both company and political sides.

3 - Crude oil price influence on food price formation
Erick Oliveira, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Rio de Janeiro, Brazil, erickmeira@poli.ufrj.br, *André Salles*

The observed co-movement of oil and food prices during recent years has drawn the attention of many researchers, specially due to the important role these commodities play in the economic growth of many countries. This study aims to examine the long-run relationship between the returns of oil prices and certain food price returns, using cointegration and Granger causality methods on selected weekly time series. The empirical results provide strong evidence that the international oil market has substantial effects on many markets, especially those related to the main arable crops.

4 - Environmental heterogeneity Pampa Biome, in southern Rio Grande do Sul — Brazil
Marcelo Dutra Da Silva, Universidade Federal de Rio Grande, 96203-900, Rio Grande, Brazil, dutradasilva@terra.com.br

The Pampa comprises complex landscapes which are being gradually changed, or simply lost, since the uses vary and encroaching on the remaining natural space. The Pampa is a unique system in South America. In Brazil, that system is present only in southern Rio Grande do Sul, covering about 170,000 km. The Pampa is heterogeneous and its mosaic combines different forms of environmental and human use. The objective of this work is to recognize the types of environmental Pampa, through spatial models for landscape analysis.

■ HA-63

Thursday, 8:30-10:00
R18-2

Logistics and Maritime V

Stream: OR and Maritime Studies
Invited session

Chair: *Liu Yang*, Business School, University of International Business and Economics, Business School, University of International Business and Economics, No. 10, Hui Xin Dong Jie, Chao Yang District, Beijing, 100029 China, 86-010, Beijing, China, amyangliu@gmail.com

1 - Solving a two-machine no-wait flowshop scheduling problem by a genetic algorithm based heuristic
King-Wah Anthony Pang, Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, Hong Kong, lgtapang@polyu.edu.hk

We present a genetic algorithm based heuristics, incorporating with several local search heuristic approaches for faster solution convergence, to solve a two machine no-wait flowshop scheduling problem with class dependent setup time that minimizes the maximum lateness of all jobs processed. This scheduling problem is useful for manufacturing industries where interruption between subsequent processes is not allowed. Results from computational experiments reveal the proposed methodology is efficient for the determination of an efficient plan for this class of scheduling problems in real life.

2 - Efficient pricing and investment for an electricity company with time-varying price
C.t. Ng, Department of Logistics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, Hong Kong, daniel.ng@polyu.edu.hk, *Ciwei Dong*

This paper considers an electricity company, which offers two tariff schemes, i.e., Schemes FR and TOU, to the customers. Under Scheme FR, the customers pay a flat price for the electricity consumption over the whole period. However, under Scheme TOU, the customers pay a high price for the consumption in the peak period and a low price for the consumption in the non-peak period, so that the customers may shift some consumption from the peak period to the non-peak period. The optimal shifted consumption by the customers and the optimal capacity and price decisions for the company are derived.

3 - Pricing and Capacity Management for Stochastic Rental Systems with Advance Demand Information in the Container Leasing Industry
Wen Jiao, Logistics and Maritime Studies, The Hong Kong Polytechnic University, Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China, Hong Kong, Hong Kong, wendy.j@connect.polyu.hk, *Hong Yan*, *King-Wah Anthony Pang*

This paper examines the pricing and capacity rationing problem for stochastic rental systems with advance demand information. In particular, we consider a container leasing company facing two types of customers – advance demand information (ADI) and walk-in customers. ADI customers request a booking before the actual demand happens, while walk-in customers require immediate service. The problem is modeled as a continuous-time markov decision process. Using value iteration, the properties of the optimal allocation and pricing policy are derived.

4 - Capacity strategy with technology investment in a duopoly competitive competition under demand uncertainty
Liu Yang, Business School, University of International Business and Economics, Business School, University of International Business and Economics, No. 10, Hui Xin Dong Jie, Chao Yang District, Beijing, 100029 China, 86-010, Beijing, China, amyangliu@gmail.com, *C.t. Ng*, *T.C. Edwin Cheng*, *Michael Pinedo*

We develop a four-stage model to investigate impacts of capacity strategy on technology investment. Two capacity strategies are considered: Make-to-order (MO) and Make-to-stock with holdback (SH). The technology investment refers to a firm's effort to improve its total production cost curve. Each firm goes through four stages sequentially, including technology level, capacity volume, production amount and sales target. We characterize the equilibriums in different competitions. Then, we evaluate the impacts of capacity strategy on firms' technology investment.

■ HA-64

Thursday, 8:30-10:00
R18-3

Hospital Planning

Stream: Humanitarian Operations Research
Invited session

Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de
Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - A Discrete Event Simulation Model to Improve the Outpatient Appointment Schedule of Chinese Public Hospital
Li Luo, Industry Engineering, Sichuan University, No.24 South Section 1, Yihuan Road, Chengdu , China, 610065, No.29 Jiuyanqiao Wangjiang Road, Chengdu, 610064, 610064, Chengdu, Sichuan Province, China, luolicc@163.com, *Qiyun Song*, *Mingying Tan*, *Yong Lei*

In China, healthcare resources are scarce and are concentrated in regional central hospitals, leading more patients to seek out hospitals for optimal treatment. Reducing average patient wait time (APWT) in outpatient departments before consultation can both improve the hospital service level and reduce the cross-infection risk level. The study aims to identify a superior appointment procedure to reduce APWT in the appointment patient arrival pattern (APAP). A discrete event simulation model was developed to study the outpatient appointment schedule.

2 - A Variable Neighbourhood Search algorithm for the hospital case mix planning problem
Jully Jeunet, Université Paris-Dauphine, CNRS, Lamsade, Place du Maréchal de Lattre de Tassigny, 75775, Paris Cedex, France, jully.jeunet@dauphine.fr, *Nico Dellaert*

The hospital case mix planning problem resides in the determination of a tactical plan of patients of several pathology groups so as to allocate at best available resources over the horizon. This problem can be formulated as a mixed integer program. As exact methods fail to provide the optimal solution in a reasonable time, we develop a VNS algorithm with neighbourhoods defined in terms of plan changes. Exploration is performed using two operators : period change (one patient is moved to another period) and swap (patients of two groups in two periods are exchanged).

3 - A Model of Critical Care Unit Activities Through Queueing Theory
Izabela Komenda, Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, United Kingdom, komendai@cardiff.ac.uk, *Jeff Griffiths*, *Vincent Knight*

The random behaviour of arrivals and lengths of stay within a Critical Care Unit (CCU) make for a complex system. Dealing with the constraints on the healthcare system at the acute level is difficult. In this study an overview of queueing theoretical mathematical models of patients' flow will be presented. Predictions from the model are compared to the observed performance of the Units, and the sensitivity of the models to changes, for example, in Unit size is explored. We also propose a game theoretical model of CCUs to study the effect of patient diversion using an adapted Markov chain.

4 - An Application of Queuing Theory to Hospital Systems
Bilgehan Tekin, Business and Management, Cankiri Karatekin University, Cankiri Karatekin University, Faculty of Economics and Administrative Sciences, Central District, 18100, Cankiri, Central District, Turkey, bilgehantn@hotmail.com

In this study, queuing theory models are applied to two hospital; one of them private, one of them public are choosen as samples. In these hospitals eight clinics are taken into consideration. In this research queuing theory applications in area of health care is firstly determined. Next health systems and services are mentioned. Then, types of hospitals in health sector in Turkey are discussed. Lastly, application part will be mentioned.At the end of the study, analysis show that the patient spend more time in private hospitals than public ones.

■ HA-65

Thursday, 8:30-10:00
R18-5

Game Theory and Experimental Design

Stream: Game Theory and Experimental Design
Invited session

Chair: *Tcvetana Volkova*, Department of production safety and industrial ecology, Ufa state aviation technical university, Davletshinoi street, 19-23, 450097, Ufa, Republic of Bashkortostan, Russian Federation, tsvetana.volkova@gmail.com

1 - German Bundestag elections 2009: Testing the representative capacity of parties and coalitions
Andranik Tangian, WSI, Hans Boeckler Foundation, Hans Boeckler Str. 39, 40476, Duesseldorf, Germany, andranik-tangian@boeckler.de

The positions of five leading German parties on over 30 topical issues are compared with results of public opinion polls. The outcomes are summarized in the party indices of popularity (average percentage of population represented) and universality (percentage of issues with majority representation), as well as in similar indices for party coalitions. The selection of issues and the information on party positions are given for the last Bundestag elections 2009.

2 - Testing Rationality of Collective Household Consumption
Fabrice Talla Nobibon, Decision Sciences and Information Management, KU Leuven, Naamsestraat 69, 3000, Leuven, Belgium, fabrice.tallanobibon@kuleuven.be, *Laurens Cherchye*, *Yves Crama*, *Thomas Demuynck*, *Bram De Rock*, *Frits Spieksma*

This paper derives algorithms for testing rationality of collective household consumption on large data sets. We consider both the extension of the Generalized Axiom of Revealed Preference (GARP) and the extension of the Strong Axiom of Revealed Preference (SARP) to collective households with two decision makers or members. We establish that testing these extensions is NP-complete. We present exact algorithms based on mixed-integer programming (MIP) formulations of the axioms, and we propose simulated annealing heuristics for the solution of global optimization formulations.

3 - Collusion and Bargaining for Royalty in the tendering of a BOT project: Rubinstein's alternation-offers model with outside options
Chao-Chung Kang, Department of Business Administration and Graduate Institute of Management, Providence University, 200, Chung-Chi, Rd., 433, Shalu, Taichung, Taiwan, cckang@pu.edu.tw, *Szu-Chi Huang*

This study modified the Rubinstein's alternating offers model with outside options to analyze the royalty bargain problem based on the assumption in which the government adopted the "Beauty Contests' method to evaluate the best applicant from the bidders. Results of this paper show as: the cartel will only collude with the second-best applicant to quit bargaining or collude to announce by a public notice to give up participation in re-tender if payoff from outside options of government is large.

■ HA-66

Thursday, 8:30-10:00
R18-4

Sustainable Living: Cognitive, Social, Economical, Ecological and World View

Stream: Sustainable Living: Cognitive, Social, Economical, Ecological and World View
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Pedamallu Chandra Sekhar*, Department of Medical Oncology, Dana-Farber Cancer Institute, Boston, 02115, Ipswich, MA, United States, pcs.murali@gmail.com

1 - New Advances in the Financial Sector and Their Impacts in Economics and Sustainability
Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr, *Busra Temocin*, *Azar Karimov*, *Erdem Kilic*

We represent the financial sector and related, in fact, coupled fields, by Stochastic Hybrid Differential Systems with Jumps, a new and wide modeling frame involving diffusion, impulsiveness and the local (regional) - global differentiation. We discuss market incompleteness and, especially, insider information and speculation, including the conditions of the economy and the state of the society, and study the optimal wealth accordingly. A particular interest exists in the development and its sustainability.

2 - Social networks and strategies for local development: the case of several districts in peru
Azucena Magda Garcia, Programa de Engenharia de Produção, Universidade Federal do Rio de Janeiro, Ilha do Fundão Cidade Universitária Centro de Tecnologia Bloco F - Sala 103 Rio de Janeiro - RJ - Brasil, Brazil, azu_mg@hotmail.com, *Roberto dos Santos Bartholo Junior*

The study aimed to describe and analyze the characteristics of life of people of the Altiplano immigrants and to understand the role of relationships in a social network as a survival strategy. We to local development districts in Alto de la Alianza, Ciudad Nueva and Coronel Gregorio Albarracin Lanchipa of the province of Tacna (Peru), and we applied to informal enterprises and family businesses to survive; they represent an important sector for generating employment and income for the local economy. We demonstrate its ability to generate opportunities to improve the living conditions.

3 - Methodology for municipalities sustainable development assessment
Alexej Orlov, Students Science Association, Institute for applied system analysis of the National Technical University of Ukraine, Peremohy ave. 37, 03056, Kyiv, Ukraine, orlov.alexej@gmail.com

The world practices show efficiency of using the sustainability indicators to measure sustainable development of a system. The proposed methodology provides the tools for sustainability assessment at the level of municipality; it is based on the Sustainable Development Gauging Matrix framework (SDGM), which was successfully applied on country and region level. Methodology specifies the participatory process of initial indicators set generation, their normalization, aggregation, and defines the procedure to analyze the obtained values in order to provide the recommendations for decision makers.

4 - Applications of Multimethodologies at the Northwest of Argentina
Maria Alejandra Castellini, Facultad de Ingeniería, Universidad Nacional de Salta, Bolivia 5150, 4400, Salta, Salta, Argentina, mac@unsa.edu.ar, *Horacio Rojo*, *Mischel Carmen N. Belderrain*

This paper presents applications of Multimethodologies (MM), in micro and small organizations at the Northwest of Argentina, a region of a developing country. Since 2010, 20 of them were interviewed, promoting stakeholders participation. (i) In a bakery, it was applied Strategic Options Development and Analysis (SODA) to identify priorities of those involved, and Linear Programming (LP) to optimize the production plan; (ii) in a school uniform workshop, SODA and inventory model with restrictions in a distributor of cleaning products, Soft System Methodology and LP were applied.

■ HA-67

Thursday, 8:30-10:00
R19-1

Higher Education

Stream: Education Policy
Invited session

Chair: *Jakob Krarup*, Dept. of Computer Science, University of Copenhagen, Ydervang 4, DK-3460, Birkeroed, Denmark, krarup@diku.dk

1 - Solving the Balanced Academic Curriculum Problem using the ACO Metaheuristic
José-Miguel Rubio, Pontificia Universidad Católica de Valparaíso, Chile, jose.rubio.l@ucv.cl, *Wenceslao Palma*, *Broderick Crawford*, *Ricardo Soto*

The balanced academic curriculum problem (BACP) consists in the courses assignation to academic periods satisfying all the load limits and prerequisites constraints. In this paper we present the design of a solution to the BACP based on the ACO metaheuristic, more specifically the best-worst ant system. We have applied our solution approach to both benchmark and real instances. Results show the efficiency of our solution compared with other well-known metaheuristics.

2 - Is industrial engineering education creating perfectionist and/or anxiety prone individuals?
Hande Güngör, Vocational School of Health Services, Pamukkale University, Denizli, Turkey, hgungor@pau.edu.tr, *Ozan Capraz*, *Askiner Gungor*

This study aims to understand the influence of the industrial engineering education on the perfectionism and the anxiety levels of students. Two questionnaire forms are used: Multi-dimensional Perfectionism Scale and State and Trait Anxiety Inventory Form-2. Data evaluation is done using the alpha reliability test, the single sampling Kolmogrov-Smirnov test, the independent sampling one-way ANOVA, the independent sampling t-test and the correlation analysis. The results may be beneficial to designers of IE programmes.

3 - Reliability of test scores in Rasch model
Mikhail Lutsenko, Mathematics, St. Petersburg Transport University, Moskovskij pr.9, 195257, St.Petersburg, Russian Federation, ml4116@mail.ru, *Natalia Shadrinceva*

A statistical game between Nature and Statistician is constructed. The game value is a probability of correct assessment of a person being tested. An optimal strategy of Statistician in the game is optimal randomized decision function of statistical problem. The game is solved by MS Excel for Rasch model if test has 10 items. Reliability of test scores is found without assumption about priori distribution of the Examinee's level of knowledge. In many important cases the reliability of assessment turns out to be very low.

4 - Candidate Teachers' Use of the Faculty Building and Evaluation of the Physical Environment
Dürdane Tor, Educational Sciences, Middle East Technical University, Turkey, durdaneltor@gmail.com, *Cennet Engin Demir*

To enhance qualified teacher education, the places in which learning occurs would influence social, professional, and individual development of candidate teachers. Therefore, there has been a growing interest in the role of the physical environment in higher education. The purpose of this study is to understand how the physical environment of candidate teachers' faculty building shapes their use of it. Overall findings indicated that candidate teachers use the faculty building to take courses, but not to join academic and social activities due to the location of the building.

■ HA-69

Thursday, 8:30-10:00
R19-3

OR in Sustainable Urban Development

Stream: OR for Sustainable Development
Invited session

Chair: *Rasa Apanaviciene*, Dept of Civil Engineering Technologies, Kaunas University of Technology, Studentu str. 48-401, LT-51367, Kaunas, Lithuania, rasa.apanaviciene@ktu.lt

1 - A multi-criteria approach to evaluate energy efficiency actions in an urban context
Dulce Coelho, Electrical Engineering, College of Engineering of Coimbra (ISEC) and INESC Coimbra, Rua Pedro Nunes, Quinta da Nora, 3030 - 199, Coimbra, Portugal, dcoelho@isec.pt, *Carlos Henggeler Antunes*, *António Martins*

In order to allow municipalities and other local actors to be able to implement sustainable energy plans, effective decision support methods and tools for urban energy planning are required, taking into account existing municipal, regional and national policies, plans, procedures and regulations that affect local energy and climate issues. A methodological framework based on a multi-criteria sorting model is proposed to perform the classification of energy efficiency actions in a real urban context.

2 - Trading of power reserves in Baltic trading zone under auction conditions
Neringa Radziukynien, Laboratory of Systems Control and Automation, Lithuanian Energy Institute, Breslaujos str. 3, 44403, Kaunas, Lithuania, neringa@mail.lei.lt, *Virginijus Radziukynas*, *Arturas Klementavičius*, *Darius Naujokaitis*

In this paper we examine the auction-based electricity markets from the viewpoint of a reserve power provider and evaluate the operating reserves that are currently traded in the Baltic trading zone. We derive the critical points for effective market design from the selected trading strategies and apply them to define the incentive conditions and rules for the power reserve auction. We also present the mathematical reserve trading model based on the combination of security-constrained economic dispatch and probabilistic bidding model, with minimized risk for power reserve providers.

3 - Effectiveness evaluation model for public-private partnership (PPP) projects of infrastructure development
Rasa Apanaviciene, Dept of Civil Engineering Technologies, Kaunas University of Technology, Studentu str. 48-401, LT-51367, Kaunas, Lithuania, rasa.apanaviciene@ktu.lt, *Rta Rudzianskait - Kvaraciejien*

Different infrastructure development projects have been delivered through PPPs around the world: primarily in transport, energy, telecommunications, water, health and education sectors. Besides the successful practice, various problems have been encountered in PPPs of infrastructure development. Thus, the future implementations of PPP projects needs to be evaluated from business as well as sustainable development perspectives in order to contribute to the development of local economies. For this purpose authors present PPP effectiveness evaluation model based on Random Forests methodology.

4 - Assessment of EU support's impact on urban development
Jrat Venckauskait, Department of Urban Engineering, Vilnius Gediminas Technical University, Sauletekio ave.11, LT10223, Vilnius, Lithuania, vjurate@vgtu.lt, *Marija Burinskien*, *Vitalija Rudzkien*

In SWOT analysis of Lithuanian EU structural support use strategy 2007-2013 noted that Lithuanian network of cities is sufficiently gradually distributed, and should lead to the even development of the country. However, most of the economic activities are attracted to the largest cities. The article aims to identify the most important indicators of urban environments; to create 3 different assessment models based on different mathematical and logical calculations; to collect relevant survey data; to define the evaluation's accuracy by using numerical methods (eg. Fisher's distribution).

■ HA-71

Thursday, 8:30-10:00
R16-1

Scheduling and Analyzing Sports Leagues

Stream: OR in Sports
Invited session

Chair: *Stephan Westphal*, Institute for Numerical and Applied Mathematics, University of Goettingen, Lotzestr. 16-18, 37083, Göttingen, Germany, s.westphal@math.uni-goettingen.de

1 - Round robin scheduling with minitournaments
Dries Goossens, Operations Research and Business Statistics (ORSTAT), KU Leuven, Naamsestraat 69, 3000, Leuven, Belgium, Dries.Goossens@econ.kuleuven.be, *Kimmo Nurmi*, *Jari Kyngas*

We present a method to schedule a round robin tournament which involves minitournaments, each hosted by one team. At the end of the season, the number of home games should be balanced over the teams, despite the fact that in minitournament matches only the host team plays at home. The problem may be further complicated by many other constraints, e.g. preassigned matches. To obtain a schedule for this league format, we sequentially solve four distinct combinatorial problems. We apply this method to the Finnish national ice hockey league for players under the age of 20.

2 - A unified framework and general concavity conditions for optimal sports betting
David McDonald, School of Management, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, d.mcdonald@soton.ac.uk, *Ming-Chien Sung*, *Johnnie Johnson*

The Kelly betting strategy is the optimal solution under log-utility for allocation of wealth among a range of alternative bets when at least one presents a positive expected return. This paper presents a unified framework for estimating Kelly strategies in all market types and conditions, including betting exchanges, where the bettor can place bets for and against an outcome. We present general concavity conditions that apply in most situations; when they do not, we elaborate on alternative methods for locating global optima.

3 - Sports Scheduling for Major German Sports Leagues
Stephan Westphal, Institute for Numerical and Applied Mathematics, University of Goettingen, Lotzestr. 16-18, 37083, Göttingen, Germany, s.westphal@math.uni-goettingen.de

Every major sports league is faced with the challenge of finding schedules for its games such that a variety of requirements are synchronized and many different objectives are achieved simultaneously. Among other things, the sports sites shall only be used at given time slots.

Apart from these fundamental aspects, we outline specific requirements and goals of the German Soccer League (DFL), the German Basketball League (Beko BBL), and the German Hockey League (DEL) and we describe the algorithmic approaches that we developed for these leagues.

■ HA-72

Thursday, 8:30-10:00
R16-2

Structural Bioinformatics

Stream: Computational Biology, Bioinformatics and Medicine
Invited session

Chair: *Piotr Lukasiak*, Institute of Computing Science, Poznan University of Technology, ul.Piotrowo 2, 60-965, Poznan, Poland, Piotr.Lukasiak@cs.put.poznan.pl
Chair: *Marta Szachniuk*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl

1 - Quality evaluation of biomolecules
Piotr Lukasiak, Institute of Computing Science, Poznan University of Technology, ul.Piotrowo 2, 60-965, Poznan, Poland, Piotr.Lukasiak@cs.put.poznan.pl, *Maciej Antczak*, *Tomasz Ratajczak*, *Jacek Blazewicz*

Tertiary structure prediction of biomolecules using computational methodologies has made momentous advance over the last decade due to the improvement of technologies and continuous growing of sequence and structure databases. With growing number of known sequences and structural models the estimation and evaluation of models quality become the crucial step for further analysis. Our methodology driven by the idea of local 3D neighborhood of atoms in a model equipped with powerful visualization tools gives a unique opportunity to receive detailed and intuitive analysis of biomolecules.

2 - Graph clustering and biomolecules
Maciej Milostan, Poznan University of Technology, Pl. M. Skłodowskiej-Curie 5, 60-965, Poznan, Poland, maciej.milostan@cs.put.poznan.pl, *Piotr Lukasiak*, *Jacek Blazewicz*

Graph clustering aims in finding related vertices in a graph. Usually such a technique is unsupervised and does not take into account labels or classes. The underlying paradigm is that the distinct clusters have substantially higher number of inner edges than outer edges. Inner edges connect vertices belonging to a given cluster, outer ones connect vertices in a cluster with those outside. We show an application of graph clustering methods to the selected problems from the field of structural analysis of biomolecules (contact graphs and maps analysis, identification of rigid bodies etc.).

3 - Novel approach to model quality assessment of proteins
Maciej Antczak, Institute of Computing Science, Poznan University of Technology, Pl. Marii Sklodowskiej-Curie 5, 60-965, Poznan, Wielkopolska, Poland, mantczak@cs.put.poznan.pl, *Piotr Lukasiak*, *Krzysztof Fidelis*, *Jacek Blazewicz*

Protein function is determined by 3D structure, but its determination requires time consuming experiments. Hence, prediction of protein structure using computational tools is great interest of humanity. Moreover, reliable computational methods designed to evaluate models quality without knowing native structure are needed in the context of structure refinement. The proposed method allows to visualize possible stereochemical, folding, and packing inconsistencies and assess applicability of the target sequence to structural template alignments - a major source of homology modeling errors.

4 - Heuristic algorithm for RNA degradation problem
Agnieszka Rybarczyk, Poznan University of Technology, 60-965, Poznan, Poland, arybarczyk@cs.put.poznan.pl, *Marta Kasprzak*, *Jacek Blazewicz*

In this work, we would like to present our recent results concerning the RNA degradation process. In our studies we used artificial RNA molecules designed according to the rules of degradation developed by Kierzek and co-workers. On the basis of the results of their degradation we have proposed the formulation of the RNA Partial Degradation Problem (RNA PDP) and we have shown that the problem is strongly NP-complete. We would like to propose a new efficient heuristic algorithm based on tabu search approach that allows to reconstruct the cleavage sites of the given RNA molecule.

■ HA-74

Thursday, 8:30-10:00
R16-4

Modeling and Analyzing Social/behavioral/technical related OR problems

Stream: Applications of Operations Research in Education
Invited session

Chair: *Marek Frankowicz*, Faculty of Chemistry, Jagiellonian University, ul. Ingardena 3, 30-060, Krakow, Poland, marek.frankowicz@gmail.com

1 - A Proposal for Timetabling of Teachers and Classes in Higher Education Institutions Using a Heuristic VNS / VND
Bruno Missi Xavier, P&D, Dataci - Companhia de Tecnologia da Informação de Cachoeiro de Itapemirim-ES; USC - São Camilo - ES; UCAM-Campos, Brazil, bmissix@gmail.com, *Alcione Silva*, *Dalessandro Vianna*, *Helder Gomes Costa*

This paper presents a proposal for the solution of the Timetabling Problems, through developing a heuristic based on a model VNS/VND, when applied to the courses of Information Systems, Systems Development, and Analysis at the University of the Espírito Santo. As a methodology, we selected two courses involving 7 classes, 37 disciplines and 21 teachers. The comparisons between the results of the manual and automated process demonstrates that the proposed method obtained a significant improvement in the quality of solution and the reduction of time required for the preparation of schedules.

2 - Computer Access, IT Skills and Employment Opportunities of Workers

Hilal Atasoy, Accounting, Temple University, 1500 Locust St Apt: 3707, 19102, Philadelphia, PA, United States, hilal.atasoy@temple.edu

This study analyzes household computer access and its impacts on employment opportunities. We find that household computer access has direct and indirect impacts on employment probability, where the indirect impacts are mediated through increases in IT skills. The direct effect of household computer access is 2% increase in employment probability and this effect decreases over time as computer penetration rates increase. Mediated effect through IT skills is 1.5% increase in employment probability. Impacts vary across demographic measures such as education, gender and urban/rural location.

3 - Systems dynamics and university reforms: Self-organization processes at the European, national and institutional level.

Marek Frankowicz, Faculty of Chemistry, Jagiellonian University, ul. Ingardena 3, 30-060, Krakow, Poland, marek.frankowicz@gmail.com

Three aspects of Higher Education (HE) reforms: Quality Assurance, staff development and curriculum design are described using complex adaptive systems (CAS) approach. Three levels (European, national and institutional) are taken into account. Examples from Poland and selected European countries are presented. Synergy of all three aspects and mutual interactions of reform processes at various levels are discussed. Usefulness of CAS approach in strategic planning and in implementation of HE reforms is pointed out.

Thursday, 10:30-12h00

■ HB-02

Thursday, 10:30-12h00
O1-2

Dynamical Systems and Mathematical Modeling in OR

Stream: Dynamical Systems and Mathematical Modeling in OR
Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Ozlem Defterli*, Department of Mathematics and Computer Science, Cankaya University, Ankara, TURKEY & Saginaw Valley State University, College of Science, Engineering and Technology, MI, USA (currently as PostDoc), 1) Cankaya Univ. Department of Mathematics and Computer Science, Yukariyurtcu Mah., No:80, 06810 Yenimahalle-Ankara, Turkey, 2) 7400 Bay Rd. SVSU P204 Univercity Center MI 48710, Michigan, USA, MI 48710, Saginaw, Michigan, United States, defterli@cankaya.edu.tr
Chair: *Firat Evirgen*, Department of Mathematics, Balikesir University, Cagis Campus, 10145, Balikesir, Turkey, fevirgen@balikesir.edu.tr

1 - Analysis of threshold dynamics of epidemic models in a periodic environment

Cansu Evcin, Scientific Computing, Institute of Applied Mathematics, Çankaya, Metu, Ankara, Turkey, cbilgir@metu.edu.tr, *Ömür Ugur*

We model and analyze the disease transmission dynamics of avian influenza within a vector host model constructed with compartments in a periodic environment using the formulation of basic reproduction ratio defined as a spectral radius of the next infection operator for compartmental epidemic models. Since simple implementation of the time-averaged systems gives rise to the comparison of these with periodic systems, we investigate the occurrence of the existence of underestimation and overestimation of the disease transmission risk in time-averaged systems.

2 - Modified Adaptive Control Method for synchronization of fractional order chaotic systems

Subir Das, Department of Applied Mathematics, Indian Institute of Technology (BHU), 221 005, Varanasi, India, sdas.apm@iitbhu.ac.in

A modified adaptive control method is developed and the parameters identification method is then applied in fractional order systems with unknown parameters. The new modified control method based on Lyapunov stability theory is successfully applied to investigate the synchronization of pair of fractional order systems amongst Genesio-Tesi, Qi and Chen systems. By means of the Adams-Bosford-Moulton method, the numerical results show that the modified method is easy to implement and reliable for synchronizing the two different fractional order chaotic systems.

3 - Higher-Order Numerical Methods for the Discrete Dynamics and Anticipation of Genetic Regulatory Systems

Ozlem Defterli, Department of Mathematics and Computer Science, Cankaya University, Ankara, TURKEY & Saginaw Valley State University, College of Science, Engineering and Technology, MI, USA (currently as PostDoc), 1) Cankaya Univ. Department of Mathematics and Computer Science, Yukariyurtcu Mah., No:80, 06810 Yenimahalle-Ankara, Turkey, 2) 7400 Bay Rd. SVSU P204 Univercity Center MI 48710, Michigan, USA, MI 48710, Saginaw, Michigan, United States, defterli@cankaya.edu.tr, *Armin Fügenschuh*, *Gerhard-Wilhelm Weber*

In this study, we will discuss genetic regulatory systems to express and predict clearly the connections and influences among the genes and environmental factors in a cell metabolism. The corresponding model is described using dynamical equations based on a class of time-continuous ordinary differential equations and containing unknown parameters to be optimized. Accordingly, time-discrete version of that model class will be analyzed by using a class of explicit Runge-Kutta methods. Error and convergence analysis of these numerical schemes will be given by an illustrative example.

4 - Constrained Nonlinear Optimization Problem with Fractional Order Dynamical System
Firat Evirgen, Department of Mathematics, Balikesir University, Cagis Campus, 10145, Balikesir, Turkey, fevirgen@balikesir.edu.tr

In this work, a constrained nonlinear optimization problems are modeled with gradient based fractional order dynamical system. The behavior of dynamic system in arbitrary longtime interval is determined by the variational iteration method with multistage strategy. Furthermore, the efficiency of the fractional model against the integer model for solving optimization problem is shown by comparing with some traditional method.

■ HB-03

Thursday, 10:30-12h00
O1-3

Service Systems 2

Stream: Service Systems (contributed)
Contributed session

Chair: *Michal Penn*, Industrial Engineering and Management, Technion, Technion City, 32000, Haifa, Israel, mpenn@ie.technion.ac.il
Chair: *Celia Glass*, Cass Business School, City University, 106 Bunhill Row, EC1Y 8TZ, London, United Kingdom, c.a.glass@city.ac.uk

1 - Reliability performance of a parallel k-out-of-n system with repairs and vacations
George Mytalas, Statistics, Athens University of Economics and Business, Greece, mytalas@aueb.gr, *Michael Zazanis*

We derive the reliability of a system consisting of two independent sets of components with finite population and a single repair machine. The life times of components are independent, exponentially distributed random variables with certain parameter. This can be viewed as an extension of the k-out-of-n system with repairs with two sets of components. The system operates under the (N1,N2) policy. The reliability, and other operational characteristics of this system are derived.

2 - Customized routing rules for small, hierarchical call centres
Celia Glass, Cass Business School, City University, 106 Bunhill Row, EC1Y 8TZ, London, United Kingdom, c.a.glass@city.ac.uk, *Ann van Ackere*, *Roger Knight*

We propose a new type of routing rule, and demonstrate how it can reduce overall staff numbers with an appropriate level of cross-training. In the process, fairness in workload distribution is improved, and quality of service to customers is maintained. The new routing rule is driven by server workload, rather than just customer waiting time, as is traditionally the case. Computational results indicate significant potential savings.

3 - Optimal Manpower Allocation in Call Center under Uncertainty in Call Volume and Multi-Skilled Workforce
Dipankar Bose, Production, Operations and Decision Sciences, XLRI Jamshedpur, XLRI Jamshedpur, Circuit House Area (East), 831001, Jamshedpur, Jharkhand, India, dbose.iimc@gmail.com, *Ashis Chatterjee*, *Samir Barman*

In this paper, we identify the relative gain from multi-skilled workforce over specialized workforce in call center business. The allocation of manpower is either based on approximate call volume or the actual call volume provided by client. The problem is similar to a single period stochastic optimization model. Assuming call volume follows multivariate normal distribution; we use Sample Based Optimization for computational study. We propose some guidelines for the investment in multi-skilled workforce. Additionally, we examine the effects of Service Level Agreement (SLA) on the decision.

4 - Optimal strategies in identifying working risk factors
Catarina Marques, BRU - Business Research Unit, Instituto Universitário de Lisboa, Av. das Forças Armadas, 1649-026 , Lisbon, Portugal, cmvamarques@gmail.com, *José G. Dias*

This study explores optimal strategies in dealing with unobserved heterogeneity in the context of working conditions. A clusterwise strategy avoids stuck-in-the-middle solutions, and provides a better projection of the optimal solution into a low-dimensional space. This segment-level method identifies risk factors underlying working conditions as well as optimal allocation strategies using concomitant variables. Model calibration is performed at European level using survey data and provides important insights at country level.

■ HB-04

Thursday, 10:30-12h00
O4-4

Applications of Global Optimization

Stream: Convex Optimization
Invited session

Chair: *Fabio Schoen*, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Firenze, via di Santa Marta, 3, 50139, Firenze, Italy, fabio.schoen@unifi.it

1 - Inversion of a Neural Network via Global optimization
Veronica Piccialli, Dipartimento di Ingegneria Civile e Ingegneria Informatica, Università degli Studi di Roma Tor Vergata, via del Politecnico, 00133, Rome, Italy, piccialli@disp.uniroma2.it, *Fabio Schoen*, *Marco Sciandrone*

Neural networks are tools for the approximation of input-output mappings represented by a set of data observations. In many applications, the inversion process, i.e., finding one or more input values that produce a desired output given a trained neural network, is of particular interest. The inversion of a neural network may lead to different global optimization problems. In this talk, we present some solution algorithms for different inversion problems and we report numerical results both on academical problems and real world applications.

2 - A dual support method for SVM training
Brahmi Belkacem, LAMOS Laboratory, Operations Research Departement, University of Bejaia, Cedex 02 BP 203, Darguina, Bejaia, Algeria, bra_belka@yahoo.fr, *Bibi Mohand Ouamer*

We present a new dual method for solving SVM training problems that combines adaptive methods and decomposition approach. This approach is iterative and composed in two phases: the first phase is the construction of the dual solution and the second reach the optimal solution for the dual SVM problem formulation. Numerical experiments on the dataset UCI show that our approach is effective for solving SVM problems.

3 - Exact Method for Maximizing Convex Quadratic Programming
Ahmed Chikhaoui, Computer Sciences, UNIVERSITY TIARET, TIARET ALGERIA, TIARET, Algeria, AH_CHIKHAOUI@YAHOO.FR

The aim of this paper is to present a new algorithm for maximizing a convex quadratic programming problem. Constraints are linear. The stopping criterion is a test of the combination of the cost function allows. The optimal solution is an exact solution and is always a peak when it is unique. A significant result is that the double product does not affect the accumulation of the function. The structure of the algorithm is very similar to simplex method for the linear case.

■ HB-05

Thursday, 10:30-12h00
O4-1

Stochastic Optimal Control

Stream: Optimal Control
Invited session

Chair: *Eugene Khmelnitsky*, Industrial Engineering, Tel Aviv University, Lebanon Str., 69978, Tel Aviv, Israel, xmel@tau.ac.il

1 - Optimal control in semi-markov model with periodically happening exterior actions

Peter Shourkoff, Higher mathematics, National Research University Higher School of Economics, Bolshoy Trehsvyatitelsky side street, bld. 3, 109028, Moscow, Russian Federation, shnourkoff@gmail.com

The stochastic semi-Markov model with periodic exterior actions is developed and investigated. Our model describe various dynamic systems in technics and economy. A model basis is the semi-Markov process with finite set of states which periodically reaches boundary values of considered set of states. After reaching of boundary value process is exposed to exterior action or control. As a result of such action process is transferred into one of inwardnesses which conditionally are considered as possible. We prove that the strategy of exterior actions is optimal.

2 - Growth Rates and Average Optimality in Risk-Sensitive Markov Decision Chains

Karel Sladky, Department of Econometrics, Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic, Pod Vodarenskou vezi 4, 18208, Prague 8, Czech Republic, sladky@utia.cas.cz

Risk-sensitive optimality is studied in Markov Decision Chains, i.e., cumulative rewards generated by a Markov chain are evaluated by an exponential utility function with a given risk sensitivity and we are interested in expectation of the resulting utility function. Necesssary and sufficient optimality conditions for the growth rates of expected utility as well as for mean value of the corresponding certainty equivalent (in general depending also on the starting state) along with policy and value iteration methods for finding optimal control policy will be discussed.

3 - Stochastic optimal control problem for linear switching systems

Nergiz Kasimbeyli, Industrial Engineering, Anadolu University, Anadolu University, Faculty of Engineering, ESKİSEHİR, Turkey, nkasimbeyli@anadolu.edu.tr, *Charkaz Aghayeva*

Optimal control problem for switching systems are actual at present. Earlier the problems of stochastic optimal control of nonlinear switching systems were considered and necessary condition of optimality is obtained. The present work is devoted to the optimal control problem of linear stochastic switching system. The contribution of this paper is to present a necessary and sufficient condition of optimality for linear quadratic optimal control problem for a switching systems with constraints.

4 - Optimal control of a two-state markov chain

Eugene Khmelnitsky, Industrial Engineering, Tel Aviv University, Lebanon Str., 69978, Tel Aviv, Israel, xmel@tau.ac.il

We consider an optimal control problem for minimizing a total discounted cost of the dynamics of a two-state Markov chain and propose a new methodology for studying properties of optimal control. The necessary optimality conditions in the form of the maximum principle allow studying the state-costate dynamics over the regular and singular control regimes. By making use of the properties of the costate process we prove the optimality of a threshold policy and calculate the value of the threshold in a general case as well as in a specific case of the cost function.

■ HB-06

Thursday, 10:30-12h00
O4-2

Variational Analysis, Generalized Differentiation and Optimization

Stream: Generalized Differentiation and Optimization
Invited session

Chair: *Ewa Bednarczuk*, Modelling and Optimization of Dynamical Systems, Systems Research Institute, Warsaw, Poland, bednarcz@ibspan.waw.pl
Chair: *Alexander Kruger*, School of Science, Information Technology & Engineering, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

1 - Primal attainment in convex infinite-dimensional optimization duality

Marco A. López-Cerdá, Statistics and Operations Research, Alicante University, Ctra. San Vicente de Raspeig s/n, 3071, Alicante, Spain, marco.antonio@ua.es

In this talk we present some conditions guaranteeing that the optimal value of a given infinite-dimensional convex optimization problem and its corresponding surrogate Lagrangian dual coincide, and also that the primal optimal value is attainable. The conditions ensuring this kind of converse strong Lagrangian duality involve the weakly-inf-(locally) compactness of suitable functions and the linearity or relative closedness of some sets depending on the data. Some applications are given, including an extension of the Clark-Duffin theorem for ordinary convex programs.

2 - About an Infinite Intersection Rule

Alexander Kruger, School of Science, Information Technology & Engineering, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au, *Marco A. López-Cerdá*

An important group of calculus results in variational analysis consists of rules which allow to represent normals (of a certain type: convex, Fréchet, limiting or other) to the intersection of a finite collection of sets at a point via normals to particular sets at or around this point. Using the extended version of the Extremal principle, it is possible to develop an intersection rule for Fréchet normals to infinite intersections in Asplund spaces.

3 - On the concept of criticality for vector-valued functions

Ewa Bednarczuk, Modelling and Optimization of Dynamical Systems, Systems Research Institute, Warsaw, Poland, bednarcz@ibspan.waw.pl

In the present talk we propose the definition of the criticality for vector-valued functions based on the concept of quasi-relative interior. This allows us to make the concept of criticality operational for vector optimization problems where the interior of the order generating cone is empty. Based on the introduced concept we prove necessary optimality conditions for closed convex pointed cones and cone-convex vector-valued functions as well as for closed convex pointed generating cones and general directionally differentiable vector-valued mappings.

4 - SECOND-ORDER ANALYSIS IN CONIC PROGRAMMING: Applications to stability and optimality

Hector Ramirez, Mathematical Engineering Department, Universidad de Chile, Avda. Blanco Encalada 2120, Piso 5, Santiago Centro, Santiago, RM, Chile, hramirez@dim.uchile.cl

This talk is devoted to the study of a broad class of problems in conic programming. In this framework we develop a second-order generalized differential approach of variational analysis to calculate appropriate derivatives and coderivatives of the corresponding solution maps. These developments allow us to provide verifiable conditions for isolated calmness and for the Aubin property of the considered solution maps.

■ HB-07

Thursday, 10:30-12h00
O4-3

Nonlinear Optimization and Applications II

Stream: Nonlinear Programming
Invited session

Chair: *Simone Göttlich*, School of Business Informatics and Mathematics, University of Mannheim, A 5, 6, Mannheim, 68131, Germany, goettlich@uni-mannheim.de

1 - Optimizing geometries in complex networks
Christian Ringhofer, Arizona State University Tempe, 85287-1804, Arizona, United States, ringhofer@asu.edu, *Michael Herty*

Flows on complex networks, such as air travel systems and production networks, can be modeled by systems of stochastic differential equations. To obtain macroscopic information about the dynamic transport picture, we reorganize the underlying graph structure to allow for a homogenization limit, leading to a relatively simple advection - diffusion equation for the large time behavior of macroscopic densities. This leads to a nonlinear optimization problem for the node coordinates.

2 - The connection between combinatorial and continuous optimization for a class of traffic flow network models
Sebastian Kühn, Mathematics, University Kaiserslautern, Postfach 3049, 67653, Kaiserslautern, Rheinland-Pfalz, Germany, skuehn@mathematik.uni-kl.de, *Oliver Kolb*, *Simone Göttlich*

We present two solution approaches for the optimization of a linearized traffic flow network model based on conservation laws. One relies on the classical Lagrange formalism, whereas the other uses a discrete mixed-integer framework. We compare both approaches and show the relation between both approaches theoretically. Furthermore we present the result of some numerical experiments showing the quality of the solutions.

3 - Analytic derivatives: symbolic versus automatic
Zsolt Csizmadia, Xpress, FICO, FICO House, Starley Way, Birmingham, United Kingdom, zsoltcsizmadia@fico.com

Automatic differentiation is an efficient and often the only viable method for calculating dense or large Hessian matrices. Symbolic derivatives are easy to interpret, efficient to recalculate if only a certain position needs to be perturbed and recognizing repetitions is straightforward. The talk will compare the challenges in implementing efficient first and second order symbolic and automatic differentiation tools. We will provide some insights into how to select the best tool for a non-linear solver, assuming the solver has full access to the derivative engine.

4 - Optimizing Battery Load Schedules
Inken Olthoff, Zuse Institute Berlin, Germany, olthoff@zib.de

As the influence of renewable energy grows, also the flexible storage of energy in batteries gains in importance. One aspect is constructing battery load schedules, which provide charging and discharging periods while considering the properties of battery and power grid. The main challenge is to deal with the nonlinear loss of energy while discharging the battery. In this talk, we will describe the Battery Scheduling Problem and discuss different solving strategies. Taking into account sudden changes in the parameters, we need a strategy which finds good solutions in a reasonable time.

■ HB-08

Thursday, 10:30-12h00
O3-2

Keynote - S. Mehrotra

Stream: Invited Lectures - Keynotes and Tutorials
Keynote session

Chair: *Christos Vasilakis*, Clinical Operational Research Unit, University College London, 4 Taviton Street, WC1H 0BT, London, United Kingdom, c.vasilakis@ucl.ac.uk

1 - Optimizing Healthcare: Budgets, Operations, Policies, and Beyond
Sanjay Mehrotra, Industrial Engineering and Management Sciences, Northwestern University, C246, Tech, 2145 Sheridan Road, 60208, Evanston, IL, United States, mehrotra@northwestern.edu

Healthcare, particularly in US, is a large and complex system. Policies are determined based on legislated priorities, and decisions are often made based on suboptimal algorithms. There is a growing interest in optimal resource utilization, while preserving the ethical equipoise between equity, justice and utility in healthcare. Solutions require a transdisciplinary collaborative approach, where industrial and systems engineers, operations researchers, and management scientists can make significant contributions by developing realistic data-driven and model based approaches to promote evidence based decision making and informing policy changes. The need to bring greater realism to the decision models also motivates new methodological developments that can then benefit application in areas other than health. The central consideration in developing innovative strategies to improve the health system is to save patients' lives and to improve their quality of life. This must be balanced against risks and cost to individuals and society. This leads to problems with multiple objectives, and input from multiple experts weighing in on these objectives. The parameters of the functions modeling the objectives and constraints are uncertain as model recommendations have implications on future unknown.

Through a wealth of application problems, in this presentation we will first discuss the broader healthcare perspective, and the need and opportunities for the participation of our community. We will then focus on a few specific examples from our research illustrating the need for developing, and the use of recently introduced concepts such as robust Pareto optimality and risk adjusted decision making in the context of addressing geographic disparity in budgeting US national diabetes prevention programs, and a national policy analysis in kidney transplantation described below.

Kidney transplantation leads to longer survival, better quality of life, and significant cost savings for End Stage Kidney Disease (ESKD) patients. Kidney transplantation, however, is marred by a scarcity of kidney organs for transplantation with almost 100,000 individuals in the US on the waiting list for kidney transplantation. Despite efforts, the total number of deceased and living organ donations remains flat at about 12,000. Moreover, ESKD patient waiting time varies from one to five years depending on their area of residence. Treatment of ESKD patients through hemodialysis costs the US over $40 billion, and waiting times and wait list mortality is at an all-time high. We will present results, and share lessons learned from our five year long transdisciplinary collaboration with leading transplant surgeons, nephrologists, health ethicists, and national kidney transplant policy leaders resulting in an evidence and data-driven model based recommendation for policy changes. The modeling framework had to intertwine optimization with simulation modeling in a novel way; and the recommendations are based on analysis with over 20 years of longitudinal data with additional information collected through real-life surveys.

■ HB-09

Thursday, 10:30-12h00
O3-3

Sponsor - IBM 3

Stream: Sponsors
Sponsor session

Chair: *Mauro Dell'Amico*, DISMI, University of Modena and Reggio Emilia, Via Amendola 2, 42122, Reggio Emilia, Italy, dellamico@unimore.it

1 - On deploying successful optimization applications
Sofiane Oussedik, IBM, France, soussedik@fr.ibm.com

This presentation will give you an insight into recent ILOG optimization developments including a new generation of integrated tools and engines for optimization modeling and application development. Optimization applications developments are driven by the need to accomplish key business objectives and rapidly deploy the right flexible solutions. Use cases will be presented highlighting the encountered challenges as well as the ease-of-use of the development environments and seamless integration to build interactive Optimization based planning and scheduling applications.

■ HB-10

Thursday, 10:30-12h00
G5-1

Forecasting Tools for Online Risk Management

Stream: Risk Management in Online Social Networks
Invited session

Chair: *Vegard Engen*, IT Innovation Centre, University of Southampton, United Kingdom, ve@it-innovation.soton.ac.uk

1 - Macro-level risk management for online communities

Edwin Tye, Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, United Kingdom, et4g08@soton.ac.uk, *Joerg Fliege*, *Thanos Avramidis*

Online communities are a natural way to socialize; businesses build their own platforms to promote interaction between customers. Certain risks need to be managed for these platforms to flourish. We focus on unbalanced role proportions, where the role of a user is defined by their online behaviour (lurker, spammer, expert, etc.). We propose a compartment model which forecasts roles of participants dynamically by using in-sample forecasting to estimate future migration rates based on past observations. Consequently, community managers are enabled to intervene and proactively manage risks.

2 - Micro-Level Risk Management in Online Communities

Philippa Hiscock, Mathematics, University of Southampton, University Rd, SO17 1BJ, Southampton, Hampshire, United Kingdom, P.A.Hiscock@soton.ac.uk, *Joerg Fliege*

Online communities are capable of generating substantial value to their owners; size can exceed millions of users. Risk analysis of such business components is crucial to good management. We propose a risk framework specific to the management of micro level risks, e.g., risk of a user leaving etc. Specifically, we consider risks as discrete events; for an observation the event does, or does not occur. To predict such a response, we estimate a Bayesian probit model via a Gibbs sampler. Low level observations can then be flagged for the attention of the community owner.

3 - Using Structural Aspects to Find Susceptible Users in Social Networks

Hemank Lamba, Social Network Analysis, IBM Research, India, Plot No. 4, Phase 2, Block - C, ISID Campus, Institutional Area, Vasant Kunj, 110070, New Delhi, Delhi, India, helamba1@in.ibm.com, *Ramasuri Narayanam*

We consider the phenomenon of influence in social networks. We claim that the structural aspects of the network are better indicators to estimate the extent to which each individual is influenced by his/her neighbors in the network. For this, we develop a regression model that uses a few significant network based features such as degree and centrality. We also validate our claim using thorough experimentation on several social network data. To the best of our knowledge, ours is the first attempt in the literature to estimate the network influence from network structural properties.

4 - A Framework for Proactive Risk Management of Online Communities

Vegard Engen, IT Innovation Centre, University of Southampton, United Kingdom, ve@it-innovation.soton.ac.uk, *Bassem Nasser*, *Paul Walland*

Online communities can generate significant value to business, playing a pivotal role in innovation, marketing, corporate expertise management, product support and advertising. We present a novel and proactive method for managing online communities by modelling and monitoring risks threatening the general health or specific objectives of a community. Our solution is a risk management framework that goes beyond existing tools, supporting advanced analytical services for predicting whether risks are likely to occur in the future and what their impact on the community may be.

■ HB-11

Thursday, 10:30-12h00
G5-3

Location Applications

Stream: Location Analysis
Invited session

Chair: *Juliana Niño Vargas*, Universidad Industrial de Santander, Colombia, juliana.ing.ind@gmail.com

1 - A new methodology for locating bank branches: A case study in Turkey

Özgür Kabak, Industrial Engineering Dept., Istanbul Technical University, Isletme Fakültesi Maçka, 34357, Istanbul, Turkey, kabak@itu.edu.tr, *Ayfer Basar*, *Y. Ilker Topcu*

Finding appropriate places for branches is a strategic decision for banks. Banks consider various criteria depending on their policy, vision, etc. while making this decision. However, scientific contribution in this area is very limited. This study presents a 3 stage methodology. In the first stage, criteria are identified depending on literature review and experts' opinion. Then, importance of criteria is determined using experts' judgment and Regression Analysis. Finally, a new mathematical model is proposed to find suitable places for bank branches. The methodology is applied in Turkey.

2 - A Branch and Bound Algorithm for Pharmacy Duty Scheduling Problem

Gökhan Ceyhan, Industrial Engineering, Middle East Technical University, Çankaya, Metu campus, 06800, Ankara, Turkey, gceyhan@metu.edu.tr, *Ozgur Ozpeynirci*

In this study, we develop a branch and bound (B&B) approach for the pharmacy duty scheduling (PDS) problem. PDS is about assigning duties to a set of pharmacies on each day of the planning horizon under the regional constraints and the duty numbers that a pharmacy can be assigned. PDS is a multi-period facility location problem and it is NP-Hard. We propose different branching approaches and study on alternative lower and upper bounds. We test the algorithms on randomly generated instances. This study is supported by the Scientific and Technological Research Council of Turkey, Grant 111M107.

3 - Supply chain optimization for location of a second-generation bioethanol plant

Alexandra Duarte, Ingeniería Industrial, Universidad Nacional de Colombia Sede Manizales, Cra 25 #58-65, Manizales, Caldas, Colombia, aeduartec@unal.edu.co, *William Sarache*, *Carlos Ariel*

The main objective of this research is to address the location decision of a second-generation bioethanol plant for the processing of a coffee crop waste known as Coffee Cut Stem. The research shows the results of the feasibility study and process optimization together with the development of a mixed-integer linear programming model to find optimal location in the Colombian coffee region. The mathematical model optimizes the process performance and establishes material flow between supply chain nodes.

4 - A mathematical model based on binary integer linear programming to determinate Distribution Centers location

Juliana Niño Vargas, Universidad Industrial de Santander, Colombia, juliana.ing.ind@gmail.com, *Henry Lamos*, *Néstor Raúl Ortiz Pimiento*

In this research a mathematical model for Distribution Center location is presented. To achieve this goal, we focused on a binary integer linear programming approach, considering customers and suppliers location, transportation cost, and fixed costs as installation cost, labor cost, among others. The model's objective is the minimization of total cost. In addition, this model was validated in a real life case study in a textile trading company in Colombia, using the software GAMS. The results show an improvement of the total cost compared with the current company's distribution network.

■ HB-12

Thursday, 10:30-12h00
G5-4

Recent Advances in Dynamics of Variational Inequalities II

Stream: Recent Advances in Dynamics of Variational Inequalities and Equilibrum Problems
Invited session

Chair: *Monica-Gabriela Cojocaru*, Mathematics & Statistics, University of Guelph, Guelph, Ontario, Canada, mcojocar@uoguelph.ca

1 - Variational inequalities and applications to network models

Patrizia Daniele, Department of Mathematics and Computer Science, University of Catania, Viale A. Doria, 6, 95125, Catania, Italy, daniele@dmi.unict.it

In this talk we show how many problems of topical interest such as: transportation networks, spatially distributed economic markets, supply chain network models, financial equilibrium problems, static electric power supply chain networks, ..., can be studied in the framework of variational inequalities which express in a compact and handy form the equilibrium conditions. Moreover, we are able to characterize the above problems by means of Lagrange variables and make explicit the connection between projected dynamical systems on Hilbert spaces and evolutionary variational inequalities.

2 - A Multi-Period Dynamic Optimization Approach for Pricing and Capacity Management in the Transportation Sector

Ezgi Seremet, Industrial Engineering, Koc University, Rumelifeneri Yolu Koc Universty, İstanbul, Turkey, eseremet@ku.edu.tr, *Metin Turkay*

In this study capacity allocation and pricing problem of transportation sector is addressed based on revenue function in the dynamic programming model with uncertain demand. Decision period is divided into time units and during each time unit a certain number of booking request is arrived with a characteristic of three dimensions. The carrier has to decide whether to accept the upcoming booking request or not according to remaining capacity and weight, volume and type of the cargo.

3 - Descent and approximation techniques for solving equilibrium problems

Mauro Passacantando, Department of Computer Science, University of Pisa, Largo B. Pontecorvo 3, 56127, Pisa, Italy, mpassacantando@di.unipi.it

Most descent methods for equilibrium problems (EPs) need to solve a convex optimization problem for evaluating the gap function, but such an evaluation may be computationally expensive. In this talk we propose two different approaches to overcome this drawback. In the first approach EPs with nonlinear constraints are solved exploiting gap functions based on a polyhedral approximation of the feasible region, together with a possibly unfeasible search direction which requires exact penalties. The second approach is based on inexact evaluations of the gap function and a nonmonotone line search.

4 - Applications of Variational Inequalities in Supply Chain Management — Status Quo and Future Directions

Tina Wakolbinger, WU (Vienna University of Economics and Business), Nordbergstraße 15, Vienna, Austria, tina.wakolbinger@wu.ac.at, *Jose Cruz*

In this talk, we will provide an overview of the application of variational inequality theory in the context of supply chain management. The talk will describe recent developments with respect to research questions addressed, model settings and assumptions chosen, and computational procedures applied. Current research gaps and future directions for research will be highlighted.

■ HB-13

Thursday, 10:30-12h00
G5-5

Freight transport

Stream: Traffic
Invited session

Chair: *Tabitha Maes*, Research Group Logistics, Hasselt univeristy, Belgium, tabitha.maes@uhasselt.be

1 - A mathematical model for multimodal horticultural transportation planning

Maryam SteadieSeifi, IE&IS, Technische Universiteit Eindhoven, OPAC, Paviljoen E.11, Den Dolech 2, 5612 AZ, Eindhoven, Netherlands, m.steadie.seifi@tue.nl, *Nico Dellaert*, *Wim Nuijten*, *Tom Van Woensel*

We present an optimization model for tactical planning of a horticultural transportation system with multiple transportation modes, highly perishable products, demand and supply dynamics, and management of the reusable transport units (RTIs). The model is an extension to the network flow problem. We integrate dynamic allocation and repositioning of the RTIs with a synchronized flow of products, in order to find the trade-off between quality requirements and operational considerations and costs. We also present detailed computational results and analysis.

2 - A truck scheduling model for the hub-and-spoke logistics network with limited docks

Ying-Yen Chen, Marketing and Transportation / Logistics, Toko University, No.51, Sec. 2, Syuefu Rd., Puzih City, 61363, Chiayi County, Taiwan, yy.chen@mail.toko.edu.tw

In a limited spatial country, like Taiwan, the space of a hub in a logistics network is relative small and hard to be expanded. Every evening, several trucks queue up outside the hub. This decreases the efficiency of the hub operators and the truck drivers. In this paper, the author develops a truck scheduling model for the hub-and-spoke logistics network with limited docks. The objective is to determine the optimal truck schedules from depots to the hub with minimal driver waiting times. Some test problems are generated and Cplex software is used to try to solve these problems.

3 - An exact method to schedule the internal process of cross-dock

Mohammad yousef Maknoon, Mathematics and industrial engineering, Polytechnique Montreal, Canada, mohammad-yousef.maknoon@polymtl.ca, *Francois Soumis*, *Pierre Baptiste*

A cross-dock is a platform with the role of bundling receiving freights with the same destination to have full outgoing truckloads. In this presentation, we introduce an exact method for scheduling the internal process of cross-docking terminals. The presented model synchronizes the serving order of trucks with internal transferring and provides a detailed operational plan. A specialized branching algorithm is developed. Several structural properties and a heuristic method are proposed to enhance the algorithm. Computational experiments represent the efficiency of the developed method.

4 - A pickup and delivery selection problem with compulsory requests in an activity-based transportation framework
Tabitha Maes, Research Group Logistics, Hasselt univeristy, Belgium, tabitha.maes@uhasselt.be, *An Caris*, *Katrien Ramaekers*, *Gerrit K. Janssens*

In an activity-based transportation framework the decisions of agents are simulated to predict future freight flows. One of these agents is the carrier who daily receives multiple transport requests. In order to optimize his profit he has the liberty to refuse transport requests which are not profitable. However, a number of clients cannot be refused because of long-term contracts. The received transport requests consist of paired pickup and delivery locations and orders are less-than-truckload. A tabu-embedded simulated annealing algorithm is developed to solve the problem.

■ HB-14

Thursday, 10:30-12h00
G5-6

Intermodal Routing and Scheduling

Stream: Vehicle Routing and Scheduling with Environmental Considerations
Invited session

Chair: *Simona Mancini*, Department of Computer Sciences and Automatic Control, Politecnico di Torino, via castelgomberto 75, 10137, Torino, Italy, simona.mancini@polito.it

1 - An optimization algorithm for a Vehicle Routing Problem with backhauls and splits
Massimo Di Francesco, Department of Mathematics and Computer Science, UNIVERSITY OF CAGLIARI, 09124, CAGLIARI, Italy, mdifrance@unica.it, *Maria Battarra*, *Michela Lai*

In intermodal transportation carriers often deal with the distribution of loaded and empty containers by trucks. Our objective is to determine optimal routes such that all customers are served, importers are serviced before exporters, truck capacities hold, while allowing multiple visits at each customer. The proposed solution method builds separate routes for importers and exporters by a Tabu Search. Next, they are matched by an integer programming model. An Adaptive Guidance mechanism is used as a diversification component to generate routes that can be matched in a cost-effective way.

2 - Time-space Service Network Design for Intermodal Freight Transportation
Yi Qu, Southampton Management School, University of Southampton, 8 Duncan Hood Court, 57a Harrison Road, SO17 3TN, SOUTHAMPTON, Hants, United Kingdom, Y.Qu@soton.ac.uk, *Tolga Bektas*, *Julia Bennell*

This paper describes a time-space service network design model for intermodal freight transportation, where the objective is to minimize internal and external costs, including those of emissions, intermodal transfers and inventories. For a given set of demands, the model determines the routes and transport modes, and the flow distribution. Computational results based on a case-study intermodal data generated from the UK transportation network are presented.

3 - A frequency based approach for container assignment on an intermodal network: challenges, issues and formulations
Simona Mancini, Department of Computer Sciences and Automatic Control, Politecnico di Torino, via castelgomberto 75, 10137, Torino, Italy, simona.mancini@polito.it, *Maurizio Arnone*, *Andrea Rosa*

In this talk we address the container assignment on an intermodal network, composed by two different and separated legs, the maritime and the inland ones. We introduce different issues arising in this context, like the importance which each leg may assume in the path choice process, and the role of the intermodal exchange centers.The influence of time aspects, environmental issues and transportation costs on the decision process is also taken into consideration. We propose a MIP formulation of the problem and report and analyze computational results obtained on a real case.

4 - Analysing the suitability of urban and regional intermodal systems for urban supply planning and management
Jesus Gonzales-Feliu, CNRS, Centre National de la recherche francaise, 10100, Lyon, France, jesus.gonzales-feliu@let.ish-lyon.cnrs.fr, *Florent Laroche*, *Noemie Boissier*

This paper aims to propose a method to analyse the suitability of short-haul intermodal systems for urban supply. First, the problem of urban consolidation and the main bundling strategies related to it are presented. Then, the problem is formalised and the solution method is presented. A constructive heuristic method with focused local search post-optimisation is proposed to solve analyse real-size instances in suitable time. Finally, a solution problem analysis from a scenario simulation is carried out to identify the operability and applicability of such method.

■ HB-15

Thursday, 10:30-12h00
G5-2

Hinterland & Competition

Stream: Container Terminal Operations
Invited session

Chair: *Kap Hwan Kim*, Industrial Engineering, Pusan National University, Jangjeon-dong, Gunjeong-gu, 609-735, Busan, Korea, Republic Of, kapkim@pusan.ac.kr

1 - Allocating Appointment Times for Truck Arrivals by Multiple Trucking Companies at Container Terminals
Kap Hwan Kim, Industrial Engineering, Pusan National University, Jangjeon-dong, Gunjeong-gu, 609-735, Busan, Korea, Republic Of, kapkim@pusan.ac.kr, *Maiha Phan*

An important issue for a successful implementation of the truck appointment system is how to adjust appointment times of truck arrivals from multiple trucking companies. This study proposes a framework in which multiple trucking companies and the terminal operator arrive at the final decisions on the arrival times of trucks with which all the related participants satisfy and the total cost including that from CO2 emission is minimized at the same time. A non-linear programming model is suggested for the problem.

2 - The impact of empty container relocation with foldable containers on cost savings for hinterland transport of seaports
Koichi Shintani, School of Marine Science and Technology, Tokai University, 3-20-1 Orido, Shimizu, 4248610, Shizuoka, Shizuoka, Japan, shintani@tokai-u.jp, *Yoshiaki Ishihara*, *Rob Konings*, *Akio Imai*

This study analyzes the impact of foldable containers on cost savings in empty container relocation in the hinterland transport of seaports. We model empty container relocation by trucks as a vehicle routing problem with pickup and delivery. An ant colony algorithm-based heuristic is developed for the problem. Numerical experiments are carried out with realistic empty container repositioning scenarios in the hinterland. The study finds that foldable containers can significantly reduce the number of trips and trip length of truck haulage compared to standard containers.

3 - Joint design and pricing of port hinterland freight network services
Rob Zuidwijk, Decision and Information Sciences, RSM Erasmus University, Postbus 1738, 3000 DR, Rotterdam, Netherlands, rzuidwijk@rsm.nl, *Panagiotis Ypsilantis*

Container terminal operators actively participate in landside transport networks to enhance their connectivity to destinations inland and relieve negative effects of freight transportation. They have developed so-called extended gates in which sea port container terminals are connected to inland container terminals via frequent services via river vessel and train. We formulate the joint design and pricing of such freight network services as a bi-level mathematical program. A solution approach and some numerical results together with managerial insights are presented and discussed.

■ HB-16

Thursday, 10:30-12h00
G5-7

Practical Routing Problems under Uncertainty

Stream: Routing Problems
Invited session

Chair: *Jenn-rong Lin*, Department of Transportation Science, National Taiwan Ocean University, 2, Pei-Ning Road, 20224, Keelung, Taiwan, jrlin@mail.ntou.edu.tw

1 - Distribution systems design with two-level routing considerations under demand uncertainty

Jenn-rong Lin, Department of Transportation Science, National Taiwan Ocean University, 2, Pei-Ning Road, 20224, Keelung, Taiwan, jrlin@mail.ntou.edu.tw

We formulate and analyze a strategic design model for three-echelon distribution systems with two-level routing considerations under demand uncertainty. A hybrid genetic algorithm embedded with a simulated annealing routing heuristic is developed to efficiently find near-optimal solutions. At last, the model is applied to design a national finished goods distribution system for a Taiwan label-stock manufacturer. Through the case study, we find that the inclusion of big clients in the first-level routing and the inclusion of demand uncertainty in the analysis lead to a better network design.

2 - A special case of the vehicle routing problem with stochastic travel time

Sena Kir, Industrial Engineering, Sakarya University, Sakarya, Turkey, senas@sakarya.edu.tr, *Harun Yazgan*

In this study, we consider a delivery problem of the small and medium enterprises in Istanbul. The vehicles with different loading capacity are routed to the customers, the suppliers and the sub-suppliers considering time window constraints on variable traffic density. In our problem, the delivery between suppliers and their sub-suppliers is considered. It causes to get route the sub-suppliers twice on different time window and necessitates fixed sub-routes. We aimed to determine the lowest cost routes by using heuristic procedures under the constraints.

3 - A stochastic vehicle routing model and its specifications

Evangelia Chrysohoou, Mechanical Engineering, University of Thessaly, Pedio Areos, 38334, Volos, Greece, echryso@certh.gr, *Athanasios Ziliaskopoulos*

Evolution of emerging technologies of Freight ITSs requires research and development of new models and algorithms that can incorporate their advantages. Stochastic vehicle routing is considered as a methodological approach that seems to be the most promising to account for inherent uncertainties to the freight system. In this context this paper proposes a stochastic programming model with recourse for the VRP. Feasibility and optimality considerations are discussed. The importance of incorporating randomness in the model is considered and the expected value of perfect information is evaluated.

4 - A vehicle routing problem with random components for collecting perishables

Elsa Cristina Gonzalez La Rotta, INDUSTRIAL ENGINEERING, Universidad Católica de Colombia, CARRERA 87 A 6 A 15 TORRE 12 APTO 602, Colombia, ecgonzalez@ucatolica.edu.co, *Javier Arturo Orjuela Castro*

We show an application of vehicle routing problem in this specific sector: the collection of flowers from the production areas to the factory. We propose a model that considers various stochastic variables such as the amount of flowers offered by each source, travel time and service, and others. From the work of Gendreau 2010 et al we established a new formulation. The solution is obtained by statistical methods, mathematical optimization and Monte Carlo simulation. Once collected the data, are analyzed model outputs to generate a cost function which can be minimized.

■ HB-17

Thursday, 10:30-12h00
G5-8

Liner shipping

Stream: Maritime Transportation
Invited session

Chair: *Berit Dangaard Brouer*, DTU Management Engineering, Technical University of Denmark - DTU, Bygning 426, 2800, Kongens Lyngby, Denmark, blof@man.dtu.dk
Chair: *Fernando Alvarez*, Goteborggata 9, 0566, Oslo, Norway, jfa2@cornell.edu

1 - Optimizing ship speed and buffer time in liner shipping

Rommert Dekker, Erasmus University Rotterdam, Econometric Institute, Erasmus University Rotterdam, P.O. Box 1738,, 3000 DR , Rotterdam, Netherlands, rdekker@few.eur.nl, *Judith Mulder*

In liner shipping, ships can encounter delays both when they are sailing and when they are berthing in a port. When ships are delayed, they can reduce their delay by taking recovery actions, like increasing speed against certain costs. A higher speed, however also increases the CO2 emissions. Furthermore, buffer time can be incorporated in the route schedule to capture the delay. The goal of the ship delay recovery problem is to determine simultaneously a recovery policy and buffer time allocation. The problem is modeled using a Markov decision process with additional integer constraints.

2 - A rule-based encoding genetic algorithm applied to the container ship stowage problem

Luziana Ferronatto Carraro, Computação Aplicada, UNISINOS, Rua MANOEL PETERLONGO FILHO,377, BL02 APTO 403, 95720000, GARIBALDI, RS, Brazil, luzianacarraro@gmail.com, *Leonardo Chiwiacowsky*

With the expansion of the use of containers, the problem of determine a proper stowage plan in a container ship arose. Since containers are placed on stacks, blocking containers should be shifted to unload below containers. To minimize undesired movements, a genetic algorithm was used. The solutions were encoded by using different rules, based on strategies to represent loading and unloading processes. Tests were carried out assuming ships with different capacities and different transportation matrices. Experiments showed that better solutions are achieved as more rules are considered.

3 - Optimizing Dry-Port-based Freight Distribution Planning

Antonino Sgalambro, Istituto per le Applicazioni del Calcolo "Mauro Picone", National Research Council (CNR), Via dei Taurini 19, 00185, Roma, Italy, a.sgalambro@iac.cnr.it, *Teodor Gabriel Crainic*, *Paolo Dell'Olmo*, *Nicoletta Ricciardi*

In this talk we consider the tactical planning problem of defining the optimal routes and schedules for the fleet of vehicles providing transportation services between the terminals of a dry-port based intermodal system. An original service network design model based on a mixed integer programming mathematical formulation is proposed to solve the considered problem. An experimental framework built upon realistic instances inspired by regional cases is described and the computational results of the model is presented and discussed.

■ HB-18

Thursday, 10:30-12h00
G5-9

Advances in Stochastic Programming

Stream: Simulation, Stochastic Programming and Modeling (contributed)
Contributed session

Chair: *Leonidas Sakalauskas*, Operational Research, Institute of Mathematics & Informatics, Akademijos 4, LT-08663, Vilnius, Lithuania, sakal@ktl.mii.lt
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Semih Kuter*, Department of Forest Engineering, Cankiri Karatekin University, Cankiri Karatekin Universitesi, Orman Fakultesi, 18200, Cankiri, Turkey, semihkuter@yahoo.com

1 - Stochastic Programming for Scaling Measures
Uma Shankar, O.R. and S.Q.C., Rayalaseema University, 12345, Kurnool, Andhra Pradesh, India, drcuma.shankar@gmail.com, *Tirupathi Rao Padi*

In this paper we develop a stochastic programming problem for certain statistical measures, with selected constraints based on the essential requisites of valid scaling measures. The focus is mainly on the formulation of modeling the statistical scaling measures followed by formulation of optimization programming problem. Expedition of Bivariate stochastic processes with spread sheet quantification experiments is considered to the proposed model development. Another objective is to explore the decision variables (parameters) of the Stochastic Model from the formulated programming problem.

2 - Numerical Method for two-stage stochastic programs with chance constraints
Paul Bosch, Engineering Faculty, Diego Portales University, Ejercito 441, Santiago, 298-V, Santiago de Chile, Chile, paul.bosch@udp.cl

We extent the two-stage linear stochastic program by adding probabilistic constraints in the second stage and we describe how the two-stage stochastic programs with mixed probabilities can be treated computationally. We obtain a convex conservative approximations of the chance constraints defined in second stage, and using Monte Carlo simulation techniques for approximate the expectation function in the first stage by the average. This approach raises with another question: How to solve the linear program with the convex conservative approximation (nonlinear constrains) for each scenario?

3 - Study of well log by spectral analysis
Suzana Russo, Statistics, Federal University of Sergipe, Rua Josué de Carvalho Cunha 395, Coroa do Meio, 49035490, Aracaju, Sergipe, Brazil, suzana.ufs@hotmail.com

The exploitation of oil wells has been intensified in recent years causing a growing production of information to be analyzed making it necessary to create tools that assist in analyzing the data in order to expedite the process of identification of patterns searched. Due to restrictions in the acquisition process some information relevant to the production process may be used spectral analysis. This study applied the spectral analysis to analyze the behavior of the variable of Gamma Ray log in an oil well The best model found was ARIMA (3,1,3).

■ HB-19

Thursday, 10:30-12h00
G5-10

Location Problems

Stream: Location, Logistics, Transportation (contributed)
Contributed session

Chair: *Monica Gentili*, University of Salerno, P.te Don Melillo, Fisciano, 84084, Salerno, Italy, mgentili@unisa.it

1 - System Utility Optimization in Large Public Service System Design
Marek Kvet, Transportation Networks, University of Zilina, Univerzitna 1, 01026, Zilina, Slovakia, Marek.Kvet@fri.uniza.sk, *Jaroslav Janacek*

This paper deals with the problem of public service system design using an approximate approach to the weighted p-median problems. Real problem instances are characterized by big number of possible service center locations, which can take the value of several thousands. Current exact approaches to the p-median problem must face up to big demand on computational time and often fail when a large instance is solved. We present here an approximate method based on a reformulation of the above problem to a case of covering problem. Hereby, we study effectiveness and accuracy of suggested approach.

2 - Evaluation of the fairness degree in the public service systems
Alzbeta Szendreyova, Zilinska univerzita v Ziline, 01026, Zilina, Slovakia, Alzbeta.Szendreyova@fri.uniza.sk

Real locations of service centers often differ from the system locations, which have been designed using optimization algorithms for the location problems and for the p-median problems. In both cases, however, the question of the fair placement of centers arises. We defined a utility of the customer services by the centers and a function to express the fairness of the systems of public services as well. This contribution reports the results of experiments for determine the fairness degree of the real locations and of the system locations in public service systems.

3 - New Integer Programming formulations for the Competitive Facility Location Problems
Igor Vasiliev, Institute of Systems Dynamics & Control Theory SB RAS, 664033, Irkutsk, Russian Federation, vil@icc.ru, *Xenia Klimentova*

In Competitive Facility Location Problems (CFLP) there are two rival companies trying to cover the maximum share of the market. Competitors have to decide which facilities are to be open from the given set of possible facilities to attract the larger share of clients, while one company has an advantage to open facilities first. The problems usually are modeled as bilevel integer programs. We propose and study properties for the new one level integer programming formulations for some classes of CFLP. The work is partially supported by RFBR, grants 110100270a, 120131198mol_a, 120733045mol_a_ved.

4 - Exact and Heuristic Solution Approaches for the Sensor Location Problem
Raffaele Cerulli, Dept. of Mathematics and Computer Science, University of Salerno, Via S. Allende, 84081, Baronissi (SA), Italy, raffaele@unisa.it, *Monica Gentili*, *Lucio Bianco*, *Carmine Cerrone*

We study a well-known NP-complete optimization problem: the Sensor Location Problem. The optimal solution of the problem is the minimum number of counting sensors to be located on the nodes of a traffic network so that all link flows can be either directly monitored or indirectly inferred. We investigated the mathematical structure of the problem to provide a mixed-integer mathematical formulation. We designed and implemented a branch and bound approach and a genetic algorithm to solve the problem.

■ HB-20

Thursday, 10:30-12h00
G5-11

Tourist Route Planning

Stream: Optimization in Public Transport
Invited session

Chair: *Chistos Zaroliagis*, Computer Engineering & Informatics, University of Patras, 26504, Patras, Greece, zaro@ceid.upatras.gr
Chair: *Damianos Gavalas*, Cultural Technology & Communication, University of the Aegean, University Hill, 81100, Mytilene, Greece, dgavalas@aegean.gr
Chair: *Grammati Pantziou*, Department of Informatics, Technological Educational Institution of Athens, 12210, Athens, Greece, pantziou@teiath.gr

1 - A personalized multiple day trip to a touristic region
Ali Divsalar, Center for Industrial Management/Traffic & Infrastructure, KU Leuven, Belgium, Ali.Divsalar@cib.kuleuven.be, *Pieter Vansteenwegen*, *Dirk Cattrysse*

When a tourist has multiple days to visit a touristic region with several points of interest, it is worthwhile to select not only the attractions to visit carefully, but also the places of accommodation. The hotels selected for each overnight stay have a considerable impact on which combinations of attractions can be visited. In this research, we have modeled this situation of the integrated selection of hotels and attractions as an Orienteering Problem with Hotel Selection and Time Windows. We also created some benchmark instances and developed a metaheuristic to solve this problem.

2 - The biobjective team orienteering problem with time windows
Fabien Tricoire, Department of Business Administration, University of Vienna, Chair for Production and Operations Management, Brünner Straße 72, 1210, Vienna, Austria, fabien.tricoire@univie.ac.at, *Sophie Parragh*

We introduce the biobjective team orienteering problem with time windows (BITOPTW). The first objective is to maximize the sum of profits of visited points; it reflects the benefit associated with visiting points of interest. The second objective, the minimization of total travel costs, corresponds to the effort required to reach these points of interest. Since user preference and tolerance can vary greatly, both objectives are considered simultaneously using the Pareto approach. We present a metaheuristic to solve the BITOPTW. We compare it to valid bounds obtained using a relaxed problem.

3 - Algorithmic Methods for Deriving Multi-Modal Personalized Tourist Tours
Grammati Pantziou, Department of Informatics, Technological Educational Institution of Athens, 12210, Athens, Greece, pantziou@teiath.gr, *Damianos Gavalas*, *Charalampos Konstantopoulos*, *Konstantinos Mastakas*

We deal with the problem of determining near-optimal multiple-day tourist tours via a subset of available points of interest (POIs) within a given time span, taking into account several modes of transportation (walking, bus, metro, etc.). We model this problem as a time-dependent team orienteering problem with time windows (TD-TOPTW). We develop and compare two different approaches to solve the TD-TOPTW. Our approaches make no assumption on the periodicity of transit services. Experimental results for the city of Athens show that our approaches are able to obtain tours in real-time.

4 - Cluster-based Heuristic Approaches for the Tourist Trip Design Problem
Damianos Gavalas, Cultural Technology & Communication, University of the Aegean, University Hill, 81100, Mytilene, Greece, dgavalas@aegean.gr, *Charalampos Konstantopoulos*, *Konstantinos Mastakas*, *Grammati Pantziou*

We present two cluster-based heuristics that derive near-optimal multiple-day tours for tourists visiting a destination with several points of interest (POIs), taking into account several user preferences and POI attributes. The problem is modeled as a Team Orienteering Problem with Time Windows (TOPTW). The aim is to maximize the overall "profit" collected from visited POIs, while respecting a specified daily time budget. Our approaches improve existing methods with respect to the solutions quality, while executing at comparable time and reducing the frequency of long transfers among POIs.

■ HB-21

Thursday, 10:30-12h00
G6-1

New Project Scheduling Models

Stream: Project Management and Scheduling
Invited session

Chair: *Christoph Schwindt*, Institute of Management and Economics, Clausthal University of Technology, Julius-Albert-Str. 2, 38678, Clausthal-Zellerfeld, Germany, christoph.schwindt@tu-clausthal.de

1 - A discrete and continuous time formulation for project capacity planning
Alain Hait, Institut Supérieur de l'Aéronautique et de l'Espace, University of Toulouse, 10 avenue Edouard Belin, 31055, Toulouse, France, alain.hait@isae.fr, *Christian Artigues*

This work deals with project capacity planning problems, at the tactical level, where resources are considered on a periodic basis. Activities are constrained by time windows and sequence relations. Activity durations depend on resource allocation, variable from one period to another. We propose a discrete-time formulation for the placement of the activities to the periods and for resource allocation, associated to a continuous-time formulation to check the temporal feasibility of this placement. Finally, a decomposition approach is proposed.

2 - A Cost Minimization Multi-skilled Resource Constrained Project Scheduling Problem
Isabel Correia, Departamento de Matemática- CMA, FCT-Universidade Nova de Lisboa, Monte da Caparica, 2829-516, Caparica, Portugal, isc@fct.unl.pt, *Francisco Saldanha-da-Gama*

In this work, a multi-skilled resource constrained project scheduling problem is addressed. The project consists of a set of time dependent activities. Different cost structures are considered for the resources. The goal is to find the schedule which minimizes the total cost associated with the resources, assuring that the project makespan is below a prescribed deadline. A mixed-integer linear programming formulation is proposed for the problem and several additional inequalities are considered. Computational experiments performed with a general solver are reported.

3 - Multi-mode RCPSP with Material Ordering under Bonus-Penalty Policies
Vincent Van Peteghem, People, markets and humanities, EDHEC Business School, 24, avenue Gustave Delory, 59057, Roubaix, France, vincent.vanpeteghem@edhec.edu, *Babak Abbasi*, *Nima Zoraghi*, *Moslem Shahsavar*

In this study we consider the project scheduling and material ordering decision (time and quantity) at one stage. The objective function of the model is to minimize the total cost that consists of the material holding and ordering cost, the bonus paid by the client and the cost of delay in the project completion. The proposed algorithm contains both an outside and inside search. In each iteration, the outside search component searches for the best schedule while the inside search determines the time and quantity of orders of nonrenewable resources. Computational tests reveal promising results.

4 - Column generation based lower bounds for project scheduling problems
Christoph Schwindt, Institute of Management and Economics, Clausthal University of Technology, Julius-Albert-Str. 2, 38678, Clausthal-Zellerfeld, Germany, christoph.schwindt@tu-clausthal.de, *Tobias Paetz*

We consider project scheduling problems with objective functions that are linear in the durations of the precedence order's antichains. Examples of such functions are the project duration and certain resource leveling criteria. The problem can be stated as a huge LP with side constraints, whose LP relaxation is amenable to column generation. Depending on the type of scheduling problem, the pricing problem corresponds to a multi-constraint binary knapsack problem or a convex-weight stable set problem on a comparability graph. We report on computational experience on test sets from literature.

■ HB-22

Thursday, 10:30-12h00
G6-2

Resource constrained scheduling

Stream: Scheduling II
Invited session

Chair: *Erwin Pesch*, FB 5, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, erwin.pesch@uni-siegen.de

1 - Generating redundant cumulative constraints to compute preemptive bounds
Nicolas Bonifas, LIX & IBM, France, bonifas@lix.polytechnique.fr, *Philippe Baptiste*

We introduce a reformulation of the cumulative resource in scheduling, so that the lower bound on the makespan that one gets by energetic reasoning is at least as good as that of a preemptive schedule on the original resource. This reformulation relies on a linear program whose size depends on the capacity of the resource but not on the number of tasks, which enables to precompute the reformulations. It provides a significant improvement for all algorithms which rely on energetic reasonings, such as edge-finding techniques. We improve the lower bounds of some RCPSP instances from the PSPLIB.

2 - Asymptotic Approximation for the (High) Multiplicity Multi-Skill Scheduling Problem
Michal Penn, Industrial Engineering and Management, Technion, Technion City, 32000, Haifa, Israel, mpenn@ie.technion.ac.il, *Michael Masin*, *Shay Hakim*

The Multi-Skill Scheduling problem is a generalizes job shop and resource-constrained project scheduling problems in which for each activity there is a set of capacitated resources that can process it. The aim is to assign activities to resources and to order the activities on the resources so that the process will terminate in the smallest amount of time under the precedence relations and the resource availabilities constraints. We present an LP-based asymptotically optimal approximation scheme for the non-preemptive version of the problem as well as our numerical experiments.

3 - Job scheduling problem with human operators in manufacturing process
Simone Sbrilli, Department of enterprise engineering, University of Rome "Tor Vergata", Via del Politecnico 1, 00133, Rome, Italy, simone.sbrilli@uniroma2.it, *Alessandro Agnetis*, *Gianluca Murgia*

This work deals with complex job shop scheduling problems, in which each task requires two different resources, i.e., machines and human operators. While a machine is specified for each task, there are in general more operators enabled to performing it. The problem is to assign and sequence the tasks for each operator and sequence them on each machine in order to minimize a certain objective function. We address both makespan minimization, for which we propose two different heuristics, and the related cyclic scheduling problem, proposing a new MILP formulation.

4 - The ALMA Telescope Scheduling Problem
Philippe Michelon, LIA, Université d'Avignon et des Pays de Vaucluse, 339 Ch. des Meinajaries, Agroparc BP 91228, 84911, Avignon Cedex 9, France, philippe.michelon@univ-avignon.fr, *Boris Detienne*, *Mauricio Solar*, *Lorna Figueroa*

We investigate an offline version of the problem of selecting and scheduling astronomical observations (extension of the Order and Acceptance Problem) in the ALMA Telescope context. Observations are characterized by a processing time and a set of time windows where they can be processed. Observations are grouped into projects, and a reward is earned when all observations of a group are processed. The problem includes precedences constraints. We propose and compare several MILP approaches. This work is supported by ECOS-CONICYT action C10E02.

■ HB-23

Thursday, 10:30-12h00
G6-3

Discrete-continuous scheduling

Stream: Scheduling under Resource Constraints
Invited session

Chair: *Jan Weglarz*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, jan.weglarz@cs.put.poznan.pl

1 - Power-aware scheduling by grouping computational jobs
Rafal Rozycki, Institute of Computing Science, Poznan University of Technology, ul.Piotrowo 2, 60-965, Poznan, Poland, rafal.rozycki@cs.put.poznan.pl, *Jan Weglarz*

The paper deals with the problem of scheduling preemptive jobs on parallel identical machines with an additional doubly-constrained resource - power/energy. We assume the schedule length as the scheduling criterion. Processing characteristics of a job is defined by a dynamic model, where processing speed is related to the temporal amount of allotted power. Exact and heuristic approaches for solving the problem are showed and compared.

2 - Scheduling Bag-of-Task Applications in Grids to Minimise Computation Cost
Natalia Shakhlevich, School of Computing, University of Leeds, Woodhouse Lane, LS2 9JT, Leeds, United Kingdom, N.Shakhlevich@leeds.ac.uk, *Anastasia Grekioti*

Grid computing and more recently Cloud Computing have given rise to new scheduling models that go beyond the classical Scheduling Theory. An important feature of scheduling problems for Grids and Clouds is the cost factor: allocation of computation tasks to Grid resources should be performed in such a way that the tasks are completed by their deadlines and the cost of using resources is minimum. The talk will provide the survey of the existing Grid scheduling algorithms developed for Bag-of-Task applications, and the improvements which can be gained by adopting classical scheduling techniques.

3 - Proportional allocation of resources: stride and divisor methods
Joanna Jozefowska, Institute of Computing Science, Poznañ University of Technology, Piotrowo 2, 60-965, Poznañ, Wielkopolska, Poland, jjozefowska@cs.put.poznan.pl, *Wieslaw Kubiak*, *Lukasz Jozefowski*

In many practical situations multiple users compete for a discrete resource available in limited number of units. The goal is to allocate to each user a number of units proportional to a given weight (being a rational number) assigned to that user. Two main approaches to solving this problem are known in the literature: so-called stride scheduling algorithm and application of the methods of apportionment. Both approaches may be extended to a dynamic case. The aim of this talk is to compare the two approaches.

4 - Coordinating Distributed Energy Resources in the Smart Grid: Description of a complex optimization chain
Jean-Christophe Passelergue, Alstom Grid, Network Management Solutions, 91300, Massy, France, jean-christophe.passelergue@alstom.com, *Sebastien Lannez*

In this paper, we present a multi-stage optimization process in which various optimization problems are solved sequentially by multiple actors in order to increase the distribution network's capacity to distribute the power produced from renewable resources. The proposed new problem is more formally stated as one of maximizing social welfare by coordinating local actions on the distribution grid in order to increase the total capacity of the network. The presentation is illustrated by a real-case application.

■ HB-24

Thursday, 10:30-12h00
G6-4

Timetabling Events and Services

Stream: Timetabling and Rostering
Invited session

Chair: *Mujgan Sagir*, IE, Eskisehir Osmangazi University, ESOGU IE Dept., Meselik, Eskisehir, Turkey, mujgan.sagir@gmail.com

1 - A Mathematical Modeling Approach to Sports Tournament Problem
Mujgan Sagir, IE, Eskisehir Osmangazi University, ESOGU IE Dept., Meselik, Eskisehir, Turkey, mujgan.sagir@gmail.com
Sports scheduling deal with determining the date and the venue of the games in a tournament. Mathematical programming, metaheuristics, and hybrid methods are successfully applied to the solution of this problem. In this study an Analytic Network Process (ANP) model is developed to get importance levels of different games. The outcome is used in a mathematical model to assign the games to the timeslots in a way to optimise a predefined objective function. Turkey football league data and its current game schedule for a specific season are considered to evaluate the proposed model.

2 - Timetabling of sorting slots in a warehouse under scheduling constraints
Antoine Jouglet, Université de Technologie de Compiègne, Heudiasyc UMR CNRS 7253, Centre de Recherches de Royallieu, 60205, Compiègne, France, antoine.jouglet@hds.utc.fr, *Dritan Nace*, *Christophe Outteryck*
The sorting slot timetabling problem occurs at the end of a logistic stream of a warehouse. A sorting slot (SS) is an accumulation area where processed orders wait to be loaded onto a truck for which a known number of SS is needed from the time the first order for this truck begins to be prepared, right up until the truck's scheduled departure time. Since several orders destined for different trucks are processed simultaneously, and since the number of SS is limited, the timetabling of these resources is necessary to ensure that all orders can be processed over a considered time horizon.

3 - A MILP model for the Strategic Capacity Planning in Universities
Rocio de la Torre, Department of Management, Universitat Politècnica de Catalunya, Avda Diagonal, 647, 7th, 08028, Barcelona, Spain, maria.rocio.de.torre@upc.edu, *Manuel Mateo*, *Amaia Lusa*
We present a methodology to deal with the problem of the Strategic Capacity Planning in universities. The methodology includes the characterization of the problem, a mixed integer lineal programming (MILP) model for a variant of the problem, a discussion on the necessary data and its pre-analysis, the model resolution and an adapted approach to the uncertainties. The methodology can be used not only for planning the staff capacity in a strategic level, but also for assessing the impact of different strategies (policies for human resources, number of offered careers, etc.).

4 - Effects of Headway Variations on Railway Timetable Robustness: an Application from the Swedish Southern Mainline
Anders Peterson, Dept of Science and Technology, Linköping University, Linköping University, Dept of Science and Technology, SE-60174, Norrköping, Sweden, anders.peterson@liu.se, *Fahimeh Khoshniyat*, *Johanna Törnquist Krasemann*
In railway operations, a challenge is to create a robust timetable, where small delays can be absorbed without disturbing other traffic. Crucial is the minimum headway time separating two consecutive operations using the same infrastructural resource. This study concerns how the existing headway margin time should be distributed to ensure robustness both for long- and short-distance services. An improved timetable is computed by a MILP model and results are presented for a case study from the Swedish Southern Mainline.

■ HB-25

Thursday, 10:30-12h00
G9-1

Fuzzy Decision Theory and Analysis

Stream: Fuzzy Optimization - Systems, Networks and Applications
Invited session
Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de
Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de
Chair: *Alexej Orlov*, Students Science Association, Institute for applied system analysis of the National Technical University of Ukraine, Peremohy ave. 37, 03056, Kyiv, Ukraine, orlov.alexej@gmail.com

1 - Possibilistic OWA — type Aggregation Operator in the Decision Making Problem regarding the Country Fiscal Policy
Gia Sirbiladze, Department of Computer Sciences, Iv.Javakhishvili Tbilisi State University, 13, University st., 0186, Tbilisi, Georgia, gia.sirbiladze@tsu.ge, *Otar Badagadze*, *Khatia Sirbiladze*

A new generalization of the Ordered Weighted Averaging (OWA) operator is presented for the decision making problems regarding the country fiscal policy. Information measures of a new operator - AsFPOWA Orness, Balans, Entropy and Divergence are defined. On the basis of Orness and Entropy measures a mathematical programming problem is constructed for the valuation of the weights of the AsFPOWA operator. Expert's valuations as arguments of the AsFPOWA operator are presented by triangular fuzzy numbers. Several variants of the new aggregation operator are used for comparing decision results.

2 - Power System Planning and Operation in the Presence of Demand and Generation Cost Uncertainties Using Fuzzy Sets
Joao Tome Saraiva, INESC Porto & FEUP, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, jsaraiva@fe.up.pt, *Bruno Gomes*

Uncertainties at various levels are becoming an important issue that should be internalized in several power system models. In this paper we address the impact of demand and generation cost uncertainties modeled by fuzzy numbers in the results of power system operation models as well as in the calculation of nodal marginal prices, given the development in recent years of electricity markets. The developed approach is able to translate these uncertainties in generation powers, power flows and nodal marginal prices and it is illustrated using a case study based on an IEEE test system.

3 - A Fuzzy Reliable Quality Function Deployment Method for Risk Analysis in Dialysis Services
Sawsen Maalej, management, ISET GABES, Tunisia, sawsen1maalej@yahoo.fr, *Habib Chabchoub*

The evolution in the hospital sector and the increased risk in health services require directors in hospitals to adopt new concepts for their management. In this context, we have proposed a method of analysis and prevention of potential failures called Reliable Quality Function Deployment (RQFD). It allows the assessments of the risks to prevent failures or avoid the effects. It has been applied in a context where the patient attributes and process attributes are considered accurate. However, information provided by patients or experts may be imprecise and subjective.

■ HB-26

Thursday, 10:30-12h00
G9-7

Topics in Integer Programming

Stream: Combinatorial Optimization I
Invited session
Chair: *A. Ridha Mahjoub*, Mathematics and Computer Science, LAMSADE, Universit, Place du Mar, 75775, Paris Cedex 16, France, mahjoub@lamsade.dauphine.fr

1 - Integer knapsacks: can they have a linear number of facets ?
Akshay Gupte, Mathematical Sciences, Clemson University, O321 Martin Hall, Clemson University, 29634, Clemson, SC, United States, agupte@clemson.edu

We consider general integer knapsacks where coefficients and variable bounds form a superincreasing sequence. Our first main result describes the convex hull wherein each variable corresponds to at most one nontrivial facet. A particular variant arises in MIP when reformulating an integer variable using base expansions of some natural number. Our result generalizes an older theorem on 0/1 knapsacks and the proof uses a dynamic program. Additionally, we establish a multi-row result proving that the convex hull operator distributes over the intersection of superincreasing knapsacks.

2 - On Valid Inequalities for the Maximal Matching Polytope
Mustafa Kemal Tural, Industrial Engineering Department, Middle East Technical University, Ankara, Turkey, tural@metu.edu.tr, *Gurkan Basova*

We consider the problem of minimizing a linear function over the maximal matching polytope. Recently Taskin and Tinaz proposed an integer programming (IP) formulation for this problem. They introduced some valid inequalities and showed their effectiveness on moderate size instances. We introduce new valid inequalities for the maximal matching polytope and discuss their applicability in an integer programming solution procedure.

3 - Optimization on Integer Partitions
Vladimir Shlyk, Natural Sciences, Institute for Command Engineers, 25 Mashinostroiteley Str., 15 Kulman Str., Apt. 27, 220100, Minsk, Belarus, v.shlyk@gmail.com

We study the structure of the polytopes of integer partitions, including the case when all parts belong to a specified subset. The results may benefit solving optimization and enumeration problems on partitions, such as the Change-Making problem and the Coin Collector's problem. Characterization of facets of the polytope, properties of vertices, relations between vertices and between vertices and facets open ways to apply the well-developed methods of combinatorial and integer linear programming to approach such problems. The recent results are concerned with adjacency of vertices.

4 - 2-Stage Robust MILP with continuous recourse variables
Pierre-Louis Poirion, CEDRIC-CNAM-ENSTA, France, pierre-louis.poirion@ensta-paristech.fr, *Marie-Christine Costa*, *Alain Billionnet*

We solve a linear two-stage robust problem with mixed-integer first-stage variables and continuous second stage variables. We consider column wise uncertainty. We first focus on a problem with right hand-side uncertainty which satisfies a "full recourse property" and a specific definition of the uncertainty. We propose a solution based on a generation constraint algorithm. Then we give several generalizations of the approach: for left-hand side uncertainty, for the cases where the "full recourse property" is not satisfied and for uncertainty sets defined by a polytope.

■ HB-27

Thursday, 10:30-12h00
G9-8

Pseudo-Boolean Optimization in Computer Vision

Stream: Boolean and Pseudo-Boolean Optimization
Invited session

Chair: *Ramin Zabih*, Cornell, Computer Science, 4130 Upson Hall, 14853, Ithaca, New York, United States, rdz@cs.cornell.edu

1 - Multiplicative Bounds for Metric Labeling
M. Pawan Kumar, Center for Visual Computing, Ecole Centrale Paris, Grande Voie des Vignes, 92295, Chatenay-Malabry, France, pawan.kumar@ecp.fr

Metric labeling is an important special case of MAP estimation for pairwise graphical models. The dominant methods for metric labeling in the computer vision community belong to the move making family, due to their computational efficiency. The dominant methods in the computer science community belong to the convex relaxations family, due to their strong theoretical guarantees. In this talk, I will present algorithms that combine the best of both worlds: efficient move-making algorithms that provide the same guarantees as the standard linear programming relaxation.

2 - Efficient Learning of High Order Graphical Models for Computer Vision and Image Analysis
Nikos Komodakis, Department of Computer Science and Applied Mathematics, Ecole des Ponts ParisTech, Paris, France, nikos.komodakis@enpc.fr

Many problems in computer vision and image analysis can be formulated as discrete optimization problems that stem from minimizing the energy of a graphical model. In all these cases, besides optimization, one other important question that arises in practice is how to properly construct the energy of such a model so that it can faithfully represent any specific task at hand. In this talk I will describe a very efficient learning framework for that purpose, which can handle the training of high-order graphical models, and can also operate either in fully supervised or weakly supervised fashion.

3 - Exploiting Problem Structure for Efficient Discrete Optimization
Pushmeet Kohli, Microsoft Research Cambridge, CB1 2FB, Camrbidge, United Kingdom, pkohli@microsoft.com

Many problems in computer vision can be formulated in terms of minimizing a function of discrete variables. The scale and form of these problems raise many challenges for optimization. For instance, the problems may involve millions or even billions of variables and/or may contain high-order terms. In this talk, I will discuss how these challenges can be overcome by exploiting the sparse and heterogeneous nature of these problems. Such problem-aware approaches to optimization can lead to substantial improvements in running time and allow us to produce good solutions to many important problems.

4 - Approximate MRF Inference Using Bounded Treewidth Subgraphs
Ramin Zabih, Cornell, Computer Science, 4130 Upson Hall, 14853, Ithaca, New York, United States, rdz@cs.cornell.edu

Graph cut algorithms, commonly used in computer vision, solve a first-order MRF over binary variables. The state of the art for this NP-hard problem is QPBO, which finds the values for a subset of the variables in the global minimum. While QPBO is very effective overall there are still many difficult problems where it can only label a small subset of the variables. We propose a new approach that, instead of optimizing the original graphical model, instead optimizes a tractable sub-model, defined as an energy function that uses a subset of the pairwise interactions of the original.

■ HB-28

Thursday, 10:30-12h00
G9-2

Cops and Robber Games

Stream: Graph Searching
Invited session

Chair: *Boting Yang*, Dept. of Computer Science, University of Regina, 3737 Wascana Parkway, S4S 0A2, Regina, Saskatchewan, Canada, boting@cs.uregina.ca

1 - A simple method of computing the catch time

Nancy Clarke, Mathematics and Statistics, Acadia University, 12 University Avenue, B4P2R6, Wolfville, Nova Scotia, Canada, nancy.clarke@acadiau.ca, *Stephen Finbow*, *Gary MacGillivray*

We define the catch time of a copwin graph G to be the minimum number of cop moves, including passes, needed to guarantee the capture of the robber in the Cops and Robber game. The minimum is taken over all possible strategies under the assumption of optimal play by both sides. There are a variety of results in the literature that imply ways to compute the catch time in cubic time using some auxiliary structure. We describe a method for determining the catch time using only local information about neighbourhoods, as well as a cubic time algorithm which can be carried out with pencil and paper.

2 - The Cops & Robber game on graphs embedded in surfaces

Dirk Oliver Theis, Faculty of Mathematics and Computer Science, University of Tartu, 2 Liivi, 50409, Tartu, Estonia, dotjimdot@gmail.com

The well-known Cops & Robber game is played on finite undirected connected graphs. k cops and a robber are placed on vertices, and take turn in moving along edges. The cops win, if, after a move, a cops' piece occupies the same vertex as the robber piece. The minimum number of cops needed to catch the robber on a graph is the so-called cop-number of that graph. In this talk, we present work -some of which in progress - on the relationship between cop-number and (non-) orientable genus.

3 - Zero-visibility cops-and-robber game on graphs

Boting Yang, Dept. of Computer Science, University of Regina, 3737 Wascana Parkway, S4S 0A2, Regina, Saskatchewan, Canada, boting@cs.uregina.ca

We examine the zero-visibility cops-and-robber graph searching model, which differs from the classical cops-and-robber game in one way: the robber is invisible. We show that this model is not monotonic. We also provide bounds on both the zero-visibility copnumber and monotonic zero-visibility copnumber in terms of the pathwidth. This is joint work with Dariusz Dereniowski, Danny Dyer and Ryan Tifenbach.

■ HB-29

Thursday, 10:30-12h00
G9-3

Stochastic Models in Reliability

Stream: Stochastic Models in Reliability and Risk
Invited session

Chair: *Mahmoud Boushaba*, Mathematics, University of Constantine 1, Route Ain El bey, 25017, Constantine, Algeria, mboushabafr@yahoo.fr

1 - Dynamic reliability analysis of multi-state systems: A review and new perspectives

Serkan Eryilmaz, Industrial Engineering, Atilim University, 06836, Ankara, Turkey, seryilmaz@atilim.edu.tr

In most real life situations, a system and its components have a range of performance levels from perfect functioning to complete failure. Such systems can be evaluated by multi-state reliability theory. In this talk, we focus on dynamic reliability measures for multi-state systems.

2 - A new reliability importance measure for components in a system

Montserrat Pons, Applied Mathematics 3, Technical University of Catalonia, Av. Bases de Manresa 61-73, 08242, Manresa, Spain, montserrat.pons@upc.edu, *Josep Freixas*

A new reliability importance measure for components in a system is introduced. It evaluates to which extent the performance of a component is representative of the performance of the whole system. Its relationship with other well-known reliability importance measures is analyzed, and the ranking of components induced by this measure is compared with the ranking given by other measures.

3 - Maintenance policies before the expiration of warratny

Minjae Park, Business school, Hongik University, 72-1 Sangsu-dong, Mapo-gu, 121-791, Seoul, Korea, Republic Of, mjpark@hongik.ac.kr, *Gimun Jung*, *Dong Ho Park*

The two-factor warranty policy is investigated considering the preventive maintenance services in the warranty period using failure times and warranty servicing times under the manufacturer's perspective. Under the warranty, the replacement service is considered as well as the repair service for a failed product as warranty services and the preventive maintenance service is scheduled for system's quality and reliability in the warranty period. The real application is implemented using the proposed approach by field data.

4 - q-distributions of order k with applications to reliability

Femin Yalcin, Department of Mathematics, Izmir University of Economics, Izmir Ekonomi Universitesi Sakarya Caddesi No: 156 Balcova, Izmir, Turkey, femin.yalcin@izmirekonomi.edu.tr

In this study, we derive expressions for the probability mass functions of q-distributions of order k using Bernoulli trials with a geometrically varying success probability. For q=1, these distributions reduce to distributions of order k which have been studied much in the literature. Applications of these distributions include reliability and statistical process control.

■ HB-30

Thursday, 10:30-12h00
G9-10

Graphs and Hypergraphs

Stream: Graphs and Networks
Invited session

Chair: *Sophie Toulouse*, LIPN, University Paris 13, France, sophie.toulouse@lipn.univ-paris13.fr

1 - Spontaneous postmen problems and edge-disjoint cycle packings in graphs

Peter Recht, OR und Wirtschaftsinformatik, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, peter.recht@tu-dortmund.de

A "Spontaneous Postman Problem" is a routing problem in which a postman selects subsequent streets of his tour by a nilly-willy strategy. This spontaneous choice leads to the basic question how to partition a network into different subdistricts such that it can be guaranteed, that each district is served if the postman is "spontaneous". The structural problems of the network that arise within this framework are closely related to the investigation of local traces and maximum edge-disjoint cycle packings in graphs. A "min-max-theorem" can be proved if the graph is Eulerian.

2 - Greedoids and Bipartite Joins of Graphs

Eugen Mandrescu, Computer Science, Holon Institute of Technology, Golomb Str. 52, Holon, Israel, eugen_m@hit.ac.il, *Vadim Levit*

A set of vertices of a graph is local maximum stable (LMS) if it is maximum in its closed neighborhood. Nemhauser and Trotter Jr. (1975) proved that every LMS set is included in a maximum stable set. In 2002 we showed that the family of LMS sets is a greedoid for every forest. Further, we found such greedoids in triangle-free graphs and very well-covered graphs. Let B be a bipartite graph, and G, H be simple graphs. B-join of G and H is a graph built on the union of their vertex sets using the edge sets of G, H, and B. In this paper we present several conditions for B-join to form a greedoid.

3 - Covering r-Partite Intersecting Hypergraphs

Paul Brooks, VCU, United States, jpbrooks@vcu.edu

Konig's Theorem states that in a bipartite graph, the covering number equals the matching number. Ryser's conjecture asserts that for r-partite hypergraphs, the covering number is at most r-1 times the matching number. The conjecture is open for intersecting hypergraphs. An intersecting hypergraph whose covering number does not equal its matching number must contain a structure called a tornado. We present some properties of the covering number of tornados.

4 - Bounds on liar's dominating set

Doost Ali Mojdeh, Mathematics, University of Tafresh, Department of Mathematics, University of Tafresh, Iran, The Address 1, 19395-5746, Tafresh, Markazi, Iran, Islamic Republic Of, damojdeh@tafreshu.ac.ir

Minimum cardinality of a liar's dominating set is called liar's domination number. It is obvious that any liar's dominating set is a double-dominating set and any triple dominating set is a liar's dominating set. Thus there is a hierarchical relation between the corresponding liar's domination numbers. In this paper we study upper and lower bound for liar's domination of any graph G in terms of diameter and vertex covering number of G.

■ HB-31

Thursday, 10:30-12h00
G9-11

Challenge EURO/ROADEF - Presentation 3

Stream: Challenge EURO/ROADEF
Sponsor session

Chair: *Eric Bourreau*, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr

1 - 2014 ROADEF/EURO Challenge start: Trains don't vanish!

Eric Bourreau, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr, *Christian Artigues*, *Safia Kedad-Sidhoum*, *Vincent Jost*, *François Ramond*

This challenge is an international contest aiming at solving an industrial optimization problem. Between duties, trains never vanish. Unfortunately, this aspect is often neglected in railway optimization approaches. In the past, rail networks had enough capacity to handle all trains without much trouble but this is not true anymore. This challenge propose by SNCF, the French railway company, consists in finding the best way to handle trains between their commercial duties, including temporary parking, shuntings on railway infrastructure facilities, using different storage facilities and tracks.

■ HB-32

Thursday, 10:30-12h00
G8-1

Supply Chain Contracting

Stream: Supply Chains
Invited session

Chair: *Nishant Mishra*, Management of Technology and Innovation, Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands, nmishra@rsm.nl

1 - Performance-based Contracting in the Presence of Initial Acquisition and After-sales Service

Nishant Mishra, Management of Technology and Innovation, Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands, nmishra@rsm.nl, *Dong Li*

We analyze service contracts in the presence of lifetime buy planning, when the initial purchase and the after-sales service are both critical decisions. We consider an after-sales service supply chain where the customer loses revenue if the equipment is not working, and where, after-sales maintenance support is an important revenue stream for the supplier. Using a Stackelberg game, we compare various types of performance and warranty contracts. We find that a performance contract can result in higher product availability, although, it is typically at the expense of profits and efficiency.

2 - Optimization of capacity reservation contracts in the presence of alternative suppliers

Mehdi Sharifyazdi, Department of Strategy and Logistics, BI Norwegian Business School, Nydalsveien 37, 0442, Oslo, Norway, mehdi.sharifyazdi@bi.no

This paper uses a Stackleberg game model to formulate a contract where a supplier allocates its capacity to multiple buyers with random demand. To secure capacity utilization, the supplier offers incentives for reservation of capacity. Each buyer must reserve a minimum capacity to get a discounted price. The supplier determines incentives and capacity quotas for the buyers, while the buyers decide on how much capacity to reserve. Buyers have also the option of buying capacity from a competing supplier with higher price but no limitation. A numerical method is developed to solve the problem.

3 - Coordinating Supply Chains with Multiple Heterogeneous Risk-averse Retailers Using Sales-rebate Contract

Chun Hung Chiu, Sun Yat-sen Business School, Sun Yat-sen University, Business School, Sun Yat-sen University,, No.135, Xinggang West Road, 510275, Guangzhou, China, chchiu2000@gmail.com, *Tsan-Ming Choi*

We consider the coordination challenge with a manufacturer which supplies to multiple, heterogeneously risk-averse retailers. The manufacturer can maximize its expected profit only if the supply chain is coordinated. To achieve coordination, we develop an innovative menu of contracts of target sales rebate with fixed order quantity contract. Two new variables termed as the risk-level indicator and the separation indicator, which help the manufacturer in analyzing the risk levels of the members of the supply chain, are found, and some meaningful managerial insights are generated.

4 - Contract Choice and Ordering Decisions - impact of overconfidence

Vinay Kalakbandi, Production and Operations Management, Indian Institute of Management Bangalore, Banerghatta Road, 560076, Bangalore, Karnataka, India, vinay.kalakbandi09@iimb.ernet.in

Literature has suggested various supply chain contracts (like Buyback, Revenue Sharing, etc.) to mitigate the Double Marginalization problem. In this paper, we propose a theoretical framework on how contract information is processed by individuals to make their final contract choice and ordering quantity decisions. Our framework examines the impact of overconfidence manifested through uncertainty underestimation on these decisions. We validate our framework using an experimental setup where subjects comparatively analyze these contracts and make contract-choice and ordering decisions.

■ HB-33

Thursday, 10:30-12h00
G8-3

Lot-Sizing and Related Topics 7

Stream: Lot-Sizing and Related Topics
Invited session

Chair: *Guillaume Amand*, HEC-Ulg, University of Liège, boulevard du rectorat, 7 - Bât. B31, 4000, Liège, Belgium, guillaume.amand@ulg.ac.be

1 - Two-machine variable speed scheduling with sequence dependent setup times to minimize energy consumption

Emel Aktas, Brunel Business School, Brunel University, UB8 3PH, Uxbridge, United Kingdom, Emel.Aktas@brunel.ac.uk, *Afshin Mansouri*, *Umut Besikci*

This research revisits two-machine sequence dependent flowshop problem and integrates it with total energy consumption (TEC). We develop a novel optimisation-based decision support for the shop floor scheduling by minimizing makespan (Cmax) and energy consumption. We present a mixed integer linear formulation of the problem which can be used to find Pareto optimal front of small problems in CPLEX. We then develop lower bounds for Cmax, TEC and the whole frontier. A multi-objective genetic algorithm and a constructive heuristic are developed to find an approximation of the Pareto front.

2 - Discrete lot-sizing with major joint setups and minor sequence dependent product setups

Guoqing Wang, Department of Business Administration, Jinan University, Guangzhou, China, tgqwang@jnu.edu.cn

We consider the uncapacitated lot-sizing problem of a family of similar products. The demands of each product in each period is deterministic and given. A major setup is needed whenever some products are produced in a period, and a minor sequence dependent setup is needed whenever a product follows another one in the same period. The objective is to minimize the setup costs and inventory holding costs. We develop an algorithm to solve the problem and analyze the performance of the algorithm.

3 - A heuristic solution procedure for the dynamic lot sizing problem with remanufacturing and product recovery

Fazle Baki, Odette School of Business, University of Windsor, 401 Sunset Avenue, N9E 4C4, Windsor, Ontario, Canada, fbaki@uwindsor.ca, *Ben A. Chaouch*, *Walid Abdul-Kader*

We consider the dynamic lot sizing problem with returns and remanufacturing. We minimize the set-up costs associated with manufacturing or remanufacturing lots and the inventory holding costs. In addition to proving NP-Hardness, we develop an alternative MIP formulation. We observe that every optimal solution can be decomposed into a series of well-structured blocks. We construct a dynamic programming based heuristic that exploits the block structure of the optimal solution to solve the problem.

4 - A general lotsizing and scheduling problem with stochastic product returns

Guillaume Amand, HEC-Ulg, University of Liège, boulevard du rectorat, 7 - Bât. B31, 4000, Liège, Belgium, guillaume.amand@ulg.ac.be, *Yasemin Arda*

We consider a multi-product capacitated lotsizing and scheduling problem with sequence-dependent setups and stochastic product returns. The returned products accumulate in an input inventory and can be sold as new items after a remanufacturing process. The deterministic demand of end items can also be satisfied through a manufacturing process that is fed by an unlimited source of raw materials. An approximate dynamic algorithm is developed to solve both single-item and multi-items cases.

■ HB-34

Thursday, 10:30-12h00
G8-4

Inventory management: Multi-stage systems

Stream: Supply Chain Planning
Invited session

Chair: *Jörg Rambau*, Fakultät für Mathematik, Physik und Informatik, LS Wirtschaftsmathematik, Universität Bayreuth, 95440, Bayreuth, Bayern, Germany, joerg.rambau@uni-bayreuth.de

1 - Value of Information under Disruption Risk

Ismail Serdar Bakal, Industrial Engineering, Middle East Technical University, ODTU Endustri Muh. Bolumu, Inonu Bulvari, 06800, Ankara, Turkey, isbakal@metu.edu.tr, *Huseyin Kole*

We investigate the value of demand information and the importance of option contracts for a buyer with two suppliers under disruption risk in a single period setting. At the beginning of the period, the buyer orders from the unreliable supplier, and reserves from the reliable supplier through an options contract. We introduce three models which differ in terms of the level of information available when the final order quantity from the reliable supplier is determined. Through these models, we explore the value of advance demand and disruption information in the presence of an options contract.

2 - Analysis of value of information in multi-echelon inventory systems with a lead time dependent backordering

Ozgur Toy, Industrial Engineering, Bilgi University, Santral Istanbul, Eyup, Istanbul, Turkey, ozgur.toy@bilgi.edu.tr, *Emre Berk*

We consider a serial inventory system with a stochastic demand. The location at each stage implements (S-1, S) inventory control policy. Customers facing a stockout at the retailers may have different responses: they may prefer to wait until the next item arrival if the remaining lead time for that item is less than his/her waiting tolerance or they may leave the system hence lost. We analyse the impact of different levels of information about customer waiting tolerances on the control policy parameters and the total cost of the system. We simulate the system and discuss the results.

3 - Leveling of Base Stock levels in Multi-Stage Inventory Systems

Rene Gassen, Inventory & Supply Chain, INFORM GmbH, Aachen, Germany, Rene.Gassen@inform-software.com

Discussed will be solution strategies for optimal positioning of stock within complex supply chains. In purely distribution networks strategies are used to identify the right level of service which central warehouses should aim at to sufficiently serve downstream distributions centers as well as direct customer demand with a minimum amount of total stock. In production networks the aim is to determine suitable make-to-order stages within the production process. Modifications of known algorithms for general networks will be shown and concluded by a comparison study of different approaches.

4 - The stochastic guaranteed service model

Jörg Rambau, Fakultät für Mathematik, Physik und Informatik, LS Wirtschaftsmathematik, Universität Bayreuth, 95440, Bayreuth, Bayern, Germany, joerg.rambau@uni-bayreuth.de, *Konrad Schade*

The stochastic guaranteed service model (SGSM) aims at finding orderpoints within a multi-echelon inventory system, where the use of an (s,S)-policy is required in each node. It extends the well-known guaranteed service model (GSM) by recourse actions. We present a solution method using Sample Average Approximation and Scenario Reduction with respect to an asymmetric distance between scenarios. The SGSM finds policies that cannot be found by the GSM. Simulations for a real-world spare part system show that the SGSM can decrease inventory and recourse costs at the same time compared to the GSM.

■ HB-36

Thursday, 10:30-12h00
G7-1

Cutting and Packing 8

Stream: Cutting and Packing
Invited session

Chair: *Thiago A. de Queiroz*, Department of Mathematics, Federal University of Goiás, Av. Dr. Lamartine Pinto de Avelar, 1120, St. Universitário, 75704-020, Catalão, Goiás, Brazil, th.al.qz@catalao.ufg.br

1 - Sorting criteria in Two Dimensional Orthogonal Strip Packing Problem
Fernando Garcia_Perez, Matematicas Aplicadas, Universidad de Alcala de Henares, Edificio de Ciencias. Campus Universitario, Carretera Madrid-Barcelona Km. 33,600, 28805, Alcala de Henares, Madrid, Spain, fernando.garciap@uah.es, *Miguel Delgado Pineda*, *Joaquin Aranda Almansa*, *Joaquin Aranda Almansa*

In the two-dimensional orthogonal strip packing problem, a set of rectangular items and a strip of width W and unlimited height are given. Each item has a height hj and a width wj. This problem consists of allocating orthogonally all the items, without overlapping, by minimizing the overall height of the packing. It is usual to use some criterion (decreasing height, decreasing width) to sort the pieces in order to improve the result. We present previous experimental results obtained by 903 instances from the literature and new results using k-copies of the set of pieces.

2 - Two-dimensional probabilistic Bin Packing Problem
Leila Horchani, Laboratoire Cristal- Pôle GRIFT, E.N.S.I, Campus Universitaire, de Manouba, 2010, Manouba, Tunisia, leila.horchani@gmail.com, *Monia Bellalouna*

In the probabilistic two-dimensional Bin Packing problem one is asked to pack a random number of rectangular items, without overlap and any rotation, into the minimum number of identical square bins. We consider the two procedures used for solving probabilistic combinatorial optimization problems: The re-optimization procedure and the a priori one and we focused in their asymptotic behavior through simulations. We show that under precise conditions, the a priori procedure which is a simple method generates results near the optimal ones for this NP-hard problem.

3 - Solving the two-dimensional disjunctively constrained knapsack problem with a heuristic procedure
Thiago A. de Queiroz, Department of Mathematics, Federal University of Goiás, Av. Dr. Lamartine Pinto de Avelar, 1120, St. Universitário, 75704-020, Catalão, Goiás, Brazil, th.al.qz@catalao.ufg.br, *Flávio Keidi Miyazawa*

We propose a greedy randomized constructive heuristic to solve the two-dimensional disjunctively constrained 0-1 knapsack problem. This problem arises in practical scenarios as well as a subproblem, as in the bin packing problem with conflicts. We also implemented an exact branch-and-cut algorithm within the CPLEX solver framework. Computational experiments performed on 48 small and medium random instances, created accordingly the DCKP literature, show the competitiveness of the heuristic, which solved all generated instances to optimality in 3 seconds, on average.

4 - Packing ellipsoids within a box
Rafael Lobato, University of Sao Paulo, Brazil, lobato@ime.usp.br, *Ernesto G. Birgin*, *José Mario Martínez*

The problem of packing ellipsoids appears in a large number of practical applications, such as the design of high-density ceramic materials, the study of the structure of liquids, crystals, glasses, and the flow and compression of granular materials. In this talk, nonlinear programming models and algorithms for packing ellipsoids within a box will be presented. Illustrative numerical examples will be given.

■ HB-37

Thursday, 10:30-12h00
G7-4

Multicriteria Decision Making and Its Applications VII

Stream: Multicriteria Decision Making II
Invited session

Chair: *Margaret Wiecek*, Department of Mathematical Sciences, Clemson University, Martin Hall O-208, 29634, Clemson, SC, United States, wmalgor@clemson.edu
Chair: *Gul Okudan Kremer*, Penn State University, United States, gkremer@psu.edu

1 - A New Contribution for the Calculation of Non-Supported Efficient Solutions in Multiobective Combinatorial 0,1 Problems
João Clímaco, INESC-Coimbra, 3004-512, Coimbra, Portugal, jclimaco@inescc.pt, *Carlos Gomes da Silva*

In Multiobjective L.P. all efficient solutions can be obtained optimizing weighted-sums of the objective functions (o.f.). However in Multiobjective Combinatorial 0,1 Problems only a fraction of these solutions, the supported efficient solutions, can be calculated using a similar procedure. In this work we show how the whole set of the efficient solutions can be found using the same technique by introducing perturbations in the coefficients of the original o.f. . An algorithm is proposed. Some results concerning the 0-1 knapsack and minimal spanning tree problems are presented and discussed.

2 - About an implementation of a 3-objective linear programming solver
Sebastian Schenker, Zuse Institute Berlin, Takustr. 7, 14195, Berlin, Germany, schenker@zib.de

In this talk I want to present an implementation of a 3-objective linear programming solver that computes all extreme non-dominated points (and the corresponding weight space decomposition). The first part of the talk is concerned with a worst-case example based on deformed cubes that shows that we cannot expect a small number of extreme non-dominated points even for a fixed number of objectives. In the second part of the talk the basic ideas behind the solver which is based on the weight space decomposition approach are presented.

3 - Efficient procedure for generating Pareto solutions to multi-objective linear fractional programming problems
Bogdana Stanojevic, Mathematical Institute of the Serbian Academy of Sciences and Arts, Kneza Mihaila 36, 11000, Belgrade, Serbia, bgdnpop@gmail.com

We propose two procedures for deriving weakly/strongly efficient solutions to multiple objective linear fractional programming problems (MOLFPP) starting from a non-efficient feasible solution. We introduce a weighted sum based technique to generate weakly/strongly efficient solutions to MOLFPP. Instead of weighted sum of criteria functions we use weighted sum of marginal solutions and, instead of optimizing a sum of linear ratios we solve successively few linear programming problems. A MOLFPP with three objective functions and two variables is analyzed in detail.

4 - The Whole Efficient Set of the Multiobjective Integer Linear Fractional Problem
Moncef Abbas, Recherche Opérationnelle, USTHB, Faculté de mathématiques,LAID3, El-Alia, BP 32, Bab-Ezzouar,, 16111, Algiers, Algeria, Algeria, moncef_abbas@yahoo.com, *Mohamed El-Amine Chergui*

We describe a new approach consisting to solve only linear programs to generate the set of efficient solutions of the Multiobjective Integer Linear Fractional Problem, while maintaining the initial set of feasible solutions. In fact, instead of solving Integer Linear Fractional Programming problems, we show that it is enough to solve independent ILP problems, whose objective is any linear function, in a structured tree. Furthermore, the addition of new assessments of tree nodes shows that the method outperforms widely the original one.

■ HB-39

Thursday, 10:30-12h00
G7-3

Multiple Criteria Decision Making and Optimization

Stream: Multiple Criteria Decision Making and Optimization (contributed)
Contributed session

Chair: *Ana Meca*, Operations Research Center, Universidad Miguel Hernández, Avda. Universidad s/n, Edificio Torretamarit, 03202, Elche, Alicante, Spain, ana.meca@umh.es

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Grid Computing for multi-objective optimization problems
Hassina Beggar, Network and distributed systems, CERIST, Rue des trois frères Aissiou, Ben Aknoun, 16000, algiers, Algiers, Algeria, h.beggar@dtri.cerist.dz, *Aouaouche El-Maouhab*

Solving multiobjective discrete optimization applications has always been limited by the resources of one machine: by computing power or memory, most often both. To speed up the calculations, the grid computing represents a primary solution for the treatment of these applications. In this paper, we propose a parallel implementation of the Chergui & Al method on the grid. To enhance our contribution, the main results are presented.

2 - Reference Point Methods and Approximation of Pareto Sets
Kai-Simon Goetzmann, Institut für Mathematik, Technische Universität Berlin, Sekr. MA 5-1, Straße des 17. Juni 136, 10623, Berlin, Germany, goetzmann@math.tu-berlin.de, *Christina Büsing*, *Jannik Matuschke*, *Sebastian Stiller*

In multicriteria optimization, a reference point solution is the solution closest to a given reference point in the objective space. Reference point methods are very popular in practice, while theory has mostly studied the Pareto set. We show that the two concepts are computationally equivalent in the sense that an approximate Pareto set can be efficiently constructed, if and only if there is an approximation algorithm for reference point solutions. By this result, as we illustrate by examples, approximation techniques from singlecriteria optimization can be lifted to multicriteria problems.

3 - Two phase method for Lorenz dominance in biobjective combinatorial optimization
Lucie Galand, University Paris Dauphine - LAMSADE, place du Maréchal de Lattre de Tassigny, 75775, Paris Cedex 16, France, lucie.galand@dauphine.fr, *Thibaut Lust*

The two phase method is a well-known method to find Pareto optimal solutions to biobjective combinatorial optimization problems [Ulungu and Teghem, 95]. We adapt this method to Lorenz dominance, a model proposed in economics to refine Pareto dominance by focusing on well-balanced solutions. This adaptation amounts to computing the solutions that optimize an OWA aggregator [Yager, 98] in a first phase, and all the remaining Lorenz optimal solutions in a second phase. We present the results obtained for different biobjective combinatorial optimization problems.

4 - Multi-objective Evolutionary Method for Statistical Model Selection under Uncertainty
Nasim Dehghan Hardoroudi, School of Economics, Aalto University, Finland, nasim.dehghan.hardoroudi@aalto.fi, *Ankur Sinha*, *Pekka Malo*

Selection of a statistical model among a large set of possibilities is a challenging task. In this paper we propose an evolutionary approach to regression modeling, which helps the user to visualize an efficient set of models and handle the inherent uncertainty using a Bayesian model building strategy. The algorithm considers the regression problem as a multi-objective optimization task, where the first objective is to reduce the complexity of the model and the second objective is to maximize the goodness-of-fit.

■ HB-40

Thursday, 10:30-12h00
Y12-1

DEA Applications VI

Stream: DEA and Performance Measurement
Invited session

Chair: *Zilla Sinuany-Stern*, Industrial Engineering and Management, Ben Gurion University, Beer-Sheva, 84105, Beer-Sheva, Israel, zilla@bgu.ac.il

1 - Performance Evaluation of Public and Private Medical Schools in Turkey
Hatice Ercan, Industrial Engineering, Eskisehir Osmangazi University, Faculty of Engineering, Meselik Kampusu Eskisehir, Eskisehir, Turkey, ercanhatice@gmail.com, *Abdullah Korkut Üstün*, *Sermet Anagun*

The problems of efficiency and quality of medical schools and their healthcare facilities in Turkey are considered major issues for decision makers. The purpose of this study is to evaluate educational and hospital performances of public and private medical schools by data envelopment analysis (DEA). DEA is a technique that measures the relative efficiency of decision making units. After examining efficient and inefficient units possible improvements and comparisons in terms of public and private medical schools are discussed.

2 - Industry structural inefficiency and potential gains from mergers and break-ups: an empirical approach
Antonio Peyrache, School of Economics, The University of Queensland, Australia, a.peyrache@uq.edu.au

An efficiency indicator of industry configuration (allowing for entry/exit of firms) is presented which accounts for 4 sources components: 1) size inefficiencies arising from firms which can be conveniently split into smaller units; 2) efficiency gains realized through merger of firms; 3) re-allocation of inputs and outputs among firms; 4) technical inefficiencies. A method to monitor the evolution of these components in time is introduced. Data on hospitals in Australia show that more than 40% of inefficiency is attributable to a size effect of big hospitals.

3 - Investing Capital to Increase Productivity in Production Systems Modeled by DEA
Ney Carvalho, Computer Science Departament, Federal Institute of Technology of Piauí, Avenida Senador Candido Ferraz 1645, ap 1002, 64049-250, Teresina, Piaui, Brazil, ney@infoway-pi.com.br, *Mariana Almeida*, *Carlos Martinhon*

The objective is present two mathematical formulations to model new aspects of problems modeled by DEA. In both cases, the previous scores and the productivity level K'0 of the DMU0 are computed by DEA. In the first case, we assume that each input i of DMU0 has a fixed cost ai0 and a capital C0 is available to be invested in order to maximize its productivity K0, though defining new outputs, inputs and weights. In the second case, given a productivity level intended K0, the capital required C0 to reach it is minimized. An Health Care application is presented.

4 - Measuring the Efficiency of Hospitals Operating Department
Zilla Sinuany-Stern, Industrial Engineering and Management, Ben Gurion University, Beer-Sheva, 84105, Beer-Sheva, Israel, zilla@bgu.ac.il, *Nir Shahkoohi*, *Osnat Cohen*

In this study we measured the efficiency of 24 operating department in Soroka Hospital, in Beer-Sheva, Israel. Data Envelopment Analysis (DEA) was used with 5 inputs and 3 outputs over the years 2008 and 2009. There are three operating sites in the hospital, serving 24 operating departments. There was no significant difference among the three sites efficiency. There was no difference between the efficiency of the two years considered. Looking at the operating rooms utilization (the old measure of effectiveness of operating rooms) we found that it differs significantly from the DEA rating.

■ HB-41

Thursday, 10:30-12h00
Y12-5

Markov Decision Processes and Stochastic Games II

Stream: Decision Making under Uncertainty and Environmental Applications
Invited session

Chair: *Eugene Feinberg*, Department of Applied Mathematics, Stony Brook University, and Statistics, 11794-3600, Stony Brook, NY, United States, eugene.feinberg@sunysb.edu

1 - Ordered Field Property in Stochastic Games
Jerzy Filar, School of Computer Science, Engineering and Mathematics, Flinders University, Sturt Road, 5042, Bedford Park, SA, Australia, jerzy.filar@flinders.edu.au

In the now classical 1953 paper "Stochastic Games", L.S. Shapley remarked that the value of these games need not lie in the same ordered field as the data defining the game. This remark generated a line of research aimed at characterizing the classes of stochastic games possessing the desirable "ordered field property" whereby the value does in the same ordered field as the underlying data. In this presentation we review some of the history of this problem and propose new results based on the algebraic theory of Groebner bases.

2 - Monotonic successive approximations in queueing
Herman Blok, Mathematical Institute, Leiden University, Niels Bohrweg 1, 2333 CA, Leiden, Netherlands, blokh1@math.leidenuniv.nl, *Sandjai Bhulai*, *Flora Speksma*

In many queueing models with arrival or departure control a policy with a switching curve is optimal. We propose a fast method for approximating such a curve in the following way. Suppose the queueing model can be modelled as a Markov decision process for which successive approximation converges. Often the iteration step has a monotonic property in the sense that the switching curve either increases or decreases in the iteration step, depending on the initialisation. This provides an increasingly tighter bound on the set of potentially optimal curves. We will discuss several applications.

3 - Cash-Flow Based Dynamic Inventory Management
Michael Katehakis, Rutgers University, 08854, Piscataway, NJ, United States, mnk@rci.rutgers.edu

We model a firm that uses its capital position to invest on a single-product inventory, in an environment that allows the firm to utilize debt to finance increased order quantities while excess cash can be deposited at a bank to earn interest. The demand is random and could be non-stationary over periods. The objective is to maximize the expected value of the capital at the end of a finite planning horizon. We show that the optimal policy is determined by a sequence of two threshold critical values. Furthermore, we derive an efficient algorithm to compute theses threshold values.

■ HB-42

Thursday, 10:30-12h00
Y12-3

Optimization based decision support systems

Stream: Simulation Based Decision Support
Invited session

Chair: *Davorin Kofjač*, Laboratory of Cybernetics and DSS, University of Maribor, Faculty of Organizational Sciences, Kidriceva cesta 55a, 4000, Kranj, Slovenia, davorin.kofjac@fov.uni-mb.si

1 - Application of Petri Net and Genetic Algorithm in an Optimization of Waterway with Multiple Locks and Canals
Anita Gudelj, Faculty of Maritime Studies, University of Split, 21000, Split, Croatia, anita@pfst.hr, *Danko Kezić*

Safe navigation in a waterway (WS) with multiple locks and canals is very demanding. Several problems arise here: How to control the traffic in a way that vessels are able to move in opposite directions; How to resolve possible conflicts in a case when more vessels try to acquire a particular lock at the same time; How to avoid possible deadlocks? The goal of this paper is to find optimal, conflict and deadlock free schedules in WS by an algorithm which integrates MRF1 Petri net with genetic algorithm. The algorithm is dealing with a multi-constrained scheduling problem with shared resources.

2 - Solving Berth Allocation Problem and Quay Crane Assignment with Genetic Algorithms
Davorin Kofjač, Laboratory of Cybernetics and DSS, University of Maribor, Faculty of Organizational Sciences, Kidriceva cesta 55a, 4000, Kranj, Slovenia, davorin.kofjac@fov.uni-mb.si, *Maja Skuric*, *Branislav Dragovic*

Berth allocation problem (BAP) is one of the most researched optimization problems in container ports. Along with the problem, to which berth a ship must be assigned, we must also solve the problem of assigning a specific number of quay cranes (QC) to each berth, because the servicing time of a ship depends on it. To solve such a complex problem, we have utilized genetic algorithms (GA) that have been widely used to solve similar problems. The approach has been validated against real-world data and the results obtained with GA provide significant time reductions.

3 - Living Lab Experiment Design Supported by Web Based Platform
Mirjana Kljajic Borstnar, Laboratory for Decision Processes and Knowledge-based systems, University of Maribor, Faculty of Organizational Sciences, Kidriceva 55a, 1000, Ljubljana, Slovenia, Slovenia, mirjana.kljajic@fov.uni-mb.si, *Andreja Pucihar*, *Gregor Lenart*, *Ana Malesič*

The case of user co-creation of innovative eco-tourism services in a living lab setting using a web platform is described. Living Lab is a real life environment in which researchers, developers and users are co-creating new product or service. Several methodologies have been evaluated in the context of living lab experiments, building on action research, experiment design, and case study. The methodological challenges in creating a living lab experiment with large sets of observed variables are analyzed, and potential of using the experiment data in modeling open innovation systems discussed.

4 - Development of an urban area emergency response decision support system based on simulation models
Andrej Skraba, Faculty of Organizational Sciences, University of Maribor, Kidriceva cesta 55a, 4000, Kranj, Slovenia, Slovenia, andrej.skraba@fov.uni-mb.si, *Radovan Stojanovic*, *Simon Berkowicz*, *Rafaelle de Amicis*, *Doron Elhanani*, *Giuseppe Conti*, *Davorin Kofjač*

We outline the development of a Geographical Information Processing System designed to cope with environmental pollution-related security within urban scale environments. This research, sponsored by NATO (GEPSUS SfP 983510 project), is in the development phase and a collective adaptive systems approach was adopted in order to increase the efficiency and accuracy of emergency response options. Theoretical considerations regarding system development are provided as well as technical details of implementation. The prototype hardware systems as well as the software implementation are presented.

■ HB-43

Thursday, 10:30-12h00
Y12-2

Decision Support for Network Processes & Supply Chain Management

Stream: Decision Support Systems
Invited session

Chair: *Jorge E. Hernández*, School of Management, University of Liverpool, Liverpool, United Kingdom, J.E.Hernandez@Liverpool.ac.uk
Chair: *Fatima Dargam*, SimTech Simulation Technology, Ries Strasse 120, 8010, Graz, Austria, F.Dargam@SimTechnology.com

1 - Effect of wholesale competition in supply chains: analysis with multiple decision makers
Yuly Andrea Arboleda Valencia, Universidad Nacional de Colombia, Kr 76 26-21, 050025 , Medellin, Antioquia, Colombia, yaarbole@unal.edu.co, *Santiago Arango*

Previous studies have shown that the bullwhip effect occurs when a wholesale customer place orders to its sole supplier of a scarce product. In this study we analyze the phenomenon when competition is included at the wholesale level, so they order to one supplier. We use agent-based modeling to show how wholesale customers inflate orders; then the supplier invests in capacity to fulfill the orders. Preliminary results show that customers tend to inflate their orders when faced with exhausted products, competition in the level, and different delays in the system.

2 - Supply chains as mobile communicating systems; a system and communication theoretic view

Hossein Sharifi, Management School, University of Liverpool, Chatham Builing, University of Liverpol, L699 7ZH, Liverpool, Merseyside, United Kingdom, sharifi@liv.ac.uk, *Hossein Attari*, *Hossam S. Ismail*, *Jorge E. Hernández*

The space of communication in supply networks (SN) is presented using a communication and system theoretic approach. An alternative interpretation of communication in supply chain based on mobility concept which refers to the variation in the topology of the communicating links is offered. With this the mathematics of mobile communicating systems may be deployed for modeling and representing system (SN) complexity. To represent this communication space we set a new vision on structural model of communication in SN, entailing three features including being multilayered, hierarchical and nested.

3 - MCDA and Simulation-Optimization Approach applied to Strategic and Operational Alignment in Supply Chain Management

Edson Trevisan, USP, Av. Prof. Mello de Morais, 2231 - Sala A-15, 05508-030, Sao Paulo, Select State for USA, Canada, or Mexico, Brazil, edsontrevisan21@gmail.com, *Thiago Brito*, *Rui Carlos Botter*

Supply chains usually have complex dynamics, divergent objectives and large number of alternatives, wherein combining OR methodologies may provide a robust decision framework. This study discusses the usefulness of MCDA, DES and optimization for simulation applied to an iron ore transportation system between Brazil and Asia. The results revealed that the mixed methodology is computationally efficient, provides accurate results about system performance and valuables insights of the system variables relationship, facilitating the alignment of operational and strategic objectives of the system.

4 - A Simulation and Assessment Model for Product Lifecycle Management

Valentina Boschian, Dipartimento di Ingegneria e Architettura, Univeristà di Trieste, Via Valerio 10, 34127, Trieste, Italy, valentina.boschian@di3.units.it, *Noemi Augenti*, *Maria Pia Fanti*, *Giorgio Iacobellis*, *Giovanni Lucci*, *Agostino Marcello Mangini*, *Walter Ukovich*

This paper focuses on the Product Lifecycle Management (PLM) issue as a systematic concept for managing products and product related information. The presented results deal with a discrete event simulation model, based on processes described by the Unified Modeling Language, and a novel approach to assess the benefits introduced by the adoption of a PLM approach based on Key Performance Indicators definition and on the Analytic Hierarchy Process methodology. This work contributes to the project amePLM - Advanced Platform for Manufacturing Engineering and Product Lifecycle Management.

■ HB-44

Thursday, 10:30-12h00
Y12-4

Methods for Economic and Financial Applications

Stream: Mathematical Methods for Decision Support
Invited session

Chair: *Adriana Gnudi*, Mathematics, Statistics, Computer science and Applications, University of Bergamo, Via dei Caniana, 2, 24127, Bergamo, Italy, adriana.gnudi@unibg.it
Chair: *Elisabetta Allevi*, Department of Economics and Management, University of Brescia, Contrada Santa Chiara, 50, 25122, Brescia, Italy, allevi@eco.unibs.it

1 - A Markov Chain Method to Bootstrap Multivariate Continuous-Valued Stochastic Processes

Cristian Pelizzari, Department of Economics and Management, University of Brescia, Contrada Santa Chiara, 50, 25122, BRESCIA BS, Italy, pelizcri@eco.unibs.it, *Roy Cerqueti*, *Paolo Falbo*, *Gianfranco Guastaroba*

Models for energy markets involve the maximization of expected profits of producers. The estimation of expected values often requires a joint simulation of the stochastic processes driving prices and quantities of fuels and electricity. Such task is extremely complex, due to the peculiar properties of the series (jumps, stochastic volatility, spikes, regimes). We advance a data driven algorithm to bootstrap multivariate continuous-valued stochastic processes based on Markov chains. We choose the partition of the continuous support of the processes by means of a Tabu Search heuristic.

2 - Social influence and dynamic demand for new products

Edward Thommes, Univesrity of Guelph, N1G 2WQ1, Guelph, Ontario, Canada, ethommes@uoguelph.ca

We propose a continuous time (with its agent-based counterpart) model for the evolution of consumers' preferences in a differentiated market setting. The novelty lies in using both a partial differential equation and an agent based model for the evolution of the consumers' preferences incorporating personality characteristics of and social interaction among consumers, plus a producers' pricing game for new products. The model computes the total demand for each product over time, with an accent on adoption of "new/green".

3 - Dynamic Spatial Auction Market Models with General Cost Mappings

Elisabetta Allevi, Department of Economics and Management, University of Brescia, Contrada Santa Chiara, 50, 25122, Brescia, Italy, allevi@eco.unibs.it, *Adriana Gnudi*, *Igor Konnov*

In this work we suggest a dynamic equilibrium model for a system of auction markets joined by transmission lines subject to joint balance and capacity flows constraints. The model involves commodity storage within a given time period and we construct an extended primal-dual system of variational inequalities whose solutions yield an equilibrium trajectory of this system. Moreover we consider the case where the mappings need not be integrable and propose an inexact splitting type method.

■ HB-45

Thursday, 10:30-12h00
Y10-3

Game Theory and economic modeling

Stream: Cooperative Game Theory
Invited session

Chair: *Jacek Mercik*, Management and Computer Science, Wroclaw University of Technology, Wyspianskiego 27, 50-370, Wroclaw, Poland, jacek.mercik@pwr.wroc.pl

1 - Consistent Conjectural Variations Equilibrium (CCVE) in a Mixed Oligopoly Model

Vyacheslav Kalashnikov, Systems and Engineering, ITESM (Monterrey Technological Institute), ITESM, Ave. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, Nuevo Leon, Mexico, kalash@itesm.mx, *Vladimir Bulavsky*, *Nataliya Kalashnykova*

We study a model of mixed oligopoly with conjectural variations equilibrium and a discontinuous demand function. The agents' conjectures concern the price variations followed by their production increase or decrease. We establish existence and uniqueness results for such equilibrium. To introduce the notion of consistent (interior) equilibrium, we develop a consistency criterion for the conjectures and prove the existence theorem for the interior equilibrium. On the base of these results, we also investigate the behavior of the consistent conjectures depending upon a parameter.

2 - Learning in Highly Polarized Conflicts
Sigifredo Laengle, Department of Management Control, University of Chile, Diagonal Paraguay 257, Of. 1302A, 833015, Santiago, Santiago de Chile, Chile, slaengle@fen.uchile.cl, *Gino Loyola*

Negotiations are often conducted in highly polarized environments, which are also uncertain and dynamic. However, the intense rivalry involved in these conflicts does not always prevent an agreement from being reached. A recently proposed static model sets out the conditions under which either an agreement is achieved or negotiations break down in this environment (Laengle and Loyola, Optim Lett, 2011). Nevertheless, important aspects related to partial mutual knowledge of players in a dynamic context are not yet been studied. To fill this gap, we develop an extension.

3 - Long-term economic analysis of selected labor market policy strategies in Slovakia
Filip Ostrihon, Institute of Economic Research, Slovak Academy of Sciences, Slovakia, filip.ostrihon@savba.sk, *Tomas Domonkos*, *Miroslava Dolinajcová*

The paper aims to analyze the impact of various labor market policy strategies on the long-term economic development of Slovakia. Used model is constructed on the basis of a neoclassical framework, further augmented with extensive public sector, used mainly to investigate the impact of government decision making, and the concept of OLG. The paper consists of three parts. In the first section the model's structure is described. The second part is dedicated to the additional assumptions of the model and to the scenarios. In the last section the results for the case of Slovakia are discussed.

4 - Classification for committee with veto and stability of power indices
Jacek Mercik, Management and Computer Science, Wroclaw University of Technology, Wyspianskiego 27, 50-370, Wroclaw, Poland, jacek.mercik@pwr.wroc.pl

Decision making by committee may be modeled via simple games. Some committee's members are attributed with veto, i.e., they may stop the action temporarily or permanently (transforming a winning coalition into a losing one). Classification of such games and axiomatisation of power indices are presented in the paper. Special emphasis is given to particular characteristics of winning coalitions and consequently to a priori power indices.

■ HB-46

Thursday, 10:30-12h00
Y10-1

Game Theory and Social Network II

Stream: Game Theory and Social Networks
Invited session

Chair: *Elisenda Molina*, Statistics, Universidad Carlos III de Madrid, Madrid, Spain, elisenda.molina@uc3m.es

1 - Diffusion of influence in communities
Alonso Silva, Mathematics of Dynamic Networks and Information, Alcatel-Lucent Bell Labs France, Route de Villejust, 91620, Nozay, France, alonso.silva@alcatel-lucent.com, *Marc Lelarge*, *Vijay G Subramanian*

We consider a social network of two interacting communities. Intra-community connections occur with a greater probability than inter-community connections. Each agent has a choice between two possible technologies and her decision depends on her neighbors' decision. We assume that on each edge there is an incentive for each of the endpoints to have their technologies match, which is modeled as a coordination game. We study the best-response dynamic for the evolution of the system: at each time, agents choose the strategy with best payoff, given the current behavior of their neighbors.

2 - Centrality measures based on power indices for social networks
Fabián Riquelme, Departament de Llenguatges i Sistemes Informatics, Universitat Politècnica de Catalunya, Campus Nord - Ed. Omega, Desp. S-109, Jordi Girona Salgado, 1-3, E-08034, Barcelona, Spain, farisori@lsi.upc.edu, *Xavier Molinero*, *Maria Serna*

In 2012 we defined influence games, simple games where a coalition wins if it is able to convince enough agents to participate in a collective task. Influence is exerted through a social network. Classic power indices such as Banzhaf or Shapley-Shubik provide measures on the relevance of the agents. Although power indices are well known in voting systems and cooperative games, they have not been used as centrality measures for social networks. We are evaluating this approach comparing these new centrality measures with other classic ones like degree or closeness in several social networks.

3 - Group power, Centrality and Social Capital
Elisenda Molina, Statistics, Universidad Carlos III de Madrid, Madrid, Spain, elisenda.molina@uc3m.es, *Ramon Flores*, *Juan Tejada*

We define a group centrality measure in social networks that considers group's relative position in the network, and also its strategic power. Following Gomez et al. (2003), we model agents' motivation to interact by means of a (symmetric) TU game, and measure the social capital (centrality) of a group as the difference between its group power in the graph restricted game and their global power in the game without any coalition structure nor any integration effect. So, we propose a group value as a priori evaluation of the prospects of a group of players that act as a unit.

■ HB-47

Thursday, 10:30-12h00
Y10-2

Resource Revenue Management and Pricing

Stream: Revenue Management and Dynamic Pricing
Invited session

Chair: *Alejandro Cataldo*, Departamento de Ingeniería Industrial y de Sistemas, Pontifica Universidad Católica de Chile, Chile, aecatald@uc.cl

1 - Resource Revenue Management for touristic packages composition
Adriana Novaes, Dipartimento di Matematica, Università degli Studi di Milano, via Bramante, 65, 26013, Crema, Cremona, Italy, adriana.novaes@unimi.it, *Giovanni Righini*

In the Resource Revenue Management Problem (RRMP) a set of resources of finite capacity, given demand and given reservation price must be allocated to a set of packages characterized by given resource composition patterns. The objective is to optimize total revenue by deciding prices, packages composition and selling units. The resulting mathematical model is non-linear and has an exponential number of variables. We propose a column generation algorithm for a basic model of the RRMP and for some variations and extensions.

2 - An Airfreight Forwarder's Resource Planning and Revenue Management
Wen He, Decision Sciences and Managerial Economics, The Chinese University of Hong Kong, Room 941, 9/F, Cheng Yu Tung Building, No.12, Chak Cheung Street, Shatin, N.T, Hong Kong, Hong Kong, hewen85@gmail.com, *Lawrence C. Leung*, *Yer Van Hui*

Analogous to travel agents, airfreight forwarders are intermediates between airlines and customers with shipping needs. They acquire cargo space from airlines and typically face regular and ad-hoc customers. This paper focuses on two strategic decisions faced by airfreight forwarders: how much capacity to plan and how to allocate the capacity between two classes. We analytically investigate the optimal capacity level and revenue management criteria. We then extend the model to incorporate additional capacity acquisition from fellow forwarders. Relevant issues are also explored.

3 - Pricing and Inventory Decisions in Competing Supply Chain Networks: The Duopoly Case
Lambros Pechlivanos, Athens University of Economics and Business, Greece, lpech@aueb.gr, *Panos Seferlis*

An optimization-based control framework that simultaneously determines the optimal inventory and product pricing policies in a duopoly framework is developed for competing supply chain networks. Nash equilibria of the game in which the two networks choose independently and simultaneously their prices and inventories every period are derived. Compared to the monopoly case, networks are now more restrained in setting prices and hence price manipulation cannot be used as extensively to alleviate congested transportation routes. Competition leads to larger industry-wide inventory levels.

4 - On Pricing and Composition Multiple Bundles
Alejandro Cataldo, Departamento de Ingeniería Industrial y de Sistemas, Pontifica Universidad Católica de Chile, Chile, aecatald@uc.cl

We study the problem of determining the optimal composition and pricing of multiple product bundles offered in a market where they compete with other bundles. We assume that the prices and characteristics of the competitor's bundles are known, and that the consumers are utility maximizers. We have developed an two-phase solution approach. The first phase derives a closed-form expression to solve the optimal pricing subproblem for the bundles assuming their composition is known, and then the second phase uses this expression to arrive at an optimal solution composition subproblem.

■ HB-48

Thursday, 10:30-12h00
Y11-1

Simulation in Management Accounting and Management Control 2

Stream: Simulation in Management Accounting and Management Control
Invited session
Chair: *Friederike Wall*, Dept. for Controlling and Strategic Management, Alpen-Adria-Universitaet Klagenfurt, Universitätsstraße 65-67, 9020, Klagenfurt, Austria, friederike.wall@uni-klu.ac.at

1 - Managerial Incentives for Capacity Investment Decisions
Christian Lohmann, Bergische Universität Wuppertal, Juniorprofessur für Controlling, Gaußstraße 20, D-42119, Wuppertal, Germany, lohmann@wiwi.uni-wuppertal.de

The paper analyzes capacity investments of an impatient manager. If the used depreciation schedule is more or less accelerated than the relative practical capacity depreciation rule, the impatient manager has an incentive to over- or underinvest depending on the historic investment growth rates. The paper investigates the effect of straight-line depreciation and partial direct expensing on average historical cost of capacity which is part of the manager's performance measure residual income.

2 - Formal and informal control to achieve competitive advantage
Birger Rapp, School of Management, IMIT, Mellansjövägen 70, 18495, Ljusterö, Sweden, birger@rapp.se

This paper is about strategy and management control. It is based on empirical longitudinal studies of large successful Swedish firms and the theoretical starting point is that the alignment of strategies and control systems affects the firm's chances of successfully positioning itself. The firm can then if its strategies and control systems are mutually consistent create value. Our empirical studies support this. It also shows the importance to find a combination of formal and informal control to support innovative behaviour. This goes beyond the traditional textbooks on management control.

3 - Robust Investment Decisions for Temperature Risk Management
Ethem Canakoglu, Industrial Engineering Department, Bahcesehir University, Besiktas, 34450, Istanbul, Turkey, Ethem.Canakoglu@bahcesehir.edu.tr, *Nalan Gulpinar*

Energy markets participants are particularly exposed to risks due to the extreme volatility of energy prices and weather phenomenon. This paper proposes a tractable approach to determining robust investment strategies using weather derivatives. The temperature uncertainty is modeled using a discrete stochastic process. We discuss how a decision maker's risk preferences can be incorporated in the problem through robust optimization. We present numerical experiments that illustrate the performance of the different robust formulations using real market data.

4 - Optimal policy for attracting FDI: Investment cost subsidy versus tax rate reduction
Yuan Tian, Ryukoku University, Japan, tian@econ.ryukoku.ac.jp, *Masaaki Kijima*

This paper examines two policies for a host government to attract FDI: investment cost subsidy and tax rate reduction. While investment cost subsidy is provided by the host government at the time that a foreign firm initiates FDI, tax rate reduction is applied to the profit earned by the foreign firm after investment. We demonstrate that the optimal policy for attracting FDI depends on the profit uncertainty. There exists a critical level: when the uncertainty is smaller than the critical level, investment cost subsidy is optimal; otherwise, tax rate reduction is optimal.

■ HB-49

Thursday, 10:30-12h00
Y11-2

Optimization models for portfolio selection and capital budgeting

Stream: Operational Research and Quantitative Models in Banking
Invited session
Chair: *Renata Mansini*, Department of Information Engineering, University of Brescia, 25123 , Brescia, Italy, rmansini@ing.unibs.it

1 - How to find concentrated but efficient portfolios?
Zongxin Li, School of Mathematics and Statistics, Xi'an Jiaotong University, No.28, Xianning West Road, 710049, Xi'an, Shaanxi, China, lzx@stu.xjtu.edu.cn

Inspired by data mining technique and behavior finance, we propose a new portfolio selection model which replaces the covariance matrix in MV by the introduced greedy matrix. By describing transaction cost with inequality constraints, we further establish a realistic portfolio selection model which incorporates typical market frictions. They are solved by a specific algorithm for nonconvex quadratic programs. A series of empirical comparisons are carried out to show the robustness and superperformance of the concentrated optimal portfolios obtained by our new models.

2 - Surrogate Constraint Normalization Rules for a Capital Budgeting Model
José Paixão, Dept. Statistics and Operations Research/ CIO, Faculty of Sciences - University of Lisbon, Bloco C6 Campo Grande, 1749-016, LISBOA, Portugal, jmpaixao@fc.ul.pt, *Anabela Costa*

We report on the application of surrogate relaxation approaches for a linear integer program related to a capital budgeting problem. We derive and computationally test several of rules for initializing and updating the constraint weights associated to the surrogating process. The computational experience is carried out for a set of test instances previously considered in the literature.

3 - Diversification-consistent DEA tests based on directional distance measures
Martin Branda, Department of probability and mathematical statistics, Charles University in Prague, Ke Karlovu 3, 12116, Prague 2, Czech Republic, martin.branda@seznam.cz

We propose diversification-consistent DEA tests based on directional distance measures where we use risk measures as inputs and return measures as outputs. Tests with different strength can be obtained and strongly, semi-strongly or weakly Pareto efficient investment opportunities can be identified. If we consider discretely distributed returns, the strongest test is able to identify efficient investment opportunities with respect to the second order stochastic dominance. The test is empirically compared with the weaker tests using 48 representative industry portfolios from US stock markets.

■ HB-50

Thursday, 10:30-12h00
Y11-3

Finance

Stream: Optimization under Uncertainty
Invited session

Chair: *Gautam Mitra*, CARISMA, Brunel University, Department of Mathematical Sciences, Kingston Lane, UB8 3PH, Uxbridge, Middlesex, United Kingdom, gautam.mitra@brunel.ac.uk

1 - Scenario generation for a defined contribution pension plan
Diana Roman, Mathematics, Brunel University, UB8 3PH, Uxbridge, United Kingdom, diana.roman@brunel.ac.uk, *Gautam Mitra*

The problem of making investment decisions for the Employees Provident Fund of Malaysia is formulated as an ALM model. The asset return scenarios are generated independently of the liabilities and contributions. Liabilities and contributions have the same source of uncertainty, namely the population and its structure. We use an open system Markov population model with 10 states to generate "population' scenarios. Numerical examples illustrate the difference between using a deterministic optimisation model and using a stochastic programming model with scenarios for assets and liabilities

2 - Introducing Sentiment in the Predictive Analysis of Asset Behaviour: Return, Volatility and Liquidity in an Intra-day Setting
Xiang Yu, Mathematical Sciences, Brunel University, Brunel University, Kingston Lane, UB8 3PH, Uxbridge, Middlesex, United Kingdom, Xiang.yu@brunel.ac.uk, *Gautam Mitra*

We report an empirical study of a predictive analysis model for equities; the model uses high frequency (minute-bar) market data and quantified news sentiment data. The purpose of the study is to identify a predictive model which can be used in designing automated trading strategies. Given that trading strategies take into consideration three important characteristics of an asset, namely, return, volatility and liquidity, our model is designed to predict these three parameters for a collections of assets in a multivariate setting.

3 - Absolute Return Portfolios
Cristiano Valle, Brunel University, UB84UH, Uxbridge, United Kingdom, Cristiano.ArbexValle@brunel.ac.uk, *J. E. Beasley*

In this work we consider the problem of selecting an absolute return portfolio. This is a portfolio of assets that is designed to deliver a good return irrespective of how the underlying market (typically as represented by a market index) performs.We present a three-stage mixed-integer zero-one program for the problem that explicitly considers transaction costs associated with trading.Computational results are given for portfolios derived from universes defined by S&P international equity indices.

4 - Robustified asset allocation in regime-switching markets
Christina Erlwein, Department of Financial Mathematics, Fraunhofer ITWM, Fraunhofer Platz 1, 67663, Kaiserslautern, Germany, christina.erlwein@itwm.fraunhofer.de, *Peter Ruckdeschel*, *Peter Ruckdeschel*

Our asset allocation model allows for regime shifts in parameters of asset returns, changing market conditions are captured through switching volatilities and mean values. We provide a robust version of an online filtering algorithm to estimate parameters of the asset price process. Thus, outliers, peaks or missings from historical asset prices have a limited effect on forecasts of asset returns. We develop investment strategies taking into account these robustified forecasts. Our obtained optimal portfolio realistically handles regime-shifts in markets as well as outliers in historical data.

■ HB-51

Thursday, 10:30-12h00
Y11-4

Advance in Portfolio Optimization

Stream: Financial Optimization
Invited session

Chair: *Shushang Zhu*, Department Finance and Investment, Sun Yat-Sen University, Xingangxi Road No.135,, 510275, Gangzhou, China, sszhu@fudan.edu.cn

1 - Robust Portfolio Selection via Learning with Mixture Model
Shushang Zhu, Department Finance and Investment, Sun Yat-Sen University, Xingangxi Road No.135,, 510275, Gangzhou, China, sszhu@fudan.edu.cn, *Minjie Fan*, *Duan Li*

We integrate the robust optimization approach and the mixture distribution modeling technology into portfolio selection. Bayesian learning approach is adopted to specify the confidence region of estimated weights of the mixture, based on which, the robust mean-CVaR portfolio selection problem is formulated. We show that the problem can be reformulated as linear program or second-order cone program. In this framework, we can combine the information from different channels, including the investor views, to predict the asset returns robustly and then manage the portfolio in a reliable way.

2 - Coherent risk minimization-based SVMs and its application to credit rating
Jun-ya Gotoh, Industrial and Systems Engineering, Chuo university, 1-13-27 Kasuga, 112-8551, Bunkyo-ku, Tokyo, Japan, jgoto@indsys.chuo-u.ac.jp, *Akiko Takeda*, *Rei Yamamoto*

A generalized criterion for two-class support vector classifications (SVCs) is developed on the basis of minimization of coherent risk measures. Not only does it include existing criteria, such as the margin maximization and nu-SVC, as special cases, but it also includes distributionally robust SVCs. This extension is further applicable to multi-class classification, regression and outlier detection. Numerical examples demonstrate how the developed methods work for bond rating.

3 - Optimal Execution Problem under CVaR Framework
Mengfei He, Systems Engineering & Engineering Management, The Chinese University of Hong Kong, William M.M.W. Engineering Building 514, The Chinese University of Hong Kong, Shatin, New Territories, Shatin, Hong Kong, Hong Kong, mfhe@se.cuhk.edu.hk, *Duan Li*

Equity traders always need to manage price impact when executing a large order of stocks. We propose a mathematical model that includes momentum effect in the market price dynamics to capture the price impact and also adopts a coherent risk measure to ensure the time consistency of the derived optimal policy. The derived approximate optimal policy is state dependent with two prominent features: i) to trade more when the current price drift is negative and vice versa; and ii) to trade faster at earlier periods, in addition to liquidate a fixed proportion of inventory at each period.

4 - Dynamic mean-risk portfolio management with two risk measures in continuous-time
Jianjun Gao, Automation, Shanghai Jiao Tong University, Room 533, SEIEE Building,, Shanghai Jiao Tong University, 800, Dongchuan Road,, NA, Shanghai, China, jianjun.gao@sjtu.edu.cn

In this paper, we study the dynamic portfolio selection model with multiple risk measures in continuous-time model. In our model, we use both variance and conditional value-at-risk(CVaR) as a combined risk measure, which balances the shortcomings of these risk measures. We develop the analytical portfolio policy and efficient frontier of this mean-variance-CVaR portfolio optimization model. With help of these results, we conduct a complete comparison of mean-variance, mean-CVaR and mean-varance-CVaR portfolio policies.

■ HB-52

Thursday, 10:30-12h00
B13-1

Forecasting with Neural Networks & Computational Intelligence II

Stream: Forecasting & Time Series Prediction
Invited session

Chair: *Devon Barrow*, Management Science, Lancaster University, 17 Slaidburn Drive, LA1 4QX, Lancaster, United Kingdom, d.barrow@lancaster.ac.uk

1 - Streamflow forecasting with wavelet neural network model
Alpaslan Yarar, Civil Engineering, Selcuk University, Turkey, ayarar@selcuk.edu.tr, *Mustafa Onucyildiz*

Some models, like ANFIS, became very popular for the hydrologic engineering. Wavelet Transform has become a useful tool for the analysis of the variations in time series. In this study, a hybrid model, Wavelet-Neuro Fuzzy (WNF), has been used to forecast the streamflow data of 5 stations, which belong to Sakarya Basin in Turkey. In order to evaluate performance of the model, Linear Regression (LR) model has been used with the same data sets. The comparison has been made by Errors of the models. Results showed that hybrid WNF model forecasts the streamflow more accurately than LR model.

2 - Using a Cooperative Coevolutionary Multiobjective Algorithm to train Radial Basis Function Neural Networks
Christian von Lucken, Facultad Politécnica, Universidad Nacional de Asunción, Cerro Leon 494 esq. Mexico, 1341, Asunción, Asunción, Paraguay, clucken@pol.una.py, *Manuel Avalos Godoy*, *Arturo Ferreira Duarte*, *Enrique Davalos*

This work presents a training model for Radial Basis Function Neural Network (RBFNN). A RBFNN training determines values for centers and spread widths of the hidden layer radial functions, as well as weight values. This work uses Least Mean Square to obtain weights, and a competitive cooperative coevolutionary multiobjective algorithm to determine the parameters for each hidden layer node. The training model was evaluated in time series prediction showing similar results than those provided by a model representing the state-of-the-art in bioinspired algorithms for time series prediction.

3 - Forecasting the solvency of 6 European Banks with the use of ANN and other time series techniques
Pavlos Gkologiannis, Electrical and Computer Engineering, National Technical University of Athens, Greece, pcgkol@gmail.com, *Christina Konstantinidou*, *Vassilios Assimakopoulos*

In this research, we develop model which includes macroeconomic and banking variables that are correlated with the possibility of banking failure. To this direction, an ANN model is surveyed. The model uses as data banking ratios related to the liquidity of six European banks such as deposits, NPL and Tier I as well as financial ratios such as GNP and CPI. The performance of the proposed model is benchmarked against the forecasting accuracy of widely used time series forecasting techniques (Naïve, SES, Holt, Damped and THETA). Results indicate that in some cases ANN outperform other methods.

4 - Cross-Validation for Forecast Combination — an empirical study of combining predictions across time series subsamples with neural networks
Devon Barrow, Management Science, Lancaster University, 17 Slaidburn Drive, LA1 4QX, Lancaster, United Kingdom, d.barrow@lancaster.ac.uk, *Sven F. Crone*

Cross-validation and bootstrapping are widely used to estimate the accuracy of a predictor by averaging prediction errors across subsamples of data. Beyond error estimation, bootstrapping has been extended to allow forecast combination through bootstrap aggregation or bagging. In the spirit of the Bagging algorithm, we propose 'cross-validation aggregating' or crogging, averaging over the outcomes of a set of forecast models trained using mutually exclusive cross-validation replicates of the original learning set. Results show that crogging can give substantial gains in forecast accuracy.

■ HB-53

Thursday, 10:30-12h00
B13-2

Integrating Wind into the Electricity Grid

Stream: Energy systems and markets
Invited session

Chair: *Paula Carroll*, Management Information Systems, UCD, Quinn Business School, Belfield, 4, Dublin, Ireland, paula.carroll@ucd.ie

1 - Application of non linear optimization to electrical network planning considering renewable resources
Mostafa Bakhtvar, School of Electrical, Electronic and Communications Engineering, University College Dublin, 151A, Electricity research Centre, Dublin 4, Dublin, Dublin, Ireland, mostafa.bakhtvar@ucdconnect.ie, *Paul Cuffe*, *Mario Dzamarija*, *Andrew Keane*

We study electricity network properties using the intrinsically nonlinear AC optimal power flow (ACOPF) platform. A single scenario ACOPF allows for large system studies. We consider a multi-scenario, voltage stability constrained ACOPF. Variable levels of renewable energy resources are taken into account. Continuous Sigmoidal approximations of discrete constraints are assessed. We present a complete formulation of our multi-scenario, voltage stability constrained ACOPF. Recent results in optimal exploitation of existing infrastructure for the purpose of wind capacity allocation are shown.

2 - Unit Commitment Methods Incorporating High Levels of Renewable Generation
Ciara O'Dwyer, Electrical, Electronic & Communications Engineering, UCD, Engineering Building Room 157, Belfield, Dublin 4, Ireland, ciara.m.odwyer@gmail.com, *Damian Flynn*, *Alexander Melhorn*

Due to the variable and uncertain nature of wind and solar generation, it is a challenge for current unit commitment (UC) methods to provide robust and implementable results. In order to ensure sufficient system flexibility, shorter time resolutions need to be considered and stochastic UC methods provide valuable insight. In both cases the complexity and runtime for UC increases. Are stochastic methods necessary to evaluate the use of storage and other flexible resources? Could robust dynamic reserve targets, derived from available forecasts, or other non-stochastic methods, be as effective?

3 - Analysis of UK natural gas market using a rolling optimisation model
Mel Devine, Department of Mathematics & Statistics, University of Limerick, Limerick, Ireland, mel.devine@ul.ie

Recently gas demand in the UK has become increasingly uncertain; leading to an increased need for models of the UK gas market that include stochastic demand. In this work, a Rolling Optimisation Model (ROM) of this market is described. It takes as an input demand scenarios simulated from a stochastic process of UK gas demand. The outputs of ROM are the flows of gas i.e., how the sources of supply meet demand, and the daily price of gas. The model fits well to data form 2012. This allows ROM to be used to predict future flows & prices of gas & to investigate various 'What-if' scenarios.

4 - Stochastic wind power modeling in investment models

Pernille Seljom, NTNU, 1479, Kurland, Norway, pernille.seljom@ife.no

The availability of wind power is modeled as stochastic parameter in a TIMES model of the Danish heat- and electricity sector. The wide scale development of wind power in Denmark makes operational short-term uncertainty an important issue in optimal investment strategies. A two-stage model is used where the investment decisions are made at the first stage, and the operational decisions are taken at the second stage after the wind conditions are revealed. Hourly wind production data from 2000 -2011 is the basis for the stochastic scenario generation.

■ HB-54

Thursday, 10:30-12h00
B14-1

Games and Information for Sustainable Operations Management

Stream: Long Term Planning in Energy, Environment and Climate
Invited session

Chair: *Helene Le Cadre*, MINES ParisTech, 06904, Sophia Antipolis, France, helene.le_cadre@mines-paristech.fr

1 - On the Feedback Solutions of Differential Oligopoly Games with Hyperbolic Demand Curve and Capacity Accumulation

Arsen Palestini, MEMOTEF, Sapienza University of Rome, Rome, Italy, Arsen.Palestini@uniroma1.it, *Luca Lambertini*

We characterise the equilibrium of a differential market game with hyperbolic inverse demand where firms are quantity-setters and accumulate capacity over time. The related Hamilton-Jacobi-Bellman are solved in closed form both on infinite and on finite horizon setups and the optimal strategies are determined. Analysing the feasibility of horizontal mergers in both static and dynamic settings, it appears that such a demand structure makes mergers more likely to occur than they would on the basis of the standard linear inverse demand.

2 - Capacity Markets: NonSense or Necessity?

Helene Le Cadre, MINES ParisTech, 06904, Sophia Antipolis, France, helene.le_cadre@mines-paristech.fr, *Michaël Soubra*

Capacity market implementation is controversial due to the speculations observed in the US. We model the capacity market as a multi-level game. We prove that it admits a unique equilibrium in prices, quantities of tra-ded energy and investment. We design a feedback mechanism where a prin-cipal can complement the investments already performed by the generators to meet the demand and deliver certifi-cates to the generators' capacity production. Finally, simulation enables us to optimize the market design to reach efficient outcomes.

3 - Competition in supply chains with risk-averse retailer

Hongyan Li, Department of Economics and Business, Business and Social Science, Fulgsangs alle 4, 8210, Aarhus V, Denmark, hojl@asb.dk, *Tianhui You*

Price and service quality are two key competition factors among service companies. This study addresses a supply chain competition problem when the retailer faces stochastic Poisson demand rates and is risk aversion. Supply chain members need to determine product prices, delivery lead times. The competition situations under the centralized, decentralized supply chains are analyzed respectively. The utility-based competition models are formulated, and the equilibrium results are presented. At last, the study is extended to include supplier's capacity competition.

4 - Modelling for local long term sustainability: the Case of the City of Bologna

Edi Assoumou, Centre de Mathematiques Appliquees, Mines ParisTech, Sophia Antipolis, France, edi.assoumou@cma.ensmp.fr, *Guido Croce*, *Francesco Tutino*, *Valérie Roy*

Bologna is a city of 380000 inhabitants that has a long history of active involvement in local energy planning and has initiated several actions to increase citizen's awareness. Its reference energy strategy aim at a 20% reduction of CO2 emissions in comparison to the CO2 level of 2005. In this paper we use a formal bottom-up optimization model of local energy flows to analyze the long-term evolution of the Bologna's energy system up to 2050. Doing so we discuss the systemic connection between concrete short-term actions and longer term objectives.

■ HB-55

Thursday, 10:30-12h00
B14-2

Methods of Multi-criteria Decision Analysis

Stream: Multi-Criteria Decision Making and Environmental Management
Invited session

Chair: *Ruud Teunter*, Operations, University of Groningen, PO Box 800, 9700AV, Groningen, Netherlands, r.h.teunter@rug.nl
Chair: *Anastasia Motrenko*, Applied mathematics and management, MIPT, Moscow, Russian Federation, pastt.petrovna@gmail.com

1 - An application of Calibration Sampling problem: the case of the Electre Tri met

Valentina Minnetti, Scienze Statistiche, Università La Sapienza, Italy, valentina.minnetti@uniroma1.it, *Renato De Leone*

In multi-criteria decision analysis, we address on the well known Electre Tri method, including the estimations of some parameters. Previous analysis of De Leone & Minnetti about the parameters estimation led to a two phases procedure. The core of it is the LP problem estimating the profiles, which requires a training set of alternatives. We use the calibration sampling method, formulated as a mix-integer non linear programming (MINLP) problem, in order to provide the weights of alternative involved in the training set. An attempt to linearize the (MINLP) problem is also provided.

2 - Multi Actor Multi Criteria Analysis for the city distribution context: a new evaluation framework

Lauriane Milan, Vrije Universiteit Brussel, Belgium, Lauriane.Milan@vub.ac.be, *Cathy Macharis*

Urban areas are facing several challenges. One of them is how to organize freight transport in a sustainable way. Most of the measures that have been tested suffer from a lack of systematic evaluation and long term adoptions often fail, because not all stakeholders were taken into account (Macharis & Melo, 2010). The new City Distribution—Multi Actor Multi Criteria Analysis (CD-MAMCA) assessment framework incorporates the city distribution actors and their objectives as the primary focus complemented with a Multi-Criteria Decision Analysis performed with the GDSS-PROMETHEE GAIA.

3 - The risk factors of breast cancer: a classification with multiple-criteria

Manel Zribi, URECA, faculty of economic science and management tunisia, BP47, SOUKRA, 2036, ARIANA, TUNIS, Tunisia, manel0306@yahoo.fr

In order to early detect the different symptoms of the breast cancer, we propose a system that can predict malignant and non-cancerous tumors as well as non-tumors. The designed decision support system uses the ELECTRE-TRI as multi-criteria approach for classifying the risk factors of breast cancer into discrete categories. According to the obtained results the system seems to be efficient and robust. Key words: Classification, risk factors, multiple-criteria, ELECTRE-TRI

4 - Location estimation of digital signage using multi criteria decision analysis
Fahad Mehmood, DIGEP, Politecnico di Torino, Corso Duca Degli Abruzzi, 24, 10129, Torino, Torino, Italy, fahad.mehmood@polito.it

During the last few years, advertisements in the form of digital screens have become extremely popular. The selection of an ideal location for installing digital signage is extremely important. Multi criteria decision analysis software ELECTRE is used in order to select the best spots for digital signage in Turin as well as the important criterias and the possible alternatives have been discussed in detail. This work is an important application of multi criteria decision analysis and can be useful for companies pursuing digital signage advertisement strategy.

■ HB-56

Thursday, 10:30-12h00
B15-3

OR Applications in Transportation and Logistics II

Stream: OR Applications in Industry
Invited session

Chair: *Oleg Gusikhin*, Ford Research & Advanced Engineering, Dearborn, United States, ogusikhi@ford.com

1 - Heuristics to minimize fuel consumption in heterogeneous fleet vehicle routing
Oleg Gusikhin, Ford Research & Advanced Engineering, Dearborn, United States, ogusikhi@ford.com, *Fei Peng*, *Amy Cohn*, *David Perner*

We study a variant of the heterogeneous vehicle routing problem where the vehicle cost is a function of both vehicle type and the route. Many vehicle fleets are usually made up of different vehicle types, resulting in differences in fuel consumption. Even in a homogeneous fleet, vehicles often differ by age and condition and consequently different in fuel consumption. We propose two heuristic methods that take into account the cost structures, and provide computational results, including a comparison with a Genetic Algorithm based method seen in the literature.

2 - A Novel Solution Approach for Large-Scale VRP with Stochastic Customers
Dauwe Vercamer, Marketing, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, Dauwe.Vercamer@ugent.be, *Dirk Van den Poel*, *Birger Raa*

In the door-to-door sales industry, it often occurs that a customer is not at home. Not using this information when making sales routes may result in low profits. In order to maximize the profitability, we use predictive analytics to determine each customer's lifetime value, including variables measuring the percentage of time they are home. This information is then used to determine which customers can enter the routes given the fleet size constraint. We then use a VNS to allocate all remaining clients to one of the routes. Our research was successfully implemented at a Belgian company.

3 - Compact Integer-programming model for the pickup-and-delivery vehicle routing problem
Abdur Rais, DPS, Centro Algoritmi, Universidade do Minho, Campus de Gualtar, 4710-057, Braga, Portugal, abdur.rais@gmail.com, *Filipe Alvelos*, *Sameiro Carvalho*

Many important real-world applications are studied as "rich" vehicle routing problems that are variants of the well-known vehicle routing problem. We address the pickup-and-delivery version of this problem and consider further generalization by allowing transshipment in the network. First we describe a compact integer-programming formulation without time aspects and later extend it to accommodate time windows for services. We discuss several variants that are either captured by our models or can be easily captured through simple modification. Computational work gave promising results.

4 - Routes optimization for hazardous materials transportation in bogotÁ, colombia
Nubia Velasco, Universidad de los Andes, Carrera 1 Este # 19A - 40, Edificio Mario Laserna, N.A, Bogotá, Colombia, nvelasco@uniandes.edu.co, *Eliecer Gutierrez*, *Jorge Victoria*

This paper is focused on developing a decision support algorithm based on Multiobjective Variable Neighborhood Search (MO-VNS), to design the distribution routes to transport HazMats. The problem consists on satisfy a set of demands, with a heterogeneous fleet minimizing the total distance and risks. This problem corresponds to a heterogeneous fleet vehicle routing problem (HFVRP) with several objectives. We propose two algorithms tested on random and real instances from Bogotá, Colombia. The efficiency of the algorithms is measured using different metrics.

■ HB-57

Thursday, 10:30-12h00
B15-4

OR for Sustainability

Stream: Environmental Issues in Operations Management
Invited session

Chair: *Ricardo de Souza*, Production Engineering, COPPE-UFRJ, Brazil, ricardo@sage.coppe.ufrj.br

1 - Extending CSR to a Global Supply Chain
Robert Mefford, School of Business, University of San Francisco, 2130 Fulton St., 94117, San Francisco, CA, United States, mefford@usfca.edu

This paper traces the evolution of Corporate Social Responsibility (CSR) in a large MNE in the electronics industry. This process has now progressed to the diffusion of CSR to its supply chain partners. The methods this firm is using to extend sustainability into its global supply chain are discussed as well as the constraints and obstacles encountered. Recommendations are made as to how to improve the efficacy of the process.

2 - OR for Sustainability: Assessing Contribution, Concepts and Research Issues
Miles Weaver, School of Management, Edinburgh Napier University, Craiglockhart Campus, Edinburgh Napier University, EH14 1DJ, Edinburgh, United Kingdom, m.weaver@napier.ac.uk, *Andrea Bonfiglioli*, *Joao Quariguasi Frota Neto*

The purpose of this paper is to assess OR contribution and concepts used to address the "grand challenge' of sustainability. Firstly, systematic literature reviews of ABS ranked journals in OR are classified by sustainability dimension (i.e. economic, social, environmental and governance) and further by OR concepts and tools applied. Secondly, the emerging themes identified at a round-table discussion of OR society members in the UK attending the YOR18 conference in Exeter 2013 are presented. Research and practical implications for the OR community to address this challenge is outlined.

3 - Mixing problem structuring methods for sustainability: the case of reverse logistics
Ricardo de Souza, Production Engineering, COPPE-UFRJ, Brazil, ricardo@sage.coppe.ufrj.br, *Jonathan Rosenhead*, *Marcos Estellita Lins*, *Rogerio Valle*

Reverse logistics is a process to recover waste material back in the production chain. It can contribute to sustainability in many ways. Stakeholders, whose interests divert, include: government, manufacturers, importers, distributors, retailers, consumers, private and informal sectors. The reverse logistics network is complex and choices are needed about its structure. This paper reports on a formalization of this problem using parts of SODA and SSM (as input to Life Cycle Assessment) applied to the development of the Brazilian electronic waste reverse logistics, enforced by a statutory law.

■ HB-58

Thursday, 10:30-12h00
B15-6

Computational Statistics and Data Mining

Stream: Computational Statistics
Invited session

Chair: *Sergio B. Villas-Boas*, PESC, UFRJ / COPPE, Department of Systems Engineering and Computer Science (PESC), Graduate School of Engineering (COPPE), Federal University of Rio de Janeiro, 21.941-972, Rio de Janeiro, Rio de Janeiro, Brazil, sbvb@sbvb.com.br

1 - A risk analysis based on a two-stage delayed diagnosis regression model
Xin Shi, Business School, Manchester Metropolitan University, Aytoun Building, Aytoun Street, Manchester, United Kingdom, x.shi@mmu.ac.uk

This paper presents a two-stage regression model for quantifying different stages of a disease progression with delayed diagnosis time and for identifying the risk factors associated with each stage. A hazard-based regression model is also proposed for a further risk analysis. We apply the developed methods to hepatitis C data and the analysis shows that considering the delayed diagnosis significantly improved the model fit in comparison with the conventional model.

2 - Forecasting and Minimizing The Failures Of Pipe Industry With Logistic Regression Models
Gizem Kavlak, Industrial engineering, TOBB University of Economics and Technology, Muhsin Yazıcıoğlu cad. 1451. sok. 4/10 Çukurambar, 06520, Ankara, Çankaya, Turkey, kavgiz@gmail.com

This paper is about prediction of failures that encountered in manufacturing of industrial pipes. The main objective is to use Logistic Regression Modeling to predict and explore relations between failures. With the aid of this study, occurences of failures will be minimized and potential future failure occurences will be eliminated. Few variables have been investigated in terms of their relative contributions towards different failure types via FMEA. According to error terms of models, it has been discussed whether the well-founded model is the most powerful prediction tool in this subject.

3 - Exploiting the Anomaly Detection for High Dimensional Data using Descriptive Approach of Data Mining
Bharat Singh, IT, Indian Institute of Information Technology, Allahabad, jhalwa, devghat, 211012, allahabad, Uttar Predesh, India, bharatbbd1@gmail.com, *Nidhi Kushwaha*, *O. P. Vyas*

Now days, enormity of High Dimensional data has been used in various applications. Most of the data mining techniques in descriptive analysis require a part of data sets into a fixed number of clusters based on user input, explicitly or learning by observation. An efficient and scalable data mining technique is required to deal with such type of data. This paper, present a new algorithm to approach the problem of outlier detection in High Dimensional data with the help of descriptive analysis. Our technique is based on the hybridization of density-based and distance-base outlier detection.

4 - Clustering using Xavier Hyperbolic Smoothing Clustering Method and Parallel Computing
Sergio B. Villas-Boas, PESC, UFRJ / COPPE, Department of Systems Engineering and Computer Science (PESC), Graduate School of Engineering (COPPE), Federal University of Rio de Janeiro, 21.941-972, Rio de Janeiro, Rio de Janeiro, Brazil, sbvb@sbvb.com.br, *Marcelo Lins*, *Adilson Elias Xavier*

We consider the minimum sum of distances clustering problem. The mathematical modeling of this problem leads to a min-sum-min formulation which is strongly non differentiable. The Xavier Clustering Method (XCM), transforms the original problem to a sequence of differentiable unconstrained minimization problems. The proposed method XCM-OpenMP is a re-design of XCM to make it be viable for parallel computing.Results of XCM and XCM-OpenMP are compared. It was achieved speed-up of a factor more than 10. Results show that the larger the dataset, the more speed-up using XCM-OpenMP.

■ HB-59

Thursday, 10:30-12h00
B15-5

Soft OR and Multimethodology IV

Stream: Soft OR / Systems and Multimethodology
Invited session

Chair: *Alberto Paucar-Caceres*, Business School, Manchester Metropolitan University, All Saints Campus, Oxford Road, M15 6BH, Manchester, United Kingdom, a.paucar@mmu.ac.uk

1 - Measuring Consumer Loyalty for E-Retailing Services Based on Fuzzy Cognitive Map
Yuching Chern, Institute of Management of Technology, National Chaio-Tung University, Hsinchu City, Taiwan, ycchen.mt00g@g2.nctu.edu.tw

This study aims at developing a loyalty measurement model for e-retailing services using fuzzy cognitive map. The causal relationships among factors of loyalty in e-retailing context were established using structural equation modeling. Key antecedents influencing states of customer online loyalty were identified and loyalty measures derived from an empirical case. Simulated scenarios were analyzed for exploring performance changes when stimuli enhanced on elements. This study addresses the applicability of soft methods and provides strategic implications for service innovation in e-markets.

2 - Understanding the concept of Environmentally Responsible Management (ERM) from a holistic perspective: A Cybernetical Approach
Andrea Martinez lozada, Universidad de los Andes, Cra. 7c bis# 141A-27, Bogotá, CUN, Colombia, cata0531@gmail.com, *Angela Espinosa*

This paper is the extension of Curkovic (2003) suggesting a more holistic understanding of ERM. The researchers recommend the use of the Viable System Model (VSM) as a conceptual model to map the organization, and to reflect about its sustainability. A parallel is drawn between VSM and ERM that answers questions regarding causal relationships between ERM factors. The paper makes an analysis of the instruments suggested by Curkovic (2003), and proposes improvements on these. Future researchers and managers will have a stronger theoretical framework to implement ERM programs.

3 - Ontologies to Guide Rich Picture Construction
Robert Pooley, Computer science, HeriotWatt University, Riccarton, Edinburgh, EH14 4AS, Edinburgh, United Kingdom, r.j.pooley@hw.ac.uk, *Eshrag Refaee*

Rich Pictures (RPs) are a used to capture world views. Introduced in Soft Systems Methodology (SSM), they have as few constraints as possible. Their open ended nature is stressed. In ontologies, things are itemized and relationships show how they combine. A system model contains things from its ontology if they match relationships. Ontologies constrain, RPs permit; combining them wins. Ontologies can check an RP. We have a tool; things are placed and linked by relationships. RP fits if tool can draw it. If not, ontology is incomplete or RP extends beyond the domain.

■ HB-60

Thursday, 10:30-12h00
B15-7

Knowledge Applications

Stream: Knowledge, Information & Technology
Invited session

Chair: *Jenny Streichhan*, Heinz Nixdorf Institute, University of Paderborn, Fürstenallee 11, 33102, Paderborn, NRW, Germany, jenny.streichhan@hni.upb.de

1 - A review for ICT Productivity definitions
Gil Greenstein, Faculty of Management of Technology, Holon Institute of Technology, 52 Golomb st., P.O.B 305 Holon, 5810201, Holon, Israel, gilgr@hit.ac.il, *Irena Milstein*, *Aviv Zeevi*, *Yulong Jin*, *Niv Ahituv*, *Edward A. Stohr*

The traditional approach to productivity measurement as related to information and communication technology (ICT) has become obsolete in the recent years. The existing definition of productivity is based upon the ratio concept (output divided by input). However, we believe that this definition should be updated and replaced by a concept of multidimensional capability enhancement. This paper reviews the literature on ICT Productivity that has been published since 1990. The 397 articles are examined in four dimensions: productivity measure, input resource, sector, and level.

2 - An Analysis of Online Purchase Decision Making Processes: the Effect of Individual Characteristics
Sahar Karimi, Manchester Business School, Manchester Business School, Booth street west, M15 6PB, Manchester, – Please Select (only U.S. / Can / Aus), United Kingdom, saharkarimi@hotmail.com, *K. Nadia Papamichail*, *Christopher Holland*

This study explores how online purchase decision-making processes unfold and examines variations in the process across individuals. Video recording and business process modeling are used to capture and model the process. The results introduce a new dimension of "phase' for this dynamic process. Five phases, each comprise a set of sequential stages with a particular goal, are identified. They are influenced by consumers' knowledge and maximization tendency. The paper suggests its application for marketers who need to facilitate phases of the process in addition to decision-making stages.

3 - A business process oriented knowledgebase for on-the-fly generation of adaptive, tailor-made workflows
Jenny Streichhan, Heinz Nixdorf Institute, University of Paderborn, Fürstenallee 11, 33102, Paderborn, NRW, Germany, jenny.streichhan@hni.upb.de, *Wilhelm Dangelmaier*

Faster product cycles lead to a speedup in knowledge generation and induce the need for an efficient and flexible knowledge management. Based on a real setting, where properties of complex materials like composite are analyzed, a business process oriented knowledge database was developed.

The database allows the generation of tailor-made workflows from abstract process components related to material testing. The workflow is automatically adapted during runtime to the actual circumstances. The adaption also incorporates lessons-learned from past process performance experiences.

■ HB-62

Thursday, 10:30-12h00
R18-1

Emerging Applications of Finance in Economics and Environment IV

Stream: Emerging Applications of Finance in Economics and Environment
Invited session

Chair: *Omer Kayhan Seyhun*, Banking and Financial Institutions Department, Risk Centralization Division, Central Bank of Turkey, Istiklal Street No 10, Ulus, 06100, Ankara, Turkey, kayhan.seyhun@tcmb.gov.tr

1 - Turkey's Government Policies versus Stock Markets Evaluation via Game Theory
Tuba Yılmaz, Econometrics, Marmara University, Goztepe Campus, Faculty of Economics Room No: 320, Kadikoy-İstanbul-Turkey, 34000, İstanbul, Turkey, tuba.yilmaz@marmara.edu.tr, *Tuncay Can*

The effects of economic policies on ISE index in Turkish economy have been studied with economic fiscal and monatery policies of the state are discussed, which are money supply, government expenditures, government debting ratio and tax rates via game theory. The game targeted optimum real economic growth. It has been discerned that, the optimal real growth target is occured by the decrease on the government debt securities yield ratio and relative price decrease on the stock exchange market. The decrease of savings causes more consumption which leads positive contribution to growth.

2 - A novel approach to exploring company's financial soundness: Investor's perspective
Zivile Kalsyte, Kaunas University of Technology, LT – 51368, Kaunas, Lithuania, kalsyte@yahoo.com

Prediction of company's life cycle stage change; creation of an ordered 2D map allow to explore company's financial soundness from a rating agency perspective. Prediction of trends of main valuation attributes are our objectives. The algorithms are based on a random forest (RF) and a nonlinear data mapping technique t-Distributed Stochastic Neighbor Embedding. Information has 5 different perspectives: balance, income, cash flow, stock price and risk indicators, were aggregated via proximity matrices of RF to explore company's financial soundness from rating agency perspective.

3 - Contribution of macroeconomic factors to the prediction of small bank failures
Davide Mare, Business School, University of Edinburgh, 29 Buccleuch Place, EH89JS, Edinburgh, United Kingdom, davide.mare@ed.ac.uk

Microprudential regulation is an integral part of the banking supervisory framework. By analyzing the link between economic conditions and the survival of small banks, we shed some further light on the importance of regional patterns once we assess individual bank stability over time. Our findings have important policy implications. First, the usage of a wider spectrum of information lessens the dependency of off-site monitoring on accounting data. Second, capital requirements for small rural banks might take into account the overall risk in tune with the application of capital buffers.

■ HB-63

Thursday, 10:30-12h00
R18-2

Recent Advances in Earthquake Studies and Geoscience Applications

Stream: Recent Advances in Earthquake Studies and Geoscience Applications
Invited session

Chair: *Aysegul Askan*, Civil Engineering, Middle East Technical University, Inonu Bulvari, 06531, Ankara, Turkey, aaskan@metu.edu.tr
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Evacuating Cities in Emergency Situations - Multiobjective Approaches
Joao Coutinho-Rodrigues, Dep. Civil Engineering, University of Coimbra, Faculty of Sciences & Tech. and INESC-Coimbra, Polo II, 3030-290, Coimbra, Portugal, coutinho@dec.uc.pt, *Lino Tralhão*, *Nuno Sousa*, *Luís Alçada-Almeida*

Fires, earthquakes, floods, hurricanes, acts of terrorism, nuclear accidents and other catastrophes that may occur in urban areas are an important concern for emergency services such as fire departments and medical assistance. Multiobjective modeling approaches to design evacuation plans for an urban area in a location/routing problem were developed and tested. The approaches aim at determining the number and location of rescue facilities (shelters), and the routes that individuals should take to reach a shelter. GIS was used as source of input data and to present results is test situations.

2 - Image Acquisition Scheduling and Cloud Avoidance for Agile Hi-Resolution Earth Observing Optical Satellite
Snezana Mitrovic Minic, Simon Fraser University, British Columbia, Canada, snezanam@sfu.ca, *Joe Steyn*

An agile satellite that can rapidly slew its imager boresight in both roll and pitch angles can be used for obtaining cloud-free optical images. After detecting the cloud coverage for the area over which the satellite will pass in the next few minutes, the image acquisition scheduling problem is solved on-board the satellite. We present a mathematical programming formulation of the problem and an experimental study comparing heuristic solution approaches. The problem instances were generated with varying cloud coverage scenarios simulating the weather conditions over a real geographic area.

3 - A Novel Non-parametric Adaptive Regression Methodology for Ground Motion Prediction
Fatma Yerlikaya Ozkurt, Scientific Computing, Institute of Applied Mathematics, Industrial Engineering Department, Middle East Technical University, 06800, Ankara, Turkey, fatmayerlikaya@gmail.com, *Aysegul Askan*, *Gerhard-Wilhelm Weber*

Ground Motion Prediction Equations (GMPEs) are used for determining the peak ground response at a particular distance from an earthquake source. There are several methods proposed for relating the peak ground responses (acceleration or velocity) as a function of distance from the source, site class of the instrument where the data is recorded and magnitude of the earthquake. In this study, we employ a new forecasting algorithm, called CMARS, on the strong ground motion database of Turkey for deriving a new GMPE. CMARS is capable of modeling high-dimensional data with nonlinear structure.

4 - Advanced Numerical Optimization Methods for Inverse Problems in Earth Sciences
Aysegul Askan, Civil Engineering, Middle East Technical University, Inonu Bulvari, 06531, Ankara, Turkey, aaskan@metu.edu.tr

In this study, a recent waveform inversion method for crustal velocity tomography (Askan et al., 2007) is reviewed in detail for its efficiency and the challenges encountered. The objective is to evaluate least-squares optimization for solving the nonlinear full waveform inverse problem of determining the crustal velocity and intrinsic attenuation properties of sedimentary valleys located in seismically active regions. The efficiency of the method and challenges encountered are discussed along with and the sensitivity of the method to various model parameters.

■ HB-64

Thursday, 10:30-12h00
R18-3

Crisis and Disaster Operations

Stream: Humanitarian Operations Research
Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de
Chair: *Silja Meyer-Nieberg*, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de

1 - A Decision Support Tool for Security Operations in Uncertain Environments
Erik Kropat, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de, *Silja Meyer-Nieberg*

Security operations require a rapid decision making in an often uncertain environment. Such missions include airport security, search & rescue operations, harbour protection and crisis & disaster management. We present a decision support framework that supports the operations center in mission planning as well as the control of the ongoing mission. It offers a focused operational picture based on the data from the network of multiple sensor platforms. We conclude with experiments in context of maritime security operations, detection & tracking and surveillance missions in urban scenarios.

2 - Immediate Disaster Relief: Searching for Missing Persons under Uncertainty
Silja Meyer-Nieberg, Department of Computer Science, Universität der Bundeswehr München, 85577, Neubiberg, Germany, silja.meyer-nieberg@unibw.de, *Erik Kropat*

After a natural disaster or a terrorist attack, it is extremely important to localize injured persons fast and reliably. The task the searchers are faced with resembles an interception of a moving entity by a team of searchers. This can be an extremely challenging task since the uncertain estimations of the position may be misleading and important time may be lost. The question remains how to coordinate the search such that the injured person is localized with a greater reliability. This talk introduces a hybrid swarm-based approach for an interception game which leads to promising results.

■ HB-65

Thursday, 10:30-12h00
R18-5

Strategic Management - Performance Optimization

Stream: Game Theory and Experimental Design
Invited session

Chair: *Stefan Wolfgang Pickl*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg-München, Bavaria, Germany, stefan.pickl@unibw.de
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Technological Superiority
Jens Leth Hougaard, Institute of Food and Resource Economics, University of Copenhagen, DK-1958, Copenhagen, Denmark, jlh@foi.ku.dk, *Mette Asmild*

Consider subsamples of production units operating under the same technology. We measure which subsample that offers the best production possibilities by way of a technology index and set up an axiomatic framework. We single out two basic families of such indexes and define a binary superiority relation on the set of subsamples of production plans. An empirical illustration shows how the suggested approach differs from the "program efficiency" approach.

2 - The Expected Performance of Maximin and Minimax Regret Rules
Chin Hon Tan, Industrial and Systems Engineering, National University of Singapore, 1 Engineering Drive 2, 117576, Singapore, Singapore, Singapore, isetch@nus.edu.sg, *Joseph Hartman*

Minimizing maximum regret and maximin are two decision rules that are commonly used in decision making under ambiguity. Even though the maximin rule can result in a higher expected outcome than the minimax regret rule in selected problems, the former is generally considered to be more conservative than the latter. We show that, contrary to conventional belief, maximin and minimax regret have similar expected outcomes for a class of simple optimization problems under a general setting. Problems where minimizing maximum regret significantly outperforms maximin are also discussed.

3 - View point Survey of the Isfahan province's health managers of reliance information system
Asadollah Shams, Management, Isfahan University and Medical Sciences, Isfahan, Iran, Islamic Republic Of, shams@mng.mui.ac.ir, *Zohreh Shams*

The main objective of this study is determining knowledge of different health institution's managers about nine philosophical principles of (PHC) especially reliable information system and technology. The used method was Descriptive—Analysis. Research tools have been administrated questionnaire about 9 philosophical principles of PHC. Study population of 384 individual of managers of Isfahan health centers have been considered. T-test and Pearson correlation analysis was used for analysis.

4 - Drug shortage - mathematical inventory model and computational experience
Jelena Hadzi-Purić, Department for Computer Science, Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000, Beograd, Serbia, Serbia, hadzipuric@gmail.com, *Jeca Grmusa*

Drug shortage is an important health care problem as it represents a change in the drug supply that has the potential to compromise patient care. We have developed cost minimization model with no amortization value that captures the complexity of inventory storage, local facilities, repacking and outsourcing. We solve the shortage problem with a real world data set, and compare the solution with similar model. Computational results show that our model provides better insights to the problem and thus allows better decision support.

■ HB-66

Thursday, 10:30-12h00
R18-4

Optimization and Natural Sciences

Stream: Optimization and Natural Sciences
Invited session

Chair: *Alexander Plakhov*, Department of Mathematics, University of Aveiro, Campus Santiago, 3810-276, Aveiro, Portugal, plakhov@ua.pt

1 - Minimum time optimal control solution for interplanetary trajectory problem, Earth to Mars case study
M. Navabi, Dynamics and Control, Shahid Beheshti University, GC, 123, thr, Iran, Islamic Republic Of, sciences.edu@gmail.com, *E. Meshkinfam*

The aim of this paper is to achieve minimum time orbit transfer in a given radius utilizing two methods. The methods are Gradient Projection and Collocation. The gradient projection is an iterative numerical procedure for finding an extremum of a function of several variables that are required to satisfy various constraining relations. In the collocation method a 4th order approximation of equations is considered for optimality. It is assumed a constant thrust rocket and a circular orbit for the initial and final times

2 - Mathematical Modeling and An Application of Filled Function Method In Entomology
Nurullah Yilmaz, Mathematics, Suleyman Demirel University, Department of Mathematics, Suleyman Demirel University, East Campus, 32260, ISPARTA, Turkey, nurullahyilmaz@sdu.edu.tr, *Ahmet Sahiner*, *Ozan Demirözer*

Determining of the population fluctuations of pest species is very important in plant protection and have significant role in order to provide pest control decisions. Herewith in this study, population fluctuation of Macrosiphum rosae (L.) which is one of the most important pest on Oil-bearing rose (Rosa damascena Miller) was investigated.

To achieve the goal, fuzzy logic modeling is used to obtain information for untested data and filled function method which is a global optimization method is employed for the first time in these kinds of problems to reach extremes of population.

3 - Robust Optimal sliding mode controller for attitude control of a spacecraft
Hamed Rangraz, New Technologies Engineering Faculty, shahid behedhti university, Velenjak, shahriari square, shahid beheshti university, tehran, tehran, Iran, Islamic Republic Of, phd.faculty@gmail.com, *Mohamad Navbvi*

Optimum sliding mode controller is designed as robust control for attitude control of a spacecraft. Thruster is selected as control actuator and its modeling uncertainties are determined which could be start time, shutdown time and thrust value variations that considerably decrease the control reliability.Due to high nonlinear nature of control system, it is simulated in MATLAB Simulink with nonlinear attitude dynamics implementation and second-order SMC design. Valuable Results attained due to lowering control attempt and fuel consumption against modeling uncertainties with high accuracy.

4 - A quadrature-collocation method for frictional contact problems
Hüseyin Oğuz, Mathematic, Dumlupınar University, Dumlupınar University, 43000, Kutahya, Turkey, huseyinoguz2010@gmail.com

Plane contact of punch and elastic layer, taking friction forces into account, is considered. It is assumed that,the normal and shear stresses are related by Coulomb's law in the contact area and normal and shear forces act on the punch. First,exact Cauchy type singular integral equation of the second kind with kernel, represented in explicit analytical form, is obtained. A scheme for solving the integral equation by the direct collocation method is described. The effects of parameters of the materials on various subjects of interest are investigated and shown graphically and tabular form

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■ HB-67

Thursday, 10:30-12h00
R19-1

Contemporary Issues in Education

Stream: Education Policy
Invited session

Chair: *Hanife Akar*, Department of Educational Sciences, Middle East Technical University, Orta Dogu Teknik Universitesi, Egitim Fakultesi EF 316, 06531, Ankara, Turkey, hanif@metu.edu.tr

1 - What exactly did Torricelli do?
Jakob Krarup, Dept. of Computer Science, University of Copenhagen, Ydervang 4, DK-3460, Birkeroed, Denmark, krarup@diku.dk

One of my grandchildren is 7 years of age. I enjoy following her homework assignments, for the time being exercises with ruler and compass: points, straight lines, angles, triangles, and circles. No more is needed to fully appreciate what Torricelli did around 1645 in his solution to the 3-point Fermat problem with weights (+1,+1,+1). An equally straightforward approach does also suffice for solving the related Courant-Robbins 'Complementary Problem' with weights (-1,+1,+1) and its generalization to the 3-point Fermat problem with arbitrary weights.

2 - Operations Research in Education: social analysis and decisions in the intercultural school
Rina Manuela Contini, Literature, Arts and Social Sciences, University of Chieti-Pescara, Via di Vestini, 31, 66013, Chieti, Italy, rm.contini@unich.it, *Antonio Maturo*

The paper addresses the problem of multi-objective and multi-agent decision for the integration of new generation in a multi-ethnic scholastic environment that, can promote cohesion in culturally heterogeneous society. The techniques used in this research are: the Analytic Hierarchy Process (AHP), for the division of a complex objective in sub-objectives and in simple criteria (Saaty & Peniwati,2007); as for the interpretation of the results of the questionnaires methods for the treatment of indecision, subjective probability and fuzzy logic are used.

3 - Educational Aspirations of Families with Disadvantaged Human and Cultural Capital
Hanife Akar, Department of Educational Sciences, Middle East Technical University, Orta Dogu Teknik Universitesi, Egitim Fakultesi EF 316, 06531, Ankara, Turkey, hanif@metu.edu.tr, *Mustafa Levent Ince*

Families' educational aspirations were investigated through a cross-sectional national survey in districts with poor residents. Although the primary school students' background reflected low levels of human and cultural capital, findings showed that social capital investments in the family and school context with poor resources increased parents' educational aspirations for their childrens' better future, occupation, and being a good citizen. Educational policy in a centralized educational system should target schools in poor districts with differentiated school quality investments.

■ HB-69

Thursday, 10:30-12h00
R19-3

Sustainable Construction Processes

Stream: OR for Sustainable Development
Invited session

Chair: *Tatjana Vilutiene*, Department of Construction Technology and Management, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT01001, Vilnius, Lithuania, tatjana.vilutiene@vgtu.lt

1 - A multi-objective input-output model to assess employment impacts of energy efficiency measures
Carla Henriques, INESC Coimbra and ISCAC Coimbra, Rua Antero de Quental, 199, Quinta Agrícola, Bencanta, 3040-316 Coimbra, Portugal, 3000-030, Coimbra, Portugal, coliv@inescc.pt, *Carlos Henggeler Antunes*

Energy efficiency plays a significant role in increasing the security of energy supply and mitigating climate change. Although this role is unquestionable, there is an ongoing discussion about the employment impacts of promoting energy efficiency measures, in particular of retrofit investments. The purpose of this paper is to provide a prospective estimation of the number of net jobs associated with the most common retrofit investment options in the building stock of Portugal, considering a methodological framework based on a Multi-Objective Input-Output model with interval coefficients.

2 - Evaluation of environmental performance of passive house - a case study of Lithuania
Tatjana Vilutiene, Department of Construction Technology and Management, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT01001, Vilnius, Lithuania, tatjana.vilutiene@vgtu.lt, *Violeta Motuziene*, *Artur Rogoza*

Article aims to assess environmental performance of the energy efficient single-family house in Lithuania (climate of northern Europe) during its life cycle. Results of the life cycle analysis have shown that energy efficient house consumes nearly 1/3 of primary energy in the construction phase; meanwhile in standard buildings this energy amount is usually less than 1/5, "weakest' parts in each subsystem were identified and improvements proposed. Results of the analysis will be used further for the ongoing project funded by a grant (No. ATE-03/2012) from the Research Council of Lithuania.

3 - Construction process management using passive and active flexibility
Jerzy Paslawski, Civil and Environmental Eng., Poznan University of Technology, Instytut Konstrukcji Budowlanych, ul. Piotrowo 5, PL 60-965, Poznan, Poland, jerzy.paslawski@put.poznan.pl

Construction process management is a very difficult task due to the commonly frequent high level of risk and uncertainty. One possible action is the introduction of a quality management system conforming with the concept of Six Sigma as a strategy of robustness. However, its implementation in the construction industry and achievement a level of 4 sigma can be considered very successful. Introducing the next robustness adaptability strategy can greatly improve the final results defined as meeting the requirements in terms of quality, time and cost.

■ HB-71

Thursday, 10:30-12h00
R16-1

Stochastic Analysis in Sports

Stream: OR in Sports
Invited session

Chair: *Jeroen Belien*, Center for Informatics, Modeling and Simulation, Hogeschool-Universiteit Brussel, Warmoesberg 26, 1000, Brussels, Belgium, Jeroen.Belien@kuleuven.be

1 - OR solves cricket's problem of handling interrupted limited overs matches fairly
Tony Lewis, Oxford Brookes University (retd.), 169 Green Ridges, Headington, OX3 8LX, Oxford, Oxfordshire, United Kingdom, aj-lewis@tiscali.co.uk

One-day cricket has a playing structure that causes problems when rain leads to a reduction in playing time and an adjustment to the requirement to win the match. Many simple processes were tried but none proved satisfactory. An OR modelling approach by Frank Duckworth and Tony Lewis has been recognised to have solved the problem to such an extent that the method, now named after them, has become the international standard and is in use world-wide. The presentation will outline the issues involved and the modelling that has devised for cricket a road leading to a successful application of OR

2 - A model of progression of records: can new record be predicted?
Petr Volf, Institute of Information Theory and Automation ASCR, Czech Republic, volf@utia.cas.cz

The time series of historical results in track and field athletic events is analyzed. The series is fitted by a nonlinear trend, then, with its aid, a Markov chain model of new record occurrence and new record value is derived and its forecasting ability is studied. In order to increase the reliability of prediction, certain local features of the recent results sequence are analyzed. Thus, the transition probabilities of the chain are improved with the aid of a pattern recognition approach. Application deals with the progression of best results in men sprints data.

3 - Stochastic process for win probability of baseball game
Norio Torigoe, School of Science, Tokai university, 4-1-1 Kitakaname, 2591292, Hiratsuka, Kanagawa, Japan, torigoe@tokai-u.jp

Win Probability Added (WPA) is one of the important index of sabermetrics. WPA attempts to measure a player's contribution to a win by figuring the factor. It is necessary for calculate WPA to obtain Win Probability (WP) beforehand. In baseball WP basically measures the probability one team will win based on score, inning, outs, and runners on base. In this study, we build the algorithm for calculating the WP at each of the situations including batter's count and calculate the WP using the observed data taken from the result of games played in Nippon Professional Baseball.

4 - A mixed integer programming model for ex post optimization in fantasy sport games
Jeroen Belien, Center for Informatics, Modeling and Simulation, Hogeschool-Universiteit Brussel, Warmoesberg 26, 1000, Brussels, Belgium, Jeroen.Belien@kuleuven.be, *Dries Goossens*, *Daam Van Reeth*, *Daam Van Reeth*

This paper presents a general mixed integer programming model for finding the optimal strategy in fantasy sport games when all data are known. As the model incorporates many of the common game rules, it can be applied to a wide variety of fantasy sport games worldwide. The computational performance of the model is illustrated using real-life data from an online fantasy cycling game. We demonstrate how the results can be used to (1) obtain general insights into good game strategies, (2) provide individual feedback for each participant, and (3) create business value for the game organizer.

■ HB-72

Thursday, 10:30-12h00
R16-2

Sequence Analysis

Stream: Computational Biology, Bioinformatics and Medicine
Invited session

Chair: *Piotr Formanowicz*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, piotr@cs.put.poznan.pl
Chair: *Pawel Kedziora*, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, Poland, pkedziora@cs.put.poznan.pl

1 - Methods for peptide sequence finding
Marcin Borowski, Institute of Computing Science, Poznan University of Technology, 60-965, Poznan, Poland, mborowski@cs.put.poznan.pl, *Jacek Blazewicz*, *Piotr Formanowicz*

In recent years we have witnessed a massive flow of new biological data. Large-scale sequencing projects throughtout the world turn out new sequences, and create new challenges for researchers. Determining amino acid sequences of protein is one of the most important issues in molecular biology. The existing direct methods can be applied only for short sequences and generaly base on data stored in databases. That is the reason of using two step methods: assembly (combinatorial methods of assembly short fragments into whole peptide) and sequencing methods (chiefly de novo peptide sequencing).

2 - Sequence alignment on GPU — algorithms for multi-pairwise and multiple sequence alignment
Pawel Wojciechowski, Poznan University of Technology, 60-965, Poznan, Poland, pwojciechowski@cs.put.poznan.pl, *Michal Kierzynka*, *Wojciech Frohmberg*

We have developed the solution that performs the alignment of every given sequence pair on GPU. Performed tests show that the implementation, with performance up to 20 GCUPS on a single GPU for affine gap penalties, is very efficient in comparison to other CPU and GPU-based solutions. We used above implementation to design an MSA algorithm on the same platform. Performed tests show that our method is highly efficient achieving up to 193-fold speedup on a single GPU while the quality of its results remains good. Multiple GPUs support with load balancing makes the application scalable.

3 - Selected algorithmic aspects of peptide assembly
Adam Kozak, Computing Science Institute, Poznan University of Technology, 12345, Poznan, Poland, adam.kozak@cs.put.poznan.pl, *Tomasz Glowacki*

Peptides are chemical compounds formed by linking 20 types of amino acids. Long peptides (proteins) consist of up to dozen thousands of amino acids. Sequence of amino acids determines their structure and therefore their functionality. Determination of amino acid order in peptide structure is called sequencing. Because existing methods for peptide sequencing allow for determination only short fragments, there is a need for assembly methods to bring these pieces together. The assembly method based on enzymatic digestion is presented and its selected algorithmic aspects are considered.

■ HB-74

Thursday, 10:30-12h00
R16-4

Educational Related OR Studies

Stream: Applications of Operations Research in Education
Invited session

Chair: *Erwin Reizes*, O.R., Fac.Ing./UdelaR,Uruguay, Luis A.de Herrera 1042,ap.1701 (home), ap.1701, 11300, Montevideo, Uruguay, bereizes@adinet.com.uy

1 - Teaching Business Analytics to Undergraduate Students with R AnaliticFlow
Yuji Nakayama, School of Management, Osaka Prefecture University, Naka-ku, Gakuen-cho 1-1, 5998531, Sakai, Osaka, Japan, nakayama@eco.osakafu-u.ac.jp, *Tomonori Ishigaki*, *Nagateu Araki*, *Hiroyuki Morita*, *Masashi Kondo*

We show that R AnaliticFlow, a free software, is effective for business analytics education for undergraduate students. Quite a few undergraduates, especially whose major is not science/engineering, are reluctant to study programming for data analysis. However, it is said that various industries need business analytics experts. R AnaliticFlow can be a solution for it. The software works as a front-end of R, a free popular statistical software and visualizes analytics flows which help them understand the main part of analytics. We provide several examples of the instruction with R AnaliticFlow.

2 - Determining the most appropriate special education and rehabilitation center by the moora method
Gökhan Özçelik, Industrial Engineering, Gazi University, Faculty of Engineering Eti Mah., Yukselis Sok No:5 Maltepe, 06570, Ankara, -, Turkey, gokhanozcelik@gazi.edu.tr, *Emel Kizilkaya Aydogan*, *Cevriye Gencer*

Special education and rehabilitation centers are established in order to train children and young people who need special education. In this study, by evaluating three different special education and rehabilitation centers which are active in Kayseri in terms of various criteria, it is aimed to determine the most appropriate corporation. For this purpose, we apply MOORA that is one of the methods of multi-criteria decision making. As the criteria; education, compliance of ergonomic, compliance of corporation building, cost, public opinion & prestige and assessment of personnel are considered.

3 - O.R. education administration
Erwin Reizes, O.R., Fac.Ing./UdelaR,Uruguay, Luis A.de Herrera 1042,ap.1701 (home), ap.1701, 11300, Montevideo, Uruguay, bereizes@adinet.com.uy

O.R.education depends on both, administration of O.R.departments in colleges un universities and administration of O.R. in social sectors of production and services, including R.& D. The design of such systems is the goal of my contribution,an application of Euro 2012s "Taxonomy of concepts and terms in administration".

Thursday, 12:00-13:30

■ HC-01

Thursday, 12:00-13:30
O1-1

Closing Session

Stream: Opening and Closing Sessions
Plenary session

STREAMS

Actuarial Sciences and Stochastic Calculus
Invited

Ricardo Josa-Fombellida
Universidad de Valladolid
ricar@eio.uva.es

Juan Pablo Rincon-Zapatero
Universidad Carlos III de Madrid
jrincon@eco.uc3m.es

Track(s): 49
4 sessions

Advanced Inventory Control and Pricing Strategies
Invited

Alf Kimms
University of Duisburg-Essen
alf.kimms@uni-due.de

Robert Klein
University of Augsburg
robert.klein@wiwi.uni-augsburg.de

Track(s): 50
2 sessions

Algorithm and Computational Design
Invited

Basak Akteke-Ozturk
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bozturk@metu.edu.tr

Haldun Sural
Middle East Technical University
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Track(s): 64
3 sessions

Analytic Hierarchy Processes, Analytic Network Processes
Invited

Josef Jablonsky
University of Economics Prague
jablon@vse.cz

Y. Ilker Topcu
Istanbul Technical University
ilker.topcu@itu.edu.tr

Chi-Cheng Huang
Aletheia University
j1225a@ms7.hinet.net

Track(s): 39
7 sessions

Applications of Operations Research in Education
Invited

Seren Basaran
The American University (GAU)
serenbasaran@gau.edu.tr

Track(s): 74
3 sessions

Artificial Intelligence, Fuzzy systems (contributed)
Contributed
Track(s): 25
5 sessions

Biomass-based Supply Chains
Invited

Magnus Fröhling
Karlsruhe Institute of Technology (KIT)
magnus.froehling@kit.edu

Taraneh Sowlati
University of British Columbia
taraneh.sowlati@ubc.ca

Track(s): 55
5 sessions

Boolean and Pseudo-Boolean Optimization
Invited

Endre Boros
Rutgers University
Endre.Boros@rutcor.rutgers.edu

Track(s): 27
4 sessions

Business Analytics and Intelligent Optimization
Invited

Richard Weber
University of Chile
rweber@dii.uchile.cl

Track(s): 57 59
3 sessions

Business Excellence in Logistics
Invited

Martin Josef Geiger
Helmut-Schmidt-University
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Track(s): 19
2 sessions

Challenge EURO/ROADEF
Invited

Marc Sevaux
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Christian Artigues
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Eric Bourreau
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Vincent Jost
CNRS - Ecole Polytechnique
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Track(s): 31 41 65
3 sessions

Combinatorial Optimization I
Invited

Silvano Martello
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Paolo Toth
University of Bologna
paolo.toth@unibo.it

Track(s): 26
13 sessions

Combinatorial Optimization II
Invited

Silvano Martello
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silvano.martello@unibo.it

Track(s): 27
8 sessions

Computational Biology, Bioinformatics and Medicine
Invited

Jacek Blazewicz
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Metin Turkay
Koc University
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Giovanni Felici
Consiglio Nazionale delle Ricerche
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Track(s): 72
4 sessions

Computational Statistics
Invited

Vilda Purutcuoglu
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Pakize Taylan
Dicle University
pakizetaylan@yahoo.com

Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 58
4 sessions

Container Terminal Operations
Invited

Ceyda Oguz
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coguz@ku.edu.tr

Christian Bierwirth
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Halle-Wittenberg
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Frank Meisel
Martin-Luther-University
Halle-Wittenberg
frank.meisel@wiwi.uni-halle.de

Ali Diabat
Masdar Institute
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Track(s): 15
5 sessions

Continuous and Discontinuous Dynamical Systems
Invited

Duygu Aruğaslan
Süleyman Demirel Üniversitesi
duyguarugaslan@sdu.edu.tr

Mevlüde Yakıt Ongun
Süleyman Demirel University
mevludeyakit@sdu.edu.tr

Track(s): 2
2 sessions

Control Theory & System Dynamics (contributed)
Contributed

Track(s): 12
2 sessions

Convex Optimization
Invited

Marc Teboulle
Tel Aviv University
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Amir Beck
Technion - Israel Institute of Technology
becka@ie.technion.ac.il

Attila Gilanyi
University of Debrecen
gilanyi@math.klte.hu

Track(s): 4
4 sessions

Cooperative Game Theory
Invited

Mariana Rodica Branzei
"Alexandru Ioan Cuza" University
branzeir@info.uaic.ro

Sirma Zeynep Alparslan Gok
Faculty of Arts and Sciences,
Suleyman Demirel University
zeynepalparslan@yahoo.com

Track(s): 45
6 sessions

Coposition and Polynomial Optimization
Invited

Immanuel Bomze
University of Vienna
immanuel.bomze@univie.ac.at

Miguel Anjos
Ecole Polytechnique de Montreal
anjos@stanfordalumni.org

Track(s): 7
5 sessions

Cutting and Packing
Invited

José Fernando Oliveira
University of Porto
jfo@fe.up.pt

A. Miguel Gomes
INESC TEC, Faculdade de Engenharia, Universidade do Porto
agomes@fe.up.pt

Track(s): 36
8 sessions

Data Mining and Decision Making
Invited

Lai-Soon Lee
Universiti Putra Malaysia
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Hsin-Vonn Seow
University of Nottingham- Malaysia Campus
Hsin-Vonn.Seow@nottingham.edu.my

Track(s): 58
1 session

Data Mining in Early Warning Systems
Invited

Inci Batmaz
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Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Elcin Kartal Koc
Middle East Technical University
kartalelcin@gmail.com

Track(s): 60
4 sessions

Data Mining in the Financial Sector
Invited

Vadim Strijov
Russian Academy of Sciences, Computing Center
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Track(s): 49
4 sessions

DEA and Performance Measurement
Invited

Dimitris Despotis
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despotis@unipi.gr

Meryem Duygun Fethi
University of Leicester
m.fethi@le.ac.uk

Ana Camanho
Universidade do Porto
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Vania Sena
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Track(s): 40
10 sessions

DEA and Performance Measurement II
Invited

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Ana Camanho
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Vania Sena
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Track(s): 41
7 sessions

Decision Analysis, Decision Support Systems, DEA and Performance Measurement (contributed)
Contributed
Track(s): 40
3 sessions

Decision Making Modeling and Risk Assessment in the Financial Sector
Invited

Cristinca Fulga
Gheorghe Mihoc-Caius Iacob Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy
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Track(s): 51
7 sessions

Decision Making under Uncertainty and Environmental Applications
Invited

Jerzy Filar
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Julia Piantadosi
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Track(s): 41
5 sessions

Decision Processes
Invited

Ahti Salo
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Alec Morton
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Jeffrey Keisler
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Track(s): 42
7 sessions

Decision Support Systems
Invited

Pascale Zaraté
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Fatima Dargam
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Shaofeng Liu
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Track(s): 43
7 sessions

Defence and Security
Invited

Ana Isabel Barros
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Track(s): 64
5 sessions

Demand and Supply Planning in Consumer Goods and Retailing
Invited

Rob Broekmeulen
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Alexander Hübner
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Heinrich Kuhn
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Winfried Steiner
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Track(s): 31
8 sessions

Discrete and Global Optimization
Invited

Xiaoling Sun
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Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 30
6 sessions

Discrete Choice Models: Estimation and Assortment Optimization
Invited

Guillermo Gallego
Columbia University
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Track(s): 50
1 session

Discrete Optimal Control
Invited

Dmitrii Lozovanu
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Gerhard-Wilhelm Weber
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Katsunori Ano
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Masayuki Horiguchi
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Track(s): 2 68
6 sessions

Discrete Optimization, Geometry & Graphs (contributed)
Contributed
Track(s): 30
1 session

Dynamic Optimization
Invited

Patrick Siarry
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Track(s): 64
1 session

Dynamic Programming
Invited

Lidija Zadnik Stirn
University of Ljubljana
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Track(s): 5
3 sessions

Dynamical Systems and Game Theory
Invited

Alberto Pinto
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Track(s): 44
4 sessions

Dynamical Systems and Mathematical Modeling in OR
Invited

Selma Belen
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Gerhard-Wilhelm Weber
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Ozlem Defterli
Cankaya University, Ankara, TURKEY & Saginaw Valley State University, College of Science, Engineering and Technology, MI, USA (currently as PostDoc)
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Track(s): 2
2 sessions

Education Policy
Invited

Hanife Akar
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Track(s): 67
2 sessions

Emerging Applications in Game Theory and Management
Invited

Leon Petrosyan
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Nikolay Zenkevich
St. Petersburg University
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Vladimir Mazalov
Institute of Appied Mathematical Research,Karelia Research Center
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Track(s): 65
3 sessions

Emerging Applications in Portfolio Selection and Management Science
Invited

Norbert Trautmann
University of Bern
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Track(s): 65
3 sessions

Emerging Applications of Finance in Economics and Environment
Invited

Kasirga Yildirak
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Omer Kayhan Seyhun
Central Bank of Turkey
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Track(s): 62
4 sessions

Energy Economics
Invited

Mette Bjørndal
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Track(s): 53
3 sessions

Energy systems and markets
Invited

Asgeir Tomasgard
Sintef Technology and society
asgeir.tomasgard@sintef.no

Track(s): 53
3 sessions

Energy, Environment and Climate
Invited

Jakub Marecek
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Track(s): 54
11 sessions

Engineering Optimization
Invited

Wolfgang Achtziger
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Track(s): 57
1 session

Environmental Issues in Operations Management
Invited

Grit Walther
RWTH Aachen
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Track(s): 57
3 sessions

Experimental Economics and Game Theory
Invited

Ulrike Leopold-Wildburger
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Gerhard-Wilhelm Weber
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Track(s): 43
3 sessions

Facility Logistics
Invited

John Bartholdi
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Track(s): 13
2 sessions

Financial and Commodities Modeling
Invited

Rita Decclesia
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Ronald Hochreiter
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Yeliz Yolcu Okur
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Track(s): 50
2 sessions

Financial Mathematics and OR
Invited

Mustafa Pinar
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Sevtap Kestel
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Gerhard-Wilhelm Weber
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Katsunori Ano
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Track(s): 48
6 sessions

Financial Optimization
Invited

Duan Li
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Nan Chen
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Fabio Tardella
Sapienza University of Rome
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Track(s): 51
6 sessions

Forecasting & Time Series Prediction
Invited

Sven F. Crone
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Robert Fildes
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Fotios Petropoulos
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Antonio Rodrigues
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Track(s): 52
13 sessions

Forecasting & Time Series Prediction II
Invited

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Fotios Petropoulos
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Antonio Rodrigues
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Track(s): 53
1 session

Fuzzy Decision Support Systems, Soft Computing, Neural Network
Invited

Heinrich Rommelfanger
J. W. Goethe University
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Track(s): 23
7 sessions

Fuzzy Optimization - Systems, Networks and Applications
Invited

Erik Kropat
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Silja Meyer-Nieberg
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Track(s): 25
4 sessions

Game Theoretical Network Models
Invited

Roman Polyak
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Track(s): 43 44
3 sessions

Game Theory and Combinatorial Optimization
Invited

Bo Chen
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Steve Alpern
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Track(s): 46
5 sessions

Game Theory and Experimental Design
Invited

Stefan Wolfgang Pickl
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Track(s): 65
2 sessions

Game Theory and Social Networks
Invited

Juan Tejada
Complutense Unversity of Madrid
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Track(s): 46
2 sessions

Game Theory, Solutions and Structures
Invited

Encarnación Algaba
Seville University
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Track(s): 46
3 sessions

Game-theoretical Models in Operations Research
Invited

M[a] Gloria Fiestras-Janeiro
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Ana Meca
Universidad Miguel Hernández
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Greys Sosic
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Track(s): 46
3 sessions

Generalized Differentiation and Optimization
Invited

Alexander Kruger
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Gerhard-Wilhelm Weber
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Track(s): 6
2 sessions

Geometric Clustering
Invited

Andreas Brieden
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Peter Gritzmann
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Steffen Borgwardt
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Track(s): 28
3 sessions

Global Optimization
Invited

Herman Mawengkang
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Gerhard-Wilhelm Weber
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Janos D. Pinter
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Track(s): 6
3 sessions

Graph Searching
Invited

Boting Yang
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Nancy Clarke
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Track(s): 28
2 sessions

Graphs and Networks
Invited

Dominique de Werra
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Track(s): 30
6 sessions

Health Care Management
Invited

Teresa Melo
Saarland University of Applied Sciences
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Stefan Nickel
Karlsruhe Institute of Technology (KIT)
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Marion Rauner
University of Vienna
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Vedat Verter
McGill University
Vedat.Verter@mcgill.ca

Track(s): 71
8 sessions

Hub Location
Invited

Sibel A. Alumur
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James Campbell
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campbell@umsl.edu

Ivan Contreras
Concordia University
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Track(s): 19
3 sessions

Humanitarian Logistics
Invited

Serhan Duran
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Track(s): 71
2 sessions

Humanitarian Operations Research
Invited

Erik Kropat
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Silja Meyer-Nieberg
Universität der Bundeswehr München
silja.meyer-nieberg@unibw.de

Track(s): 64
4 sessions

Hybridisation of Heuristic for Global Optimisation
Invited

Said Salhi
University of Kent
s.salhi@kent.ac.uk
Track(s): 14
4 sessions

IBM Research Applications
Invited

Eleni Pratsini
IBM Zurich Research Lab
pra@zurich.ibm.com
Track(s): 57
2 sessions

Information and Intelligent Systems
Invited

Zuzana Oplatkova
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Katsunori Ano
Shibaura Institute of Technology
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Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 60
4 sessions

INFORMS MSOM Stream
Invited

Victor Martínez de Albéniz
IESE Business School
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Track(s): 25
3 sessions

Initiatives for OR Education
Invited

Alexis Pasichny
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Kateryna Pereverza
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Olga Nazarenko
National Technical University of Ukraine "Kyiv Polytechnic Institute"
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Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Dmytro Fishman
University of Tartu
dmytrofishman@gmail.com
Track(s): 74
3 sessions

Invited Lectures - Keynotes and Tutorials
Invited

Marc Sevaux
Université de Bretagne Sud
marc.sevaux@univ-ubs.fr

David Simchi-Levi
Mit
dslevi@mit.edu
Track(s): 8 31
13 sessions

Invited Lectures - Plenary
Invited
Track(s): 1
3 sessions

Journals
Invited

Marc Sevaux
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Track(s): 67 70 74
5 sessions

Knowledge, Information & Technology
Invited

A. D. Amar
Seton Hall University
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Track(s): 60
2 sessions

Life Insurance, Risk and Ruin Theory, Financial Modelling
Invited

Erengul Ozkok Dodd
Hacettepe University
eozkok@hacettepe.edu.tr
Track(s): 49
3 sessions

Location Analysis
Invited

Sibel A. Alumur
TOBB University of Economics and Technology
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Ioannis Giannikos
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Mercedes Landete
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Stefan Nickel
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Francisco Saldanha-da-Gama
University of Lisbon
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Alfredo Marín
University of Murcia
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Track(s): 11
8 sessions

Location, Logistics, Transportation (contributed)
Contributed
Track(s): 19
8 sessions

Long Term Financial Decisions
Invited

Thomas Burkhardt
Universitaet Koblenz-Landau
tburkha@uni-koblenz.de
Track(s): 50
1 session

Long Term Planning in Energy, Environment and Climate
Invited

Nadia Maïzi
MINES ParisTech
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Track(s): 54
2 sessions

Lot-Sizing and Related Topics
Invited

Bernardo Almada-Lobo
Faculty of Engineering of Porto University
almada.lobo@fe.up.pt

Alistair Clark
University of the West of England
Alistair.Clark@uwe.ac.uk

Christian Almeder
European University Viadrina
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Track(s): 33
7 sessions

Machine Learning and Its Applications
Invited

Vadim Strijov
Russian Academy of Sciences, Computing Center
strijov@ccas.ru

Sureyya Ozogur-Akyuz
Bahcesehir University
sureyya.akyuz@bahcesehir.edu.tr

Track(s): 59
6 sessions

Manufacturing and Warehousing
Invited

Martin Grunow
Technische Universität München
martin.grunow@tum.de

Track(s): 35
4 sessions

Maritime Transportation
Invited

Marielle Christiansen
Norwegian University of Science and Technology
marielle.christiansen@iot.ntnu.no

Henrik Andersson
Norwegian University of Science and Technology
Henrik.Andersson@iot.ntnu.no

Track(s): 17
6 sessions

Mathematical Economics
Invited

Roman Polyak
George Mason University
rpolyak@gmu.edu

Track(s): 43
2 sessions

Mathematical Methods for Decision Support
Invited

Adriana Gnudi
University of Bergamo
adriana.gnudi@unibg.it

Elisabetta Allevi
University of Brescia
allevi@eco.unibs.it

Igor Konnov
University of Kazan
Igor.Konnov@ksu.ru

Track(s): 44
2 sessions

Mathematical Models in Macro- and Microeconomics
Invited

Ludmilla Koshlai
Institute of Cybernetics
koshlai@ukr.net

Alexander Vasin
Lomonosov Moscow State University
vasin@cs.msu.su

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Track(s): 45
7 sessions

Mathematical Programming
Invited

Sandor Zoltan Nemeth
The University of Birmingham
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Florian Potra
University of Maryland
potra@umbc.edu

Goran Lesaja
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Tamás Terlaky
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Juan José Salazar González
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jjsalaza@ull.es

Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 4
9 sessions

Mathematical Programming (contributed)
Contributed

Gerhard-Wilhelm Weber
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Track(s): 27
1 session

Matheuristics
Invited

Vittorio Maniezzo
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vittorio.maniezzo@unibo.it

Stefan Voss
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stefan.voss@uni-hamburg.de

Track(s): 14
4 sessions

Medical Decision Making
Invited

Vera Tilson
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Track(s): 67
1 session

Metaheuristics
Invited

Kenneth Sörensen
University of Antwerp
kenneth.sorensen@ua.ac.be

Marc Sevaux
Université de Bretagne Sud
marc.sevaux@univ-ubs.fr

Andreas Reinholz
German Aerospace Center (DLR)
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Track(s): 14
4 sessions

Metaheuristics (contributed)
Contributed

Kenneth Sörensen
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kenneth.sorensen@ua.ac.be

Andreas Reinholz
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andreas.reinholz@gmx.de

Marc Sevaux
Université de Bretagne Sud
marc.sevaux@univ-ubs.fr

Track(s): 15
7 sessions

Methodology of Social Complexity
Invited

Dorien DeTombe
Chair Euro Working Group
detombe@nosmo.nl
Track(s): 72
3 sessions

Mixed-Integer Non-Linear Programming
Invited

Armin Fügenschuh
Zuse Institut Berlin
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Claudia D'Ambrosio
CNRS - Ecole Polytechnique
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Sonia Cafieri
Ecole Nationale d'Aviation Civile
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Track(s): 62
9 sessions

MSOM iFORM Special Interest Group Stream
Invited

Alejandro Serrano
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aserrano@zlc.edu.es
Track(s): 31
3 sessions

MSOM Service Management SIG Stream
Invited

Moshe Haviv
Hebrew University of Jerusalem
haviv@mscc.huji.ac.il
Track(s): 3
1 session

Multi-Criteria Decision Making and Environmental Management
Invited

Vadim Strijov
Russian Academy of Sciences, Computing Center
strijov@ccas.ru
Track(s): 55
8 sessions

Multi-Objective Optimization
Invited

José Rui Figueira
Technical University of Lisbon
figueira@ist.utl.pt

Emilio Carrizosa
Universidad de Sevilla
ecarrizosa@us.es
Track(s): 39
1 session

Multicriteria Decision Making
Invited

José Rui Figueira
Technical University of Lisbon
figueira@ist.utl.pt

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Margaret Wiecek
Clemson University
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Track(s): 37
7 sessions

Multicriteria Decision Making II
Invited

José Rui Figueira
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Gerhard-Wilhelm Weber
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Margaret Wiecek
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Track(s): 37
6 sessions

Multiple Criteria Decision Making and Optimization (contributed)
Contributed

Ana Meca
Universidad Miguel Hernández
ana.meca@umh.es
Track(s): 39
1 session

New Frontiers for Little's Law
Invited

John D C Little
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jlittle@mit.edu
Track(s): 58
1 session

Nonconvex Programming: Local and Global Approaches
Invited

Tao Pham Dinh
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pham@insa-rouen.fr

Hoai An Le Thi
University of Lorraine
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Track(s): 3
4 sessions

Nonlinear Programming
Invited

Simone Göttlich
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University of Minho
emgpf@dps.uminho.pt

Ana Maria A.C. Rocha
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Track(s): 7
3 sessions

Nonsmooth Optimization
Invited

Adil Bagirov
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Antonio Fuduli
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antonio.fuduli@unical.it

Albert Ferrer
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alberto.ferrer@upc.edu
Track(s): 6
5 sessions

Opening and Closing Sessions
Invited
Track(s): 1
2 sessions

Operational Research and Control Problems
Invited

Boris Polyak
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Alexander Lazarev
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Mikhail Goubko
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mgoubko@mail.ru

Dmitry Novikov
Institute of Control Sciences, Russian Academy of Science
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Track(s): 63
7 sessions

Operational Research and Quantitative Models in Banking
Invited

Constantin Zopounidis
Technical University of Crete
kostas@dpem.tuc.gr

Track(s): 49
2 sessions

Operational Research in Financial and Management Accounting
Invited

Matthias Amen
University of Bielefeld
Matthias.Amen@web.de

Track(s): 50
1 session

Operations/Marketing Interface
Invited

Kathryn E. Stecke
University of Texas at Dallas
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Xuying Zhao
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Track(s): 57
5 sessions

Optimal Control
Invited

Gernot Tragler
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Ekaterina Kostina
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Erik Kropat
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Gerhard-Wilhelm Weber
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Track(s): 5
10 sessions

Optimization and Natural Sciences
Invited

Tatiana Tchemisova
University of Aveiro
tatiana@ua.pt

Alexander Plakhov
University of Aveiro
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Track(s): 66
1 session

Optimization for Sustainable Development
Invited

Herman Mawengkang
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mawengkang@usu.ac.id

Azizah Hanim Nasution
Graduate School of Natural Resources and Environment Management, University of Sumatera Utara
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Sadia Samar Ali
Fortune Institute of International Business , New Delhi - 110057, India
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Track(s): 66
8 sessions

Optimization in Public Transport
Invited

Leo Kroon
Erasmus University Rotterdam
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Anita Schöbel
Georg-August Universiy Goettingen
schoebel@math.uni-goettingen.de

Track(s): 20
13 sessions

Optimization under Uncertainty
Invited

Gautam Mitra
Brunel University
gautam.mitra@brunel.ac.uk

Christian Valente
OptiRisk Systems
christian@optirisk-systems.com

Track(s): 50
3 sessions

OR and Climate Change
Invited

Costas Pappis
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Track(s): 53
1 session

OR and Ethics
Invited

Cristobal Miralles
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cmiralles@omp.upv.es

Fred Wenstøp
BI Norwegian School of Management
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Track(s): 70
3 sessions

OR and Maritime Studies
Invited

C.t. Ng
The Hong Kong Polytechnic University
daniel.ng@polyu.edu.hk

Track(s): 63
5 sessions

OR and Real Implementations
Invited

Ben Lev
Drexel University
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Belarmino Adenso-Diaz
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Track(s): 58
5 sessions

OR and Scientific Computing
Invited

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Gerhard-Wilhelm Weber
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Track(s): 6
2 sessions

OR Applications in Industry
Invited

Geir Hasle
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Oleg Gusikhin
Ford Research & Advanced Engineering
ogusikhi@ford.com

Track(s): 56
10 sessions

OR Applications in the Automotive Industry
Invited

Thomas Spengler
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Thomas Volling
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Track(s): 35
4 sessions

OR for Developing Countries, Humanitarian Applications (contributed)
Contributed

Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 65
1 session

OR for Development and Developing Countries
Invited

Honora Smith
University of Southampton
honora.smith@soton.ac.uk

Elise del Rosario
Orsp
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Gerhard-Wilhelm Weber
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Hight School of Commerce of Sfax
youssef.masmoudi@gmail.com

Leroy White
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Track(s): 69
7 sessions

OR for Sustainable Development
Invited

Leonidas Sakalauskas
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Tatjana Vilutiene
Vilnius Gediminas Technical University
tatjana.vilutiene@vgtu.lt

Vida Maliene
School of the Built Environment, Liverpool John Moores University
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Track(s): 69
2 sessions

OR in Agriculture, Forestry and Fisheries
Invited

LluisM Pla
University of Lleida
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Victor M. Albornoz
Universidad Tecnica Federico Santa Maria
victor.albornoz@usm.cl

Track(s): 73
7 sessions

OR in Health & Life Sciences (contributed)
Contributed

Track(s): 72
6 sessions

OR in Industry and Software for OR (contributed)
Contributed

Track(s): 58
2 sessions

OR in Quality Management
Invited

Gulser Koksal
Middle East Technical University
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Ipek Deveci Kocakoç
Dokuz Eylul University Faculty of Economics and Administrative Sciences
ipek.deveci@deu.edu.tr

Gul Okudan Kremer
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Track(s): 65
3 sessions

OR in Sports
Invited

Joel Oberstone
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Dirk Briskorn
University of Siegen
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Track(s): 71
2 sessions

OR in the Oil and Gas Sectors
Invited

Vadim Strijov
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Track(s): 73
2 sessions

OR in Water Management
Invited

Halil Önder
Middle East Technical University
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Elcin Kentel
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Track(s): 73
2 sessions

OR: Visualization and Arts
Invited

Vitaly Podobedov
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Track(s): 66
3 sessions

Patients Flows Models and Optimization
Invited

Retsev Levi
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retsef@MIT.EDU

Track(s): 67
1 session

Policy Analytics
Invited

Alexis Tsoukiàs
Cnrs - Lamsade
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Track(s): 42
4 sessions

Preference Learning
Invited

Roman Slowinski
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Krzysztof Dembczynski
Poznan University of Technology
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Willem Waegeman
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Track(s): 36
5 sessions

Pricing and Consumer Behavior
Invited

Ozge Sahin
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Track(s): 50
1 session

Prizes
Invited

Marc Sevaux
Université de Bretagne Sud
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Track(s): 74
2 sessions

Production and the Link with Supply Chains
Invited

Lionel Amodeo
University of Technology of Troyes
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Farouk Yalaoui
University of Technology of Troyes
farouk.yalaoui@utt.fr

Track(s): 33
4 sessions

Production Management & Supply Chain Management (contributed)
Contributed

Track(s): 35
1 session

Project Management and Scheduling
Invited

Rainer Kolisch
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rainer.kolisch@wi.tum.de

Nicholas Hall
The Ohio State University
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Track(s): 21 24
9 sessions

Realistic Production Scheduling
Invited

Ruben Ruiz
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Track(s): 23
3 sessions

Recent Advances in Dynamics of Variational Inequalities and Equilibrum Problems
Invited

Monica-Gabriela Cojocaru
University of Guelph
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Patrizia Daniele
University of Catania
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Track(s): 12
2 sessions

Recent Advances in Earthquake Studies and Geoscience Applications
Invited

Aysegul Askan
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Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 63
1 session

Revenue Management and Dynamic Pricing
Invited

Yuri Levin
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Tatsiana Levina
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Christiane Barz
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Ayse Kocabiyikoglu
Bilkent University
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Track(s): 47
13 sessions

Risk Management in Online Social Networks
Invited

Joerg Fliege
University of Southampton
J.Fliege@soton.ac.uk

Track(s): 10
2 sessions

Routing Problems
Invited

Giovanni Righini
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Alberto Ceselli
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Track(s): 16
13 sessions

Scheduling
Invited

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Alessandro Agnetis
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Nicholas Hall
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Track(s): 21
11 sessions

Scheduling II
Invited

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Vitaly Strusevich
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Track(s): 22
11 sessions

Scheduling under Resource Constraints
Invited

Joanna Jozefowska
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Jan Weglarz
Poznan University of Technology
jan.weglarz@cs.put.poznan.pl

Track(s): 23
3 sessions

Scheduling, Time Tabling & Project Management (contributed)
Contributed

Track(s): 22
2 sessions

Semi-Infinite and Semidefinite Optimization and Applications
Invited

Tatiana Tchemisova
University of Aveiro
tatiana@ua.pt

Olga Kostyukova
Institute of Mathematics, National Academy of Sciences of Belarus
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Jan-J Ruckmann
University of Birmingham
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Gerhard-Wilhelm Weber
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Track(s): 3
2 sessions

Service Management
Invited

Moshe Haviv
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haviv@mscc.huji.ac.il

Track(s): 3
2 sessions

Service Systems (contributed)
Contributed

Track(s): 3
2 sessions

Simulation Based Decision Support
Invited

Viveca Asproth
Mid Sweden University
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Mirjana Kljajic Borstnar
University of Maribor, Faculty of Organizational Sciences
mirjana.kljajic@fov.uni-mb.si

Track(s): 42
2 sessions

Simulation in Management Accounting and Management Control
Invited

Friederike Wall
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Stephan Leitner
Alpen-Adria-Universität Klagenfurt
stephan.leitner@uni-klu.ac.at

Track(s): 48
2 sessions

Simulation Methods in Finance
Invited

Aysegul Iscanoglu Cekic
Selcuk University
iscanoglu@yahoo.com

Gerhard-Wilhelm Weber
Middle East Technical University
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Track(s): 48
5 sessions

Simulation, Stochastic Programming and Modeling (contributed)
Contributed

Leonidas Sakalauskas
Institute of Mathematics & Informatics
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Track(s): 18
1 session

Soft OR / Systems and Multimethodology
Invited

John Mingers
Kent University
j.mingers@kent.ac.uk

Track(s): 59
6 sessions

Software for OR/MS
Invited

Robert Fourer
AMPL Optimization
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Bjarni Kristjansson
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bjarni@maximalsoftware.com

Track(s): 56
3 sessions

Sponsors
Invited

Marc Sevaux
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Giovanni Felici
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David Simchi-Levi
Mit
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Track(s): 9
12 sessions

Stochastic Modeling / Applied Probability
Invited

Devin Sezer
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alidevin.sezer@univ-evry.fr

Track(s): 29
10 sessions

Stochastic Modeling and Simulation in Engineering, Management and Science
Invited

Erik Kropat
Universität der Bundeswehr München
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Basak Tanyeri
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Zeev (Vladimir) Volkovich
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Gerhard-Wilhelm Weber
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Track(s): 18
11 sessions

Stochastic Modeling in Energy Planning
Invited

Boris Defourny
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Track(s): 53
5 sessions

Stochastic Models in Reliability and Risk
Invited

Serkan Eryilmaz
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Track(s): 29
3 sessions

Stochastic Programming
Invited

Georg Pflug
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Giorgio Consigli
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Enza Messina
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Track(s): 28
5 sessions

Stream of INFORMS Society for Public Programs, Service and Needs
Invited

Burcu Balcik
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Track(s): 69
3 sessions

Supply Chain Optimization
Invited

Dolores Romero Morales
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Dmitry Ivanov
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Joern Meissner
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Track(s): 32
11 sessions

Supply Chain Planning
Invited

Moritz Fleischmann
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Herbert Meyr
University of Hohenheim
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Track(s): 34
11 sessions

Supply Chain Risk Management
Invited

Cagri Haksoz
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Track(s): 33 34
4 sessions

Supply Chains
Invited

Steef van de Velde
RSM Erasmus University
svelde@rsm.nl

Michael Becker-Peth
Universität zu Köln
michael.becker-peth@uni-koeln.de

Nishant Mishra
Rotterdam School of Management, Erasmus University
nmishra@rsm.nl

Track(s): 32
2 sessions

Sustainable Development Modeling with System Dynamics
Invited

Pierre Kunsch
Vrije Universiteit Brussel
pkunsch@vub.ac.be

Track(s): 2 68
3 sessions

Sustainable Living: Cognitive, Social, Economical, Ecological and World View
Invited

Claudia Rave
National University of Colombia
claudia.rave@gmail.com

Pedamallu Chandra Sekhar
Dana-Farber Cancer Institute
pcs.murali@gmail.com

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Track(s): 66
1 session

Sustainable Transport Planning
Invited

Bülent Çatay
Sabanci University
catay@sabanciuniv.edu

Richard Eglese
Lancaster University
R.Eglese@lancaster.ac.uk

Track(s): 17
3 sessions

System Dynamics Modeling and Simulation
Invited

Markus Schwaninger
Universität St.Gallen
markus.schwaninger@unisg.ch

Markus Schwenke
University of St. Gallen
markus.schwenke@unisg.ch

Track(s): 11 12
2 sessions

Teaching OR/MS
Invited

Maria Antónia Carravilla
INESC TEC, Faculty of Engineering, University of Porto
mac@fe.up.pt

Track(s): 74
3 sessions

Telecommunication, Networks and Social Networks
Invited

Pedro Ferreira
Cmu
pedrof@cmu.edu

Track(s): 10
2 sessions

Telecommunications and Network Optimization
Invited

Bernard Fortz
Université Libre de Bruxelles
bfortz@euro-online.org

Luís Gouveia
Universidade de Lisboa - Faculdade de Ciências
legouveia@fc.ul.pt

Walid Ben-ameur
Telecom SudParis
walid.benameur@telecom-sudparis.eu

Track(s): 10
8 sessions

Telecommunications, Networks and Social Networks (contributed)
Contributed

Track(s): 11
4 sessions

Timetabling and Rostering
Invited

Dario Landa-Silva
University of Nottigham
dario.landasilva@nottingham.ac.uk

Nysret Musliu
Vienna University of Technology
musliu@dbai.tuwien.ac.at

Timothy Curtois
University of Nottingham
tim.curtois@nottingham.ac.uk

Track(s): 24
6 sessions

Traffic
Invited

Maurizio Bielli
Institute of Systems Analysis and Informatics
bielli@iasi.cnr.it

Track(s): 13
10 sessions

Transportation and Logistics
Invited

M. Grazia Speranza
University of Brescia
speranza@eco.unibs.it

Daniele Vigo
University of Bologna
daniele.vigo@unibo.it

Track(s): 12
8 sessions

Transportation Planning
Invited

Herbert Kopfer
University of Bremen
kopfer@uni-bremen.de

Frank Schultmann
Karlsruhe Institute of Technology (KIT)
frank.schultmann@kit.edu

Jörn Schönberger
University of Bremen
jsb@uni-bremen.de

Track(s): 17
4 sessions

Variational Inequalities and Bi-Level Problems
Invited

Oleg Khamisov
Institute of Energy System, Siberian Branch of the Russian Academy of Sciences
khamisov@isem.sei.irk.ru

Track(s): 3
2 sessions

Vector and Set-Valued Optimization
Invited

Vicente Novo
Universidad Nacional de Educacion a Distancia
vnovo@ind.uned.es

Bienvenido Jiménez
Uned
bjimenez@ind.uned.es

César Gutiérrez
Universidad de Valladolid
cesargv@mat.uva.es

Track(s): 7
5 sessions

Vector- and Setvalued Optimization and Applications
Invited

Christiane Tammer
Martin-Luther-University Halle-Wittenberg
christiane.tammer@mathematik.uni-halle.de

Andreas Löhne
MLU Halle-Wittenberg
andreas.loehne@mathematik.uni-halle.de

Track(s): 39
4 sessions

Vehicle Routing and Scheduling with Environmental Considerations
Invited

Konstantinos G. Zografos
Lancaster University Management School
k.zografos@lancaster.ac.uk

Track(s): 13 14
2 sessions

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