

Monday, 9:00-10:20

■ MA-01

Monday, 9:00-10:20

Aula Magna

Keynote Talk 1

Stream: Keynote Speakers

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Safe tractable approximations of chance constraints

Arkadi Nemirovski, School of Industrial and Systems Engineering, Georgia Institute of Technology, 765 Ferst Drive, NW, GA 30332-0205, Atlanta, Germany, nemirovs@isye.gatech.edu

When optimizing under stochastic uncertainty, the entity of primary importance is a chance constraint $\text{Prob } \psi(x; \xi) \geq 1 - \epsilon$, for all ξ in \mathcal{P} where x is the decision vector, ψ is a random perturbation with distribution P known to belong to a given family \mathcal{P} , Q is a given target set, and $\epsilon \ll 1$ is a given tolerance. Aside of a handful of special cases, chance constraints are computationally intractable: first, it is difficult to check efficiently whether the constraint is satisfied at a given x , and second, the feasible set of a chance constraint typically is nonconvex, which makes it problematic to optimize under the constraint. Given these difficulties, a natural way to process a chance constraint is to replace it with its safe tractable approximation a tractable convex constraint with the feasible set contained in the one of the chance constraint. In the talk, we overview some recent results in this direction, with emphasis on chance versions of well-structured convex constraints (primarily, affinely perturbed scalar linear and linear matrix inequalities) and establish links between this topic and Robust Optimization.

■ MA-02

Monday, 9:00-10:20

3.2.14

Combinatorial Optimization I

Stream: Combinatorial Optimization

Invited session

Chair: *Ivana Ljubic*, Department of Statistics and Decision Support Systems, University of Vienna, Bruennerstr. 72, 1210, Vienna, Austria, ivana.ljubic@univie.ac.at

1 - Spanning Trees with Node Degree Dependent Costs and Knapsack Reformulations

Pedro Moura, DEIO, University of Lisbon, Campo Grande, Bloco C6, 1749-016, Lisbon, Portugal, pmoura@fc.ul.pt, *Luis Gouveia*

The Degree constrained Minimum Spanning Tree Problem (DMSTP) consists in finding a minimal cost spanning tree satisfying the condition that every node has degree no greater than a fixed value. We consider a generalization of the DMSTP with a more general objective function including modular costs associated to the degree of each node, which have a technological motivation in the context of telecommunications networks. We present LP models together with some valid inequalities and compare their respective linear programming relaxations using cable and wireless network based instances.

2 - Solving the Stochastic Steiner Tree Problem by Branch-and-Cut

Bernd Zey, TU Dortmund, Frankfurter Weg 3, 59439, Holzwickede, Germany, bernd.zey@tu-dortmund.de, *Immanuel Bomze*, *Markus Chimani*, *Michael Juenger*, *Ivana Ljubic*, *Petra Mutzel*

We consider the NP-hard Steiner tree problem under a two-stage stochastic model with recourse and finitely many scenarios. We discuss undirected, semi-directed, and directed cut-set based integer programming models, and suggest a branch-and-cut approach based on Benders decomposition and a derived Integer-L-shaped algorithm. We compare our different models both theoretically, namely from a polyhedral point of view, and computationally.

3 - Exact and Heuristic Algorithms for the Bounded Cycle Cover Problem

Irene Loiseau, Departamento de Computación-, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón I - Ciudad Universitaria, 1428, Buenos Aires, Argentina, irene@dc.uba.ar

We will present a new exact algorithm and heuristics for the Bounded Cycle Cover Problem. BCCP requires to determine a minimum cost cycle cover of a graph, with cycles bounded in length and number of edges. This problem arises in several situations related to telecommunications networks design, as, for example, when we want to design fiber-optic telecommunications networks that employ multiple self-healing rings to provide routing for communication traffic, even in the event of a fiber cut or other kinds of failures.

4 - Reverse Multistar Inequalities and Vehicle Routing Problems with lower bound capacities

Luis Gouveia, DEIO, University of Lisbon, Campo Grande, Bloco C6, 1749-016, Lisbon, Portugal, legouveia@fc.ul.pt, *Juan José Salazar González*

In this talk we discuss, present and test models for the Capacitated Vehicle Routing Problem with arc lower bounds. We introduce the so-called reversed multistar inequalities and two other related families of inequalities, and show that they are relevant for modelling this routing problem. We present results from a branch-and-cut algorithm which uses the new inequalities for solving instances with up to 50 customers.

■ MA-03

Monday, 9:00-10:20

3.2.15

TSP

Stream: Metaheuristics

Invited session

Chair: *José A. Moreno-Pérez*, Estadística, I.O. y Computación, University of La Laguna, La Laguna, Spain, jamoreno@ull.es

Chair: *Noraini Mohd Razali*, Mechanical & Manufacturing Engineering, Dublin City University, Dublin 9, Dublin, Ireland, norainimbr@ump.edu.my

1 - An algorithm for solving the traveling salesman problem (tsp) based on multimodal transport, using a sequence of linear problems (lp)

Luis Moreno, Systems, Universidad Nacional de Colombia, Facultad de Minas cra. 80 65-223, Bloque M8 oficina 207, 1, Medellín, Antioquia, Colombia, lmoreno@unal.edu.co, *Javier Diaz*, *Gloria Pena*

A hybrid algorithm is proposed based on heuristics and linear programming. A relaxed linear problem (LP) is solved. If the solution has several non connected circuits a new heuristic LP is used to connect the circuits, assuming the cities in each circuit in the relaxed solution are close between them. The circuits are connected as would do somebody after visiting by car several cities in a region that takes a plane to visit optimally another set of regions with additional cities. If when connecting the circuit of circuits there are again several non connected circuits the heuristic LP is solved in an iterative way that decreases the linear problem size until all the cities become shortly and easily connected.

2 - A Modified Electromagnetism-like Algorithm for Traveling Salesman Problems with Precedence Constraints

Alkin Yurtkuran, Industrial Engineering Department, Uludag University, Uludag University, Industrial Engineering

Department, 16059, Bursa, Turkey, alkin@uludag.edu.tr, *Erdal Emel*

Traveling Salesman Problem with Precedence Constraints(TSPCC) is an important variant of Traveling Salesman Problem. TSPCC belongs to the class of NP-Hard problems where there exists a precedence relationship between customers. In this study, a Modified Electromagnetism-like Algorithm(EMA) is applied to solve TSPCC problems. The key concept of the proposed algorithm is the projection of the particle space onto a new coordinate space where each precedence constraint is ensured. The computational results show that Modified EMA gives promising results within acceptable computational times.

3 - Performance comparison between different GA selection strategies in solving TSP instance.

Noraini Mohd Razali, Mechanical & Manufacturing Engineering, Dublin City University, Dublin 9, Dublin, Ireland, norainimbr@ump.edu.my, *John Geraghty*

This study presents the comparison of genetic algorithm performance on solving TSP using two different stochastic selection methods which are tournament and roulette wheel. The GA is mainly composed of three genetic operations which are selection, crossover and mutation. With the same crossover and mutation operation, the study is focussed on comparing the effect of different selection strategy to the performance of convergence that gives optimum solution. Numerical experiments show that GA with tournament selection converges much faster than roulette wheel selection.

4 - A Data Mining Based Heuristic Approach for Solution of Travelling Salesman Problem

Hande Gulkac, Computer Engineering, Okan University, Turkey, hande.gulkac@okan.edu.tr, *Semiye Gönülol*, *Ahmet Cihan*, *Halenur Şahin*, *Alpaslan Figlali*

Travelling Salesman Problem (TSP) is a well known NP-hard optimization problem. Many methods are applied including heuristics, mathematical programming and metaheuristics for obtaining good solutions. In this study a data mining based heuristic approach is applied for the solution of TSP. Procedure uses a repetitive and forced random tour generation approach. The set of best random tours are analyzed via data mining tools to obtain the relations. Using the rules derived from the relations, the TSP tour is obtained. The results are promising while considering it's simplicity.

■ MA-04

Monday, 9:00-10:20

3.2.13

Scheduling with metaheuristics

Stream: Metaheuristics

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: *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

1 - Single Machine Scheduling with Rejection: Minimizing total Weighted Completion Time and Rejection Cost

Atefeh Moghaddam, Charles Delaunay Institute, University of Technology of Troyes, 12 rue Marie Curie., Troyes, France, 10000, Troyes, France, atefeh.moghaddam@utt.fr, *Farouk Yalaoui*, *Lionel Amodeo*

It is always assumed that we have to process all jobs. However, we can break the assumption by rejecting certain jobs. In this paper, we consider that the jobs can be either scheduled on a single machine or be rejected at the cost of a penalty. Two objective functions are considered: minimizing total weighted completion times and minimizing total penalties. We apply two-phase method to find all Pareto-optimal solutions. We also propose bi-objective simulated annealing algorithm to find estimated Pareto-optimal solutions. By comparing the solutions, we show that the results are reasonably good.

2 - A Tabu Search Algorithm for Order Acceptance and Scheduling

Bahriye Cesaret, Industrial Engineering, Koc University, Koc University, Rumelifeneri yolu Sariyer, 34450, Istanbul, Turkey, b.cesaret@gmail.com, *Ceyda Oguz*, *Sibel Salman*

We develop a Tabu Search (TS) algorithm with a probabilistic local search after each iteration to solve the order acceptance and scheduling problem on a single machine with sequence dependent setup times. We compare the performance of the TS algorithm to a greedy constructive heuristic from the literature, using upper bounds based on a mixed integer programming formulation. Computational studies show that the TS algorithm gives significantly better solutions than those of the constructive heuristic in terms of objective function value in all instances tested with a small increase in run time.

3 - Approximate methods for solving the operating room planning problem

Jose M. Molina-Pariente, University of Seville, Spain, jmolina@esi.us.es, *Jose M Framinan*, *Paz Perez Gonzalez*

In this communication, we address the operating room planning problem for a surgery unit. This problem involves determining a surgery schedule that specifies the number of surgical cases to be scheduled in a given planning horizon together with the date of the intervention and the specific operating room in which each surgical case will be performed. To solve this problem, we present new constructive heuristics and a local search method. We evaluate the performance of these methods by generating a large set of instances based on an analysis of the literature.

4 - A GRASP approach to the Multi-Task Employee Timetabling Problem

Pilar Tormos, STATISTICS AND OPERATIONS RESEARCH, UNIVERSIDAD POLITECNICA DE VALENCIA, CAMINO DE VERA S/N, VALENCIA, 46022, VALENCIA, SPAIN, Spain, ptormos@eio.upv.es, *Antonio Lova*

Employee Timetabling Problem (ETP) is the operation of assigning employees to tasks in a set of shifts during a period of time while satisfying the existing constraints and preferences. An extension of this problem, the Multi-Task Employee Timetabling Problem (MTETP) implies the assignment of the sequence of tasks to be performed by each employee every working day of the planning horizon and it is especially relevant for commercial companies. A greedy randomized adaptive search procedure (GRASP) is developed to solve it and embedded in a computer-aided system (OPTIHPER). A customized version of it is in use with very satisfactory results by a leading Spanish distribution company.

■ MA-05

Monday, 9:00-10:20

3.2.16

Theory

Stream: Metaheuristics

Invited session

Chair: *Gustavo Melo*, Computer Science, Universidade Estadual do Ceará, Rua César Fonseca 410 ap 301 bairro papicu, 60176-110, Fortaleza, Ceará, Brazil, gustavo.sikora@gmail.com

Chair: *Zahira Benkhellat*, informatique, sciences exactes, Bejaia university Qlgerie, teacher, Algeria, benkhellat_zahira@yahoo.fr

1 - Analysis of software for the NGS technology: The Survival Guide

Bruno Vieira, Computational Biology & Population Genomics Group, Centro de Biologia Ambiental, Departamento de Biologia Animal, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016, Lisbon, Portugal, mail@bmpvieira.com, *Francisco Pina Martins*, *Sofia Seabra*, *Octavio Paulo*

Next Generation Sequencing (NGS) technologies allow the generation of large amounts of data in a short time span and for a relatively low cost. A multitude of software was recently developed to address the difficulties generated by NGS, such as assembling the millions of reads, contig generation and the follow up annotation. The cover rate is also relevant to the results accuracy and the detection of genetic variation, either in the form of SNPs or CNVs. In this communication we address several critical bioinformatics steps and compare current software and algorithms to tackle these problems.

■ MA-06

Monday, 9:00-10:20

8.2.30

DEA Methodology I

Stream: DEA and Performance Measurement

Invited session

Chair: *Dimitris Despotis*, Department of Informatics, University of Piraeus, 80, Karaoli & Dimitriou Street, 18534, Piraeus, Greece, despotis@unipi.gr

1 - DEA approach for evaluating performance considering institution goal

Sheu-hua Chen, Distribution Management, National Chin-Yi University of Technology, Taipin, Taichung, Taiwan, ROC, 411, Taichung, Taiwan, Taiwan, shchen@ncut.edu.tw, *Hong Tau Lee*

In the data envelopment analysis (DEA) approach some decision-making units may reach performance efficiency by their outstanding performance on some relative unimportant output items. In this research, we try to add the strictly predefined relationships of output items in the existed model that expressed the relative importance of those input or output items. According to this approach, only the DMUs that really match the predefined requirements and have good performance can be regarded as efficient units. That is to say the meaning of performance depends on the goals the organization pursues. This is meaningful for managerial practices. A case of performance evaluation of faculty in different types of university with specific development orientation is provided to illustrate the proposed idea.

2 - Assessing robustness in additive DEA with interval measurements

Maria Gouveia, ISCAC, Quinta Agricola - Bencanta, 3040-316, Coimbra, Portugal, mgouveia@iscac.pt, *Luis C. Dias*, *Carlos Henggeler Antunes*

This study addresses the problem of finding the range of efficiency for each Decision Making Unit (DMU) considering uncertain data. Uncertainty in the DMU coefficients in each factor (input or output) is captured through interval coefficients (i.e. these are uncertain but bounded). A two-phase additive Data Envelopment Analysis (DEA) model for performance evaluation is used, which is adapted to include the concept of super-efficiency to provide a robustness analysis of the DMUs in face of uncertain information.

3 - A proposition of the minimum distance model in Network DEA

Tohru Ueda, Faculty of Science and Technology, Seikei University, 3-3-1 Kichijoji-Kitamachi, 180-8633, Musashino-Shi, Tokyo, Japan, ueda@st.seikei.ac.jp, *Hirofumi Amatatsu*

Minimization of objective function in SBM model results in maximization of slacks sum. This maximization corresponds to finding a point in the production possibility set that is the farthest point from each Decision Making Unit to be evaluated. To overcome this shortage, we proposed the unified DEA model. Traditional linking constraints where continuity between input and output is kept may be too severe to evaluate efficiencies. Considering linking constraints and the unified DEA model with minimum distance, we propose a new network DEA model and discuss efficiencies of prefectures in Japan.

4 - An improving approach for estimating return to scale in DEA

Maryam Allahyar, mathematics, science and research branch islamic azad university, tehran-ashrafi esfahani highway-to hesarak, 0098, tehran, tehran, Iran, Islamic Republic Of, mayar4584@yahoo.com, *Mohsen Rostamy-malkhalifeh*

In this article a new method will be suggested for the determination of the right and left return to scale (RTS). The new approach is different from that of Golany and Yu (1997) and doesn't have its shortcomings. Our approach is able to evaluate the right and left RTS in all conditions for any unit.

■ MA-07

Monday, 9:00-10:20

8.2.47

Recent Developments in Mathematical Programming

Stream: Mathematical Programming [C]

Contributed session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Jerzy Filar*, Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd, 5095, Mawson Lakes, SA, Australia, j.filar@unisa.edu.au

1 - A Relax-and-Fix Lagrangean Relaxation Based Algorithm for a Class of Multiple-Choice Integer Problems

Abdelkader Sbihi, Information Systems and Decision Making Science, Audencia-Nantes School of Management, 8 route de la Jonelière, BP 31222, 44312, Nantes Cedex 3, France, asbihi@audencia.com

We propose a Lagrangean relaxation based-algorithm for some hard combinatorial problems. The idea is to relax a certain type of constraints then to fix variables to their optimal value. We consider: (i) the Multiple-Choice Knapsack Problem (MCKP) and (ii) the Multiple-Choice Subset Sum Problem (MC-SSP) which can be considered as a special case of the MCKP. We used MCSSP as an auxiliary problem to tighten the capacity constraint. The obtained results showed a high quality of the computed upper bounds. The benchmark has demonstrated a high efficiency of the approach.

2 - An Optimization Method for Solving Assembly Line Balancing 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*

Assembly line balancing or simply line balancing is the problem of assigning operations to workstations along an assembly line in such a way that the assignment be optimal in some sense. Assign tasks to work stations observing balancing restriction so as to minimize balance delay while keeping station work content for every station cycle time. There have been a large number of proposals for theoretical and practical methods for solving the line balancing problem. This paper use one of the optimization solution approach to solve assembly line balancing problem.

3 - Geo-spatial data mining by model-based clustering methods

Francisco Figueiredo, UNIDE, ISCTE-IUL, Lisbon, Portugal, francisco.m.fig@gmail.com, *José G. Dias*

Most of the clustering techniques are inadequate for geo-spatial data mining as they tend to ignore that spatially closer areas tend to be more similar than the others. Geo-spatial clustering aims to find groups of similar objects that are spatially close. We propose a clustering algorithm for spatial segmentation of count data under a regression framework, which combines the Neighborhood EM (NEM) and Hybrid EM (HEM) algorithms. The geo-spatial data mining approach is illustrated with georeferenced political data.

4 - Alternating Proximal Algorithms and Hierarchical Selection of Optima in Games, Control and PDE's

Juan Peypouquet, Mathematics, Universidad Tecnica Federico Santa Maria, Av Espana 1680, 2340000, Valparaiso, Valparaiso, Chile, juan.peypouquet@usm.cl, *Hedy Attouch*, *Marco Czarnecki*

We study alternating and diagonal proximal algorithms combining resolvent iterations and a penalization scheme. The resulting sequence of iterates and, under less restrictive conditions, their averages converge weakly to a point with special properties. We also analyze a splitting method for structured variational problems and comment on the robustness of these methods. The results enable us to solve constrained or bilevel optimization problems. This method is applied to best response dynamics with cost to change, optimal control problems and domain decomposition for PDE's.

■ MA-08

Monday, 9:00-10:20

6.1.36

Project Management Software and Applications

Stream: Project Management and Scheduling

Invited session

Chair: *Norbert Trautmann*, Department of Business Administration, University of Bern, IFM, AP Quantitative Methoden, Schützenmattstrasse 14, 3012, Bern, BE, Switzerland, norbert.trautmann@pqm.unibe.ch

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 - Heuristic improvement of Microsoft Project's resource-allocation capabilities

Norbert Trautmann, Department of Business Administration, University of Bern, IFM, AP Quantitative Methoden, Schützenmattstrasse 14, 3012, Bern, BE, Switzerland, norbert.trautmann@pqm.unibe.ch, *Philipp Baumann*

Microsoft Project is widely used for temporal scheduling and resource allocation of projects. We show that its integrated resource-allocation procedure uses neither the serial nor the parallel schedule-generation scheme, and that the procedure performs relatively poor. We present a bi-directional schedule-improvement heuristic. Computational results for a construction project and for the J30, J60, and J120 instances from PSPLIB indicate that this heuristic shortens the project duration considerably.

2 - Exact methods for resource levelling problems

Jürgen Zimmermann, Operations Research, TU Clausthal, Julius-Albert Str. 2, 38678, Clausthal-Zellerfeld, Germany, juergen.zimmermann@tu-clausthal.de, *Thorsten Gather*

We present exact solution methods for resource levelling problems with minimum and maximum time lags among the project activities. In particular, we consider a time window based enumeration method and two tree-based branch-and-bound procedures both with a sophisticated constructive lower bound. Furthermore, we propose a mixed integer linear programming formulation that can be solved by standard solvers such as CPLEX. All approaches are compared in a comprehensive computational study using well known test sets from literature. Instances with up to 30 activities could be solved to optimality.

3 - Temporal scheduling of concurrent engineering projects

Christoph Schwindt, Institute of Management and Economics, Clausthal University of Technology, Julius-Albert-Str. 2, 38678, Clausthal-Zellerfeld, Germany, christoph.schwindt@tu-clausthal.de, *Philipp Benke*

The concurrent engineering approach is intended to shorten the cycle time of development projects by parallelizing consecutive development phases. We consider the tradeoff between the time savings enabled by overlapping precedence-related project activities and the increase in the activity durations that is typically incurred by additional integration and coordination efforts. We investigate structural properties of the temporal scheduling problem and explain how earliest and latest start and completion times of the activities can be determined efficiently based on label-correcting algorithms.

4 - Integrated Scheduling and Staffing IT-Projects

Rainer Kolisch, TUM School of Management, Technische Universität München, Arcisstr. 21, 80333, München, Germany, rainer.kolisch@wi.tum.de, *Christian Heimerl*

In this paper we present an optimization model to address the problem of scheduling the activities of multiple IT-projects with serial structures and assigning the project work to multi-skilled internal and external human resources with static and heterogeneous efficiencies. The mixed-binary linear program is solved using ILOG CPLEX and a hybrid metaheuristic. The latter employs an efficient evaluation function exploiting the network structure of the staffing subproblem. We assess the impacts of several problem parameters on computation time and solution gaps.

■ MA-09

Monday, 9:00-10:20

6.2.53

Challenges of Mathematical Programming by Modern Applications

Stream: Mathematical Programming

Invited session

Chair: *Zuzana Oplatkova*, Dept. of Applied Informatics, Tomas Bata University in Zlin, Nad Stranemi 4511, 76005, Zlin, Czech Republic, oplatkova@fai.utb.cz

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - An optimization approach for prediction of microbial growth strategies

Pinar Ozturk, Systems Bioinformatics, Vrije University, Amsterdam, De Boelelaan 1085, 1081HV, Amsterdam, Netherlands, pinar.ozturk@falw.vu.nl, *Douwe Molenaar*

In limited nutrient conditions, microorganisms regulate cellular activities to maintain efficient growth. Efficiency is regarded as correlated with fast reproduction. Via an optimization model of the whole cell with an objective to maximize growth rate, we predict macro features of microbes at given nutrient concentrations by representing essential pathways with modules. This, as known to us, is the first time growth rate, size and shape are predicted having only intrinsic physical properties of molecules as constraints.

2 - Robust model development for non-linear models

Magderie van der Westhuizen, School of Computer, Statistical and Mathematical Sciences, North-West University, Private Bag X6001, 2520, Potchefstroom, South Africa, magderie.vanderwesthuizen@nwu.ac.za, *Giel Hattingh*, *Hennie Kruger*

The predictive capability of regression models relies heavily on the applicability of the assumptions made by the model builder. In addition, the presence of outliers may also lead to models that are not reliable. This study reports on robust techniques applied to minimal assumption regression models in an effort to improve predictive capability. The approach is based on mathematical programming techniques combined with smoothing and piecewise linear techniques. Different cases from the literature are considered and presented as illustrative examples.

3 - A Bilevel Competitive Facility Location Model with Competitor's Response

Hande Kucukaydin, Industrial Engineering, Bogazici University, Bogazici University Industrial Engineering Department, Bebek-Istanbul-Turkey, 34342, Istanbul, Turkey, hande.kucukaydin@boun.edu.tr, *Necati Aras*, *I. Kuban Altinel*

We are concerned with a problem in which a new entrant leader firm aims at finding the location and attractiveness of each new facility to maximize its profit where there are existing facilities belonging to a competitor. The competitor reacts to the leader by adjusting the attractiveness levels of its existing facilities to maximize its profit. We first formulate a bilevel mixed-integer nonlinear programming model. Then, we convert it into an equivalent single level mixed-integer nonlinear program and solve it using global optimization methods.

■ MA-10

Monday, 9:00-10:20

6.2.56

Graphs and Networks I

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 - On the Power of Decomposition for the Maximum Independent Set Problem

Andreas Brandstädt, Universität Rostock, 18055, Rostock, Germany, ab@informatik.uni-rostock.de

(joint work with C.T.Hoang, V.B.Le, V.V.Loizin, and R. Mosca) In a finite undirected graph $G=(V,E)$ a vertex set S is 'independent' (or 'stable') if the vertices in S are mutually nonadjacent. For given G , the MAXIMUM INDEPENDENT SET (MIS) Problem asks for an independent vertex set of maximum size in G . The MWS problem asks for an independent set with maximum vertex weight; the MIS problem is the MWS problem with unit weights. It is well known that MWS (MIS, respectively) is intractable and hard to approximate. We discuss various decomposition techniques such as clique separator decomposition, modular decomposition and split decomposition for solving the MWS problem efficiently on various particular graph classes. It is well known that the above mentioned decompositions are helpful tools for solving the MWS problem. One of our results allows to combine clique separator decomposition and modular decomposition. This implies various improvements of known results, among them a polynomial time algorithm for MWS on apple-free graphs which are a common generalization of chordal graphs, cographs and claw-free graphs. Finally we mention some open problems.

2 - Solving efficiently the weighted stable-set problem in claw-free graphs using a reduction operation

Paolo Nobile, Mathematics, University of Lecce, Via Arnesano, 73100, Lecce, Italy, paolo.nobile@unile.it, Antonio Sassano

Maximum weight stable sets can be computed in polynomial time for claw-free graphs (Minty, Nakamura et al., Schrijver, Oriolo et al.). In this paper we define the strongly reducible cliques, extending to the weighted case a reduction operation of Lovasz and Plummer. We use the operation for obtaining maximum weight alternating paths through matching computations. We embed the procedure in an iterative approach that constructs a given claw-free graph G node by node, maintaining the associated maximum weight stable set. The resulting algorithm has computational complexity $O(n^4 \log(n))$.

3 - Reconstruction of Permutations Respect to some Generator Sets of the Symmetric Group

Alpar Vajk Kramer, DEIO, FCUL, Portugal, vajki@web.de

We will consider the reconstruction of permutations regarding some special generator sets of the symmetric group. The generator sets considered are particular subsets of involutions such as the reversals, prefix reversals, bubble reversals or Coxeter generators and transpositions. The common property of all this generator sets is that their corresponding Cayley graph does not contain triangles.

■ MA-11

Monday, 9:00-10:20

8.2.38

Emerging Data Mining Applications in Biomedics and Biotech

Stream: Emerging Applications of OR

Invited session

Chair: *Honora Smith*, School 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

Chair: *Veronica Biga*, Department of Automatic Control and Systems Engineering, The University of Sheffield, Mappin Street, S1 3JD, Sheffield, Afghanistan, v.big@sheffield.ac.uk

1 - The Information Effect of the Infectious Diseases Outbreak on Biotechnology Stock Performance

Yi-Hsien Wang, Department of Banking & Finance, Chinese Culture University, 55, Hwa-Kang Road, Yang-Ming-Shan., Taipei, Taiwan 11114, R.O.C, 11114, Taipei, Taiwan, holland@mail2000.com.tw, Fu-Ju Yang, Kuang-Hsun Shih, Li-Je Chen

Statutory infectious diseases breakout not only affects people's health and lives, but also stagnates the economic growth. The prevalence of infectious diseases also provides the development opportunities of biotechnology corporations. The effect of the statutory infectious diseases outbreak on Taiwanese biotechnology stock price movements is examined. The empirical results point out that there exists a significantly positive abnormal return of Taiwan's biotechnology industry because of the statutory infectious epidemic.

2 - A hybrid classification method: Using a support vector machine for rule extraction on diabetes diagnosis

Chien-hsin Yang, Department of Industrial Engineering and Management, Overseas Chinese University, 100, Chiao Kwang Rd., Taichung 40721, Taiwan, Taiwan, chyang.iem91g@nctu.edu.tw, Chun-Chin Hsu

Many of the factors related to diabetes mellitus (DM) have been discovered from a succession of studies in epidemiology. However, it seems that the usability and explainability of methods are inferior to rules extraction. A support vector machine based hybrid classification method is employed to extract rules for DM diagnosis. To evaluate performance, C5 and back-propagation neural networks were used as benchmarks. Results from the hybrid approach demonstrate high accuracy and fidelity, and the rules can help for preventive medicine in DM diagnosis.

3 - Application of artificial neural network and support vector machine to classify the risk of death of hospitalized patients with acute coronary syndrome

Rodrigo Collazo, Operational Research, CASNAV/UFRJ, Costa Doria St, 17, 21910-170, Rio de Janeiro, Rio de Janeiro, Brazil, rodrigocollazo@uol.com.br, Basílio Pereira, Laura Bahiense, Amália Faria dos Reis, Amália Faria dos Reis

This study developed an artificial neural network model and a support vector machine model to classify the risk of death of hospitalized patients with acute coronary syndrome at high and low. It was used the mutual information feature selector under uniform information distribution criteria (MIFS-U) for selection of the most important input variables. The computational results show a better performance of the support vector machine model compared with the artificial neural network model and indicate the input variables age, creatinine and any prior revascularization as the most relevant.

4 - Prediction in Medicine: Statistical Models versus Artificial Neural Networks

Ana Papoila, Bioestatística e Informática, Faculdade Ciências Médicas da Universidade Nova de Lisboa, CEAUL, Portugal, apapoila@hotmail.com, Carlos Geraldes, Patricia Xufre

Artificial Neural Networks are often used in Biomedical Sciences and Medicine. A main goal is to predict a clinical outcome after taking into account a set of independent explanatory variables. ANNs arise as an alternative to logistic regression. This study compares Generalized Linear Models with binary response, with the performance of ANNs, in what concerns their predictive and discriminative power. For both approaches, validation techniques were applied. These methodologies were used to predict mortality of patients admitted to an Intensive Care Unit located in Lisbon.

5 - A Study in Different Channels' Consumer on the Purchasing Intention and Behavior of Bio-technology Products

Yuanchau Liour, Logistics Management, Takming University of Science and Technology, 11451, Taipei, Taiwan, ycliour@takming.edu.tw, Chiao-Ling Huang, Chie-bein Chen

Biotechnology has been playing an important role in modern financial society; recently, as improvement of economy environment and the development of technology, the government is committed to the implementation of biotechnology. We explore the impact of consumer attitude, consumer's purchasing intention, promotions and product involvement, and perceive risk on purchasing intention. We take Northern Taiwan area's consumer as the research objects, use SEM to analyze and make suggestions to bio-technology health food companies in accordance with the empirical conclusions.

■ MA-12

Monday, 9:00-10:20

8.2.39

AHP 01

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Grzegorz Ginda*, Dept. of Operational Research in Management, Opole University of Technology, Faculty of Management and Production Engineering, ul. Waryńskiego 4, 45-057, Opole, Poland, g.ginda@po.opole.pl

1 - Aviation and the Belgian Climate Policy (ABC) - A Multicriteria Analysis (MCA) for the evaluation of policy options to mitigate the total aviation climate change impact

Annalia Bernardini, MOSI-T, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Vlaamse Brabant, Belgium, Annalia.bernardini@vub.ac.be, *Tom Van Lier*, *Annelies Heemeryck*, *Ellen Van Hoeck*, *Cathy Macharis*

The ABC project analyses the different climate policy options aimed to reduce the climate change impacts of the aviation sector. In view to compare the different alternative policies (finan.&econ. tools, R&D, operat. procedures) the MCA method is applied. The performances of those policies are evaluated in relation to some appropriate criteria (env. performances, social-economic impacts aviation sector). A combination of the Analytic Hierarchy Process and the PROMETHEE method allows to come to a detailed analysis of the advantages and disadvantages of each of the proposed policy measures.

2 - A consistency-based method for aggregating preference information from multiple pairwise comparison matrices

Esther Dopazo, Lenguajes y Sistemas Informáticos, Universidad Politécnica Madrid, Facultad Informática, Campus de Montegancedo, 28660, Boadilla del Monte, Madrid, Spain, edopazo@fi.upm.es, *Mauricio Ruiz-Tagle*

We consider a group decision problem, where decision makers estimate their preferences of a set of alternatives into the form of pairwise comparison matrices (a well-established technique in this field). In this scenario, a fundamental problem is the generation of a priority vector for the alternatives from the pairwise matrices which represents the consensus opinion for the group. We propose a weighted logarithmic goal programming method for aggregating individual opinions into an optimal group priority vector, where the consistency of each expert is taken into consideration.

3 - An agreement-based approach for generating priority vectors from multiple pairwise comparison matrices

Mauricio Ruiz-Tagle, Facultad de Cs. de la Ingeniería, Universidad Austral de Chile, General Lagos 2086, Campus Miraflores, Valdivia, Chile, mruiztag@uach.cl, *Esther Dopazo*

The problem of importance weights analysis and determination from multiple source information is a critical issue in many fields such as machine learning, meta-search engines, multi-criteria decision making, etc. We focus on the problem of computing the importance weights and the corresponding rank ordering of a set of alternatives from information given by a group of experts into the form of pairwise comparison matrices. We present an approach based on lp distance-based aggregation functions and on the use of consensus-driven weights for quantifying the relative importance of the experts.

4 - Integrated MADA Assessment Tool

Grzegorz Ginda, Dept. of Operational Research in Management, Opole University of Technology, Faculty of Management and Production Engineering, ul. Waryńskiego 4, 45-057, Opole, Poland, g.ginda@po.opole.pl, *Mirosław Dytczak*

Integrated tool for interdisciplinary assessment of decision alternatives in management and engineering is discussed in the paper. The tool makes use of several selected MADA approaches to obtain more diversified results. A common data structure is applied to make preparation of required data less expensive in terms of both time and work effort. Component methods make it possible to include and assess influence of both intangible and tangible aspects. They are also easily implementable. The tool addresses issues of input data consistency and group decision support too. The tool is unique with regard to ability of adaptation to particular needs. Sample analysis is included which shows its applicability and scale of potential application benefits.

■ MA-13

Monday, 9:00-10:20

2.2.21

Location and GIS

Stream: Location Analysis

Invited session

Chair: *Ioannis Giannikos*, Business Administration, University of Patras, University of Patras, GR-26500, Patras, Greece, I.Giannikos@upatras.gr

1 - Enhancing Location Optimization Modeling Capabilities through the use of GIS

Alan Murray, Geographical Sciences and Urban Planning, Arizona State University, P.O. Box 875302, 85287-5302, Tempe, AZ, United States, atmurray@asu.edu

The prevalence of widely available and accessible geographic information system (GIS) packages and associated geographic data has been important to all disciplines that study, analyze and evaluate spatial problems. In this paper we summarize major characteristics of GIS relevant to location modeling and spatial optimization. A number of widely relied upon optimization models are detailed. Particular attention is given to identifying implementation and application limitations, and how these can be overcome through integration with GIS.

2 - The Geographical Information System 'Ptolemeos-Europe' and the analysis of regional geo-economic dynamics of France

John Karkazis, Business School, University of the Aegean, Chios, GR-82100, Chios, Greece, ikarkazis@aegean.gr

This paper explores the regional geo-economic dynamics of France during the period 1985-2004 employing GIS "Ptolemeos-Europe". In the beginning, the key notion of regional efficiency is introduced as well as other key regional analysis notions such as: regional discrimination cost and regional discrimination iso-curves. Based on the notion of regional efficiency the general geo-economic gravity model is introduced and its outcome, the geo-economic gravity centers and other related strategic and dynamic notions such as the capital displacement factor and the velocity of geo-economic gravity centers are presented and discussed. The above are applied to France in order to explore the strategic geo-economic trends of the 22 administrative regions of it.

3 - Improving the efficiency of WEEE collection systems using a web-based GIS application

Simão Ribeiro, Production and Systems Department, University of Minho, Portugal, Universidade do Minho, Campus de Gualtar, 4710-057, Braga, Portugal, scribeiro@gmail.com, *Jorge Pereira*, *Joel Carvalho*, *José Oliveira*, *Manuel Figueiredo*, *José Telhada*, *Luis Dias*

This project focuses on the design of a web-based GIS application to support the planning and management of collecting waste of electrical and electronic equipments (WEEE) networks. It addresses the issues of gathering and managing information needed by network optimization modules being included in an integrated computerized application, and the issues of analyzing and mapping their outputs. Several GIS and database technologies will be used, and their applicability and utility will be discussed. In overall, it is expected that relevant economic and environmental benefits will be achieved.

4 - Multiobjective Demand Covering Models based on GIS

Ioannis Giannikos, Business Administration, University of Patras, University of Patras, GR-26500, Patras, Greece, I.Giannikos@upatras.gr, *Georgios Alexandris*

In this paper we discuss a number of maximal demand covering models where the customers as well as the servers may be geographic objects rather than single points. Through the use of Geographic Information Systems (GIS), we consider different notions of coverage and develop a series of multiobjective programming models that take into account the following objectives: (a) maximization of total coverage, (b) maximization of minimum coverage and (c) minimization of distance to servers of uncovered demand objects. These models take into account the geography of each demand area in question and adjust the location of the servers accordingly.

■ MA-14

Monday, 9:00-10:20

2.2.15

Inventories in Supply Chains

Stream: Supply Chain Planning

Invited session

Chair: *Horst Tempelmeier*, Supply Chain Management and Production, University of Cologne, Albertus-Magnus-Platz, D-50923, Cologne, Germany, tempelmeier@wiso.uni-koeln.de

1 - A discrete time multi-level inventory system with a make-to-order supplier

Horst Tempelmeier, Supply Chain Management and Production, University of Cologne, Albertus-Magnus-Platz, D-50923, Cologne, Germany, tempelmeier@wiso.uni-koeln.de

We study a supply network comprising a factory following a make-to-order strategy, a warehouse using a reorder point-reorder quantity policy and distribution centers using base-stock policies in discrete time. The factory is modeled as a discrete time G/G/1 queueing system. The system is decomposed into three layers that are linked through random waiting times. An overall optimization model including as decision variables the processing time in the factory and the parameters of the inventory policies applied in the distribution system is formulated and solved.

2 - Two-Capacitated-Supplier Two-Stage Periodic-Review Supply Chain Problem Investigation

Kai Luo, Operations Management & Information Technology, HEC Paris, 1, rue de la Libération, 78351, Jouy en Josas, Paris, France, kai.luo@mailhec.net, *Laoucine Kerbache*, *Ramesh Bollapragada*

In this paper, we investigate a two-product (high-end, low-end), one retailer / two suppliers problem with random demand and periodic review. The problem is decomposed into sub-models and solved sequentially. For simple cases, closed form expressions are provided for the optimal solution. We show that, under certain conditions, the retailer should place the high-end product in the secondary inventory. For complex cases, we propose a heuristic to solve the problem and provide managerial insights.

3 - Heuristics for multi-item, two-echelon inventory system with aggregate mean wait time constraint.

Arjun Subramaniam, Applied Materials, Mountain View, California, United States, arjun.subramaniam@gmail.com, *Deepak Bhatia*

We consider a multi-item, two-echelon spare parts inventory system, with one central warehouse and multiple local warehouses. We present close-to-optimal, scalable heuristics to minimize total cost with each local warehouse subject to an aggregate mean wait time constraint. All locations operate under a continuous review system with base stock policies. We test effectiveness by comparing with the lower bound and demonstrate better performance compared to results from recently published works.

4 - Price and Perception - Understanding the Consumer Side of Recovered Products

Jonathan Linton, School of Management, University of Ottawa, 39 Sachs Forest Place, K2G 6V2, Ottawa, Ontario, Canada, linton@telfer.uottawa.ca, *Leila Hamzaoui*

We seek to address the gap in understanding consumer willingness to pay for products that are comprised of recovered materials and parts. Consequently, a survey of 320 respondents was conducted to determine the willingness to pay for different types of products containing recovered materials and components. A series of related hypotheses are provided and tested. In addition to considering issues personal attitudes to the environment and perceived risk, we consider the effects of branding and product characteristics. While the work is empirical in nature it is critical to supply chain planning as there is limited research and understanding of the consumer side of close-looped supply chains.

■ MA-15

Monday, 9:00-10:20

2.2.12

Location-routing problems

Stream: Vehicle Routing

Invited session

Chair: *Christian Prins*, Laboratoire LOSI, Université de Technologie de Troyes, BP 2060, 10010, Troyes Cedex, France, prins@utt.fr

1 - Centralized Distribution System of Infusion Solutions on a Network of Health Care Units

William Guerrero, Industrial Engineering, Universidad de los Andes, Av Cll 147 No 17-81 ap 502, 472, Bogotá, Bogotá D.C., Colombia, industrialito@hotmail.com, *Nubia Velasco*, *Ciro Alberto Amaya*, *Christelle Gueret*, *Thomas Yeung*

A methodology to improve inventory control and distribution policies in hospitals is presented. The strategy is to centralize the management of medicines into a single depot to reduce costs. It is aimed to find optimal inventory control policies for one-warehouse n-retailer distribution system based on a Markov Chain model. Results are evaluated on a real hospital. An MIP model to decide the location of the central depot and distribution routes to the Care units is also proposed. The objective is the minimization of the costs of the project and the inventory-on-hand value of the system.

2 - Solution methods for the periodic location-routing problem

Caroline Prodhon, University of Technology of Troyes, 12 rue Marie Curie, 10000, Troyes, France, caroline.prodhon@utt.fr

The well-known Vehicle Routing Problem (VRP) has been deeply studied over the last decades. Nowadays, generalizations are developed toward tactical or strategic decision levels but not both. The tactical extension or Periodic VRP (PVRP) plans a set of trips over a multiperiod horizon. The strategic extension or Location-Routing Problem (LRP) is motivated by interdependent depot location and routing decisions. The goal here is to present the very recent methods that solve the Periodic LRP, a combination of the PVRP and LRP into an even more realistic problem covering all decision levels.

3 - A cutting plane approach for the single truck and trailer routing problem with satellite depots (STTRPSD)

Juan G. Villegas, LOSI, Université de Technologie de Troyes/Universidad de los Andes, 12, rue Marie Curie, BP 2060, 10010, Troyes, France, juan_gmo_yr@yahoo.com, *Jose M. Belenguer*, *Enrique Benavent*, *Antonio Martinez Sykora*, *Christian Prins*, *Caroline Prodhon*

In the STTRPSD a truck with a removable trailer based at a main depot serves the demand of a set of customers reachable only by truck. Thus, before serving the customers in truck routes, it is necessary to detach the trailer at appropriate parking places and to transfer products between the truck and the trailer. We present a two index formulation of the STTRPSD and valid inequalities that are used within a cutting plane method to produce lower bounds, and to solve the problem with branch and cut. The results are compared with upper bounds found by GRASP/VND and ILS on 32 random instances

4 - A hybrid GRASP x Path Relinking for the Two-Echelon Location Routing Problem

Viet Phuong Nguyen, LOSI - Université de Technologie de Troyes, Troyes, France, viet_phuong.nguyen@utt.fr, *Christian Prins*, *Caroline Prodhon*

This paper presents a hybrid between GRASP and Path Relinking to solve the Two-Echelon Location Routing Problem (LRP-2E). The GRASP reinforced by a Learning Process uses three constructive heuristics to generate the initial solutions. The Path-relinking adds a memory mechanism by combining intensification strategy and post-optimization. Our method uses local searches structured by a Variable Neighbourhood Descent (VND). Computational results confirm the efficiency of this approach on two sets of LRP-2E instances. Furthermore it is competitive with the best meta-heuristic published for the LRP.

■ MA-16

Monday, 9:00-10:20

2.2.14

Rolling stock and Re-scheduling

Stream: Public Transport

Invited session

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

1 - Rolling Stock Rotation Planning for Intercity Rail Traffic

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

We consider one of the basic operational planning problems in public rail transport, the construction of a rolling stock schedule. The problem deals with the optimization of feasible rotations for individual railcars and, simultaneously, the composition of train sets from these railcars. In addition, we have to integrate several maintenance and regularity aspects. Modeling and computational preliminary results for instances of our industrial partner, DB Fernverkehr AG, which operates approximately 1.300 trains in Europe per day, are presented.

2 - Railway Rolling Stock Rescheduling with Rerouting of Passengers

Gabor Maroti, Department of Decision and Information Sciences, Rotterdam School of Management, Erasmus University Rotterdam, Burg Oudlaan 50, 3062 PA Rotterdam, The Netherlands, 3062 PA, Rotterdam, Netherlands, gmaroti@rsm.nl, *Lars Nielsen*, *Leo Kroon*

In this presentation we describe disruption management processes for a passenger railway system. In a disrupted situation, the timetable, the rolling stock circulation, and the crew duties must be rescheduled. We focus on rescheduling the rolling stock circulation. In case of a disruption, the passengers may be willing to take a detour route around the disrupted area. Then the rolling stock circulation must be rescheduled in such a way that additional seating capacity is provided along the detour route. In this presentation we describe an iterative procedure that reroutes the passengers, and that modifies the rolling stock circulation accordingly. Computational results based on real-life instances of Netherlands Railways have shown that this procedure may substantially reduce their delays.

3 - Rapid Transit Networks: Time Table and Rolling Stock

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*

In rapid transit networks, the daily operations management process includes two major tasks: 1. Train services Timetable (TT). 2. Rolling Stock (RS) assignment to the TT. The tasks are interdependent but are often solved sequentially due to restrictions on computational time and the intractability of an integrated approach. In our modeling approach we consider the integration of TT and RS. Some computational experiments will be presented.

4 - Assignment of services in bus lines under congestion

Esteve Codina, Statistics and Operational Research, UPC, Edifici C5, Desp 216 Campus Nord, 08034, Barcelona, Spain, esteve.codina@upc.edu, *Ángel Marín*, *Francisco Lopez*

A model is presented for dimensioning the number of services in bus lines operating under congested situations, which may arise in case of disruption of a Rapid Transit Network. The model takes into account bus capacity limitations and fleet availability as well as the dwell times of buses at stations. Also, an analysis of the waiting time of passengers at bus stops is made with special emphasis on this factor on the model results. The model is formulated under a system-optimum point of view and a heuristic algorithm approach is developed for larger size networks.

■ MA-17

Monday, 9:00-10:20

1.3.14

Collaborative Planning I

Stream: Transportation Planning

Invited session

Chair: *Herbert Kopfer*, Department of Business Studies & Economics, Chair of Logistics, University of Bremen, Wilhelm-Herbst-Strasse 5, 28359, Bremen, Germany, kopfer@uni-bremen.de

Chair: *Melanie Bloos*, Chair of Logistics, Bremen University, Wilhelm Herbst Str.5, 28359, Bremen, Germany, bloos@uni-bremen.de

1 - Transportation Operations Planning and Cost Allocation in a Cooperative Scenario

Andrea Nagel, Dept. of Information Systems, FernUniversität - University of Hagen, 58084, Hagen, Germany, andrea.nagel@fernuni-hagen.de, *Giselher Pankratz*, *Hermann Gehring*

Cooperative scenarios in transportation planning usually have to cope with the task of solving an optimization problem, as well as finding a fair allocation of the costs among the partners. We identify and characterize these problems for a real-life cooperation of four producers in the food and beverages industry, who decided to coordinate their distribution activities by inter-organisational transportation planning. Furthermore, we present a solution method that has been implemented, integrating a GRASP heuristic with the Shapley value approach. Finally, we show computational results.

2 - Allocating Cost of Service to Customers in Inventory Routing

Okan Ozener, Industrial Engineering, Ozyegin University, Kusbakisi Cad No:2, Altunizade Uskudar, 34662, Istanbul, Turkey, orsan.ozener@ozyegin.edu.tr, *Ozlem Ergun*, *Martin Savelsbergh*

Vendor managed inventory replenishment is a collaboration between a supplier and its customers where the supplier is responsible for managing the customers' inventory levels. In our VMI setting, the supplier exploits synergies between customers, e.g., their locations, usage rates, and storage capacities, to reduce distribution costs. Due to the intricate interactions between customers, calculating a fair cost-to-serve for each customer is a daunting task. However, cost-to-serve information is useful when marketing to new customers, or when revisiting routing and delivery quantity decisions. We design mechanisms for this cost allocation problem and determine their characteristics both analytically and computationally.

3 - Collaborative vehicle routing in a multi-depot environment

Julia Rieck, Department for Operations Research, Clausthal University of Technology, Julius-Albert-Str. 2, 38678, Clausthal-Zellerfeld, Germany, julia.rieck@tu-clausthal.de

Fierce competition urges carriers to cooperate. Particularly, medium-sized carriers only achieve the adequate area coverage by splitting transportation requests into multiple tasks (pick-up, line haul, delivery) that can be handled separately by different carriers. Hence, a carrier has to perform the delivery and pick-up services around the depot while minimizing the transportation costs. In order to improve the resulting set of single-depot solutions, we present a new collaborative method that tries to find a reassignment of tasks to carriers which decreases the overall transportation costs.

4 - The evaluation of pickup and delivery requests in cases of asymmetric information

Melanie Bloos, Chair of Logistics, Bremen University, Wilhelm Herbst Str.5, 28359, Bremen, Germany, bloos@uni-bremen.de, *Herbert Kopfer*

Collaborative transport planning aims at creating the most efficient allocation of requests to carriers for a groupage system. However, due to the nature of this system, only limited relevant information on the carriers' current planning is available system-wide. Our research focuses on evaluation criteria that create an efficient solution despite restricted information on the carriers' situation and we present initial results on the performance of evaluation criteria for individual requests.

■ MA-18

Monday, 9:00-10:20

1.3.15

New Achievements in Stochastic Models and Optimization

Stream: Stochastic Modeling and Simulation

Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Inflation Derivatives: HJM Framework and Market Models

Kwai-sun Leung, Systems Engineering and Engineering Management, The Chinese University of Hong Kong, Shatin, New Territories,, Hong Kong, N.A., Hong Kong, Hong Kong, kslung@se.cuhk.edu.hk, *Lixin Wu*

In this paper, we establish a Heath-Jarrow-Morton (HJM) type framework that governs the co-evolution of the term structure of both nominal and inflation rates. Pricing of inflation derivatives under this framework can be carried out similarly to that of nominal interest-rate derivatives under the classic HJM model. Based on the HJM framework, we further develop a market model with simple forward inflation rates using displaced diffusion processes, which results in closed-form pricing for inflation caplets and inflation swaptions. The smile model can also be developed based on the market model.

2 - On some antagonistic game related to majority voting

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

Simple majority voting is a classical approach to aggregation of individual decisions suggested by a committee of experts. In this paper, stability of such a collective decision, s.t. exclusion of some fixed number of experts, is investigated. Let some given list L of decisions be accepted by some committee of q equivalent experts, and let some number $k < q$ be fixed. How small can the cardinality of the largest sublist L' of L , acceptable by any k -members subcommittee, be? Tight lower bound of this quantity will be presented, it's asymptotical behavior and applications will be discussed.

3 - The effect of correlation in make-to-order systems

Michael Zazanis, Statistics, Athens University of Economics and Business, 76 Patission str., 10434, Athens, Greece, zazanis@aub.gr

We study the effect of correlation in the processing times of make-to-order systems using markovian queueing models and matrix-geometric techniques. Particular emphasis is placed on the correlated process with exponential marginals derived from the Kibble-Moran-Downton bivariate exponential distribution. Both exact results and logarithmic asymptotics are derived for these systems. Assemble-to-order systems with correlated demands are also analyzed.

4 - Rollover Optimization under Uncertain Regulatory Approval Date for Products with Bass Demand Rate

Hiba El Khoury, Operations Management and Information Technology, HEC- PARIS, HEC Paris, 1 rue de La liberation, 78350, Jouy en Josas, France, hiba.el-khoury@mailhec.net, *Christian Van Delft*, *Laoucine Kerbache*

Consider a company that plans to phase-out an existing product and phase-in a replacement one. If production of the existing product is stopped early, the firm will lose profit and goodwill. Yet, if production of the existing product is stopped late, the firm will experience an obsolescence cost for the existing product. We study rollover of products that follow a Bass demand rate, with the new product subject to an uncertain regulatory approval date. We minimize costs associated with the rollover and determine optimal rollover strategies for different product families.

■ MA-19

Monday, 9:00-10:20

1.3.20

Game Theory and Economics

Stream: Dynamical Systems 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: *Alberto A. Pinto*, Departamento de Matematica, University of Minho, Escola de Ciências, Universidade do Minho, 4710-057, Braga, Portugal, aapinto1@gmail.com

1 - Investments under Oligopolistic Competition in a vintage differential game

Stefan Wrzaczek, University of Technology Vienna, Institute of Mathematical Methods in Economics, Argentinierstr. 8, 1. Stock (ORDYS), 1040, Vienna, wrzaczek@server.eos.tuwien.ac.at, *Peter M. Kort*

Due to technological progress new machines are more productive. Thus it is not only important to choose the optimal amount of investments, but also the optimal age. We study an oligopoly consisting of two big firms connected by the price they get for the products. In order to include the vintage effect of investments we have to combine distributed optimal control theory with differential game theory. For the two independent variables (age and time) the concept of time consistency has to be considered for both directions. Important results for both directions can be derived and motivated.

2 - Strategic Interaction in Macroeconomic Policies: An Application of Differential Game Theory

Krishna Kumar, Managing Director, Samkhya Analytica India Pvt Ltd, 110 Sobha Opal 39th Cross, 4th T-Block Jayanagar, 560041, Bangalore, Karnataka, India, tkkumar@gmail.com, *Puja Guha*

The world economy is now highly connected, enabling development of developed and developing countries. But it is accompanied by risks of propagating adverse shocks from one country to another. Isolated macroeconomic policies guided earlier through control theoretic models need to be modified into models of policy coordination. Exploiting the concepts of non-cooperative solution through Nash-Equilibrium, and cooperative solution through Nash program in differential games with quadratic pay-offs we introduce strategic interaction in macroeconomic policy.

3 - An optimal selection of watchman routes by search game

Shuhei Morita, Dep. of Computer Science, National Defense Academy, 1-10-20, Hashirimizu, 239-8686, Yokosuka city, Kanagawa Prefecture, Japan, g48038@nda.ac.jp, *Ryusuke Hohzaki*, *Toru Komiya*, *Emiko Fukuda*

This paper deals with an optimal selection of watchman routes in a facility, such as art gallery. Art gallery problem is a famous problem in the field of computational geometry, which decides the stationary deployment of watchmen. This paper considers a dynamic patrol plan for the facility from the viewpoint of Operational Research. First, we obtain an optimal intrusion schedule for the minimum detection probability of the intruder by dynamic programming. Secondly, we formulate an optimal selection problem of watchman routes and solve it by search theory and game theory.

4 - Nonparametric prediction of bank loan recoveries

João Bastos, Technical University of Lisbon, CEMAPRE-ISEG, Rua do Quelhas 6, 1200-781, Lisboa, Portugal, jbastos@iseg.utl.pt

With the advent of the Basel II Accord, banking organizations are invited to estimate credit risk capital requirements using an internal ratings based approach. In order to be compliant with this approach, institutions must estimate the expected loss-given-default, the fraction of the credit exposure that is lost if the borrower defaults. This study evaluates the ability of nonparametric regression tree models to forecast bank loan credit losses. The performance of the models is benchmarked against recovery estimates given by historical averages and parametric fractional response regressions.

■ MA-20

Monday, 9:00-10:20

1.3.33A

Cutting and Packing 1

Stream: Cutting and Packing

Invited session

Chair: *Jose Fernando Oliveira*, Faculty of Engineering / INESC Porto, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, jfo@fe.up.pt

1 - Radical-free phi-functions for 2D objects and their applications

Tatiana Romanova, Department of Mathematical Modeling and Optimal Design, Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine, 2/10 Pozharsky St., 61046, Kharkov, Ukraine, sherom@kharkov.ua, *Nikolai Chernov*, *Yuri Stoyan*, *A. Pankratov*

Phi-functions are used to solve packing, cutting, and covering problems. Our purpose is to construct phi-functions by using simple mathematical formulas without radicals. First we introduce a special class of basic objects and prove that any 2D object whose frontier is formed by circular arcs and line segments may be represented as a union of basic objects. Then we derive a complete class of radical-free phi-functions for all pairs of basic objects. Lastly we show how to form phi-functions for more general objects. A software package is developed based on these results. Some applications are given.

2 - A constructive algorithm for leather nesting in the automotive industry

Pedro Brás, Universidade do Minho, 4710-057, Braga, Portugal, bras.pedro@gmail.com, *Cláudio Alves*, *J. M. Valério de Carvalho*, *Telmo Pinto*

We address the leather nesting problem in the context of an automotive company. In this 2-dimensional problem, irregular shapes (car seats components) have to be cut from a natural leather hide with holes, defects and quality zones. We propose a solution algorithm based on a constructive procedure. We discuss the different aspects of this procedure and explain the strategic options on which it is based. We also briefly describe the no-fit polygon method used to guarantee valid placements in the leather hides. Computational results on real instances are presented.

3 - A Hybrid Meta-heuristic Approach for Non-standard Packing Problems with Additional Conditions

Giorgio Fasano, Space Infrastructures & Transportation, Thales Alenia Space Italia, Str. Antica di Collegno 253, 10146, Turin, Italy, giorgio.fasano@thalesaleniaspace.com

This work focuses on the orthogonal packing of tetris-like items within a non-rectangular domain (with forbidden zones), in the presence of additional conditions, such as balancing. The overall problem is formulated in terms of mixed integer programming. Since non trivial cases give rise to very large-scale instances, a hybrid meta-heuristic approach has been adopted to solve recursively the problem. It is based on the concept of abstract configuration, deriving from the relative position of items. An extension considers the 2D case of polygons from a global optimization point of view.

4 - Dual feasible functions for vector packing problems

Jürgen Rietz, Departamento de Produção e Sistemas, Centro de Investigação Algorítmica, Universidade do Minho, Campus de Gualtar, 4715-082, Braga, Portugal, juergen_rietz@gmx.de, *Cláudio Alves*, *J. M. Valério de Carvalho*, *François Clautiaux*

Dual-feasible functions (DFFs) were successfully used to obtain fast valid lower bounds for the one-dimensional cutting stock problem. To accelerate the calculations, only maximal, especially extremal functions should be used. This approach works for the vector packing problem too, if the domain of the DFFs is replaced by a more-dimensional unit cube. We state necessary and sufficient conditions for such functions to be maximal respectively extremal and present some non-trivial examples. New DFFs for the problem are discussed, and computational results are reported.

■ MA-21

Monday, 9:00-10:20

6.2.47

OR in Practice I

Stream: Software for OR/MS

Invited session

Chair: *Ana Moura*, Economics, Management and Industrial Engineering, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal, ana.moura@ua.pt

1 - Optimizing Fire Station Locations for Istanbul Metropolitan Municipality

Emel Aktas, Industrial Engineering Department, Istanbul Technical University, ITU Isletme Fakultesi, Macka, 34367, Istanbul, Turkey, aktasem@itu.edu.tr, *Ozay Ozaydin*, *Sule Onsel*, *Burcin Bozkaya*, *Fusun Ulengin*

Istanbul is a densely populated city with 2000+ years of cultural heritage. We provide a max-cover type mathematical model with limited budget to help Municipality authorities determine new fire station locations in addition to existing ones. We solve this model to optimality using GAMS and increase existing fire coverage from 56% to 86%. We also consider unlimited budget, overall relocation, and increased emphasis on city's cultural treasures. We use GIS to process all geographical input data, calculate network distances and coverage ratios, and visualize various solutions of our model.

2 - Design of a spatially explicit model to optimize the selection of reforestation projects and the sizing of a detention dam to reduce peak runoff in a small watershed

Jochen Breschan, Department of Environmental Sciences, ETH Zurich, CHN K73.1, Universitaetstr. 22, 8092, Zurich, Switzerland, breschan@env.ethz.ch, *Hans Rudolf Heinimann*, *Richard Church*

We address the problem of reducing potential flood hazards within a small Alpine watershed, using combinations of 1) spatially explicit reforestation projects and 2) a detention dam at the outlet in order to reduce peak storm runoff. The objective is to optimize the location of reforestation projects and the sizing of the detention dam to cost-effectively meet targets of peak runoff reduction. We show how to cast this problem as a Mixed Integer-Linear Programming optimization model that is solved using CPLEX. Finally, we present an application of this model to the Vogelbach watershed (CH).

3 - A two-stage packing procedure for a Portuguese trading company

Ana Moura, Economics, Management and Industrial Engineering, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal, ana.moura@ua.pt, *Andreas Bortfeldt*

This work reports on the development of a prototypical decision support system, called Packing and Routing Optimizer (PRO), which is devised to solve several packing and routing problems for a Portuguese company. The daily distribution process is analyzed and three decision problems regarding automated decision support are determined. The performance of the solution approaches is evaluated by computational tests based on actual company data. The test results show that the system is able to help improving the daily decisions and to strengthen the flexibility in negotiations with customers.

■ MA-22

Monday, 9:00-10:20

3.1.10

Teaching OR/MS

Stream: Teaching OR/MS

Invited session

Chair: *Susana Colaco*, Departamento de Ciências Matemáticas e Naturais, Escola Superior de Educação- Instituto politécnico de Santarém, Complexo Andaluz, Apartado 131, 2000, Santarém, Portugal, susana.colaco@ese.ipsantarém.pt

1 - Generalized implementation of Program Evaluation Review Technique and Critical Path Method using EXCEL Spreadsheet.

Shruthi S Kumar, Telecommunication, PES Institute of Technology, 100 Ft Ring Road BSK III Stage, 560085, Bangalore, Karnataka, India, shruthulisha@gmail.com, Guruprasad Nagaraj

This paper describes implementation of the traditional PERT/CPM algorithm for finding the critical path in a project network using a spreadsheet. The problem is of importance due to recent shift of attention to using the spreadsheet environment as a vehicle for delivering MS/OR techniques to end-users. The purpose of this paper is intended to explore the need for systematic planning in teaching the network model in Operations Research to the under graduate students. We intend to create this spreadsheet mainly as a challenge to see whether the algorithm could be implemented in Excel.

2 - On using WinQSB software to solve Linear Programming problems on 11th grade High School classrooms

Ana Paula Teixeira, Mathematics, UTAD / CIO, Portugal, ateixeir@utad.pt, *Helena Monteiro*

In this work we will describe an experimental study involving one hundred and eight Portuguese students of the 11th grade, who attended to the classes of Mathematics A. The aim of this study is to investigate if the students are able to use WinQSB software to solve Linear Programming, LP, problems. We also intend to identify not only the opinion of the students about the resolution of LP problems with this software but also their main difficulties during this experience. Moreover, this study will help us to understand if it is possible to use WinQSB as a tool when teaching LP on High School.

3 - Some experiences on the design and implementation of Operations Research courses in Web-based environments

Angel A. Juan, Computer Science, Open University of Catalonia, Rambla Poblenou, 156, 08018, Barcelona, Spain, ajuanp@gmail.com, *Teresa Oliveira*, *Maria Martinez*, *Amilcar Oliveira*, *Javier Faulin*, *Sven Trenholm*

Web-based technologies have driven the growth of new learning opportunities in the Operations Research (OR) arena. We analyze how these technologies facilitate the shifting to an educational paradigm which considers students as active and central actors in their learning process. Use of computer software and collaborative learning as methodological policies to increase students' motivation for OR are also discussed, and some real experiences regarding the design and implementation of OR courses in Web-based environments are described.

4 - Modeling operations research problems with middle school students

Susana Colaco, Departamento de Ciências Matemáticas e Naturais, Escola Superior de Educação- Instituto politécnico de Santarém, Complexo Andaluz, Apartado 131, 2000, Santarém, Portugal, susana.colaco@ese.ipsantarém.pt, *Margarida Pato*, *Cecilia Rebelo*

This talk describes a classroom modeling tasks for middle school students using classical operations research problems, such as linear programming in single and multi-objective versions, set covering, set packing and set partitioning. Some students' productions to model real world problems are presented. The potentialities of using these contexts to develop communication skills, mathematical reasoning and identification of connections among mathematical ideas will be discussed.

■ MA-23

Monday, 9:00-10:20
6.2.49

MOO: Algorithms for Multi-Objective Combinatorial Optimization I

Stream: Multi-Objective Optimization
Invited session

Chair: *Luis Paquete*, Department of Informatics Engineering, University of Coimbra, Polo II, 3030-290, Coimbra, Portugal, paquete@dei.uc.pt

1 - Finite representation of nondominated sets in multiobjective linear programming

Matthias Ehrgott, Engineering Science, University of Auckland, Private Bag 92019, 1001, Auckland, New Zealand, m.ehrgott@auckland.ac.nz

Can a continuous set of nondominated solutions of a multiobjective linear programme be represented by a finite subset? We prove that a related optimisation problem is NP-hard and show that some earlier methods may perform badly. We propose a new combined method which overcomes the limitations of these methods. We show that our method computes a set of evenly distributed nondominated points for which the coverage error and the uniformity level can be measured. Finally, we apply this method to an optimization problem in radiation therapy and present illustrative results for some clinical cases.

2 - Large neighborhood search for solving the multiobjective multidimensional knapsack problem

Thibaut Lust, Laboratory of Mathematics and Operational Research, University of Mons, 9, rue de Houdain, 7000, Mons, Belgium, thibaut.lust@umons.ac.be, *Jacques Teghem*

We present a large neighborhood search (LNS) to solve the multiobjective multidimensional knapsack problem. The LNS is integrated into the two-phase Pareto local search method (Lust and Teghem, 2007). Different ratios are used to identify the items that interfere in the generation of the neighbors. The neighborhood is solved with an exact method or with a heuristic method, depending on the size of the neighborhood. We show that we obtain results never reached before (about 90% of the non-dominated points of a 250 items instance can be generated in less than 45 seconds).

3 - A polynomial time algorithm for a cardinality constrained multicriteria knapsack problem

Florian Seipp, Mathematics, University of Kaiserslautern, Paul-Ehrlich-Str. 14 -459, 67663, Kaiserslautern, Germany, seipp@mathematik.uni-kl.de, *Luis Paquete*, *Stefan Ruzika*

This talk is concerned with the cardinality constrained multicriteria knapsack problem. In this combinatorial optimization problem two binary weight functions and a real valued profit function on the items are given. The task is to choose k out of the n given items with the aim of minimizing the weights and maximizing the profit. Whereas the general multicriteria knapsack problem is known to be NP-hard, we propose an exact algorithm with polynomial running time for our problem. This algorithm computes all nondominated points by efficiently exploring the weight space.

4 - Three Algorithms for Finding Mines in a Line

Luis Paquete, Department of Informatics Engineering, University of Coimbra, Polo II, 3030-290, Coimbra, Portugal, paquete@dei.uc.pt, *Jochen Gorski*, *Mathias Jaschob*, *Kathrin Klamroth*

We introduce three algorithms for the problem of finding mines in a line. In this problem we are given a line partitioned into small segments, the time taken to either search in or travel through each segment, as well as a score value assigned to each segment. The goal is to choose the segments to visit such that the sum of the corresponding scores is maximized and the total travel and search time is minimized. The two algorithms are based on dynamic programming approaches for the multi-criteria knapsack problem. The third algorithm solves a bi-criteria shortest path problem formulation.

■ MA-24

Monday, 9:00-10:20
6.2.50

Bioinformatics I

Stream: Computational Biology, Bioinformatics and Medicine
Invited session

Chair: *Jacek Blazewicz*, Instytut Informatyki, Politechnika Poznańska, ul.Piotrowo 2, 60-965, Poznan, Poland, jblazewicz@cs.put.poznan.pl

Chair: *Piotr Formanowicz*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, piotr@cs.put.poznan.pl

1 - A new approach for measuring and visualizing quality of 3D protein models

Piotr Lukasiak, Institute of Computing Science, Poznan University of Technology, ul.Piotrowo 2, 60-965, Poznan, Poland, Piotr.Lukasiak@cs.put.poznan.pl, Krzysztof Fidelis, Jacek Blazewicz

Nowadays, there are a lot of computational methods in bioinformatics that can build protein 3D models based on the sequence, however even if real 3D protein structure is known it is hard to clearly evaluate which method is the most efficient. Accurate assessment of quality of protein models can be a crucial point for evaluation of currently available 3D protein prediction methods. In our approach one based on the idea of local descriptors similarity building appropriate measure to distinguish between "good" and "bad" models followed by new ways of visualization of models quality.

2 - Prediction of protein-protein interaction network

Xiang-Sun Zhang, Academy of Mathematics and Systems Science, Zhongguancun East Road 55, 100190, Beijing, China, zxs@amt.ac.cn

Protein-protein interaction network (PPIN) plays an indispensable role in systems biology research. In this research we predict the unknown part of the PPIN by not only collecting all predicted PPIs based on the Domain-Domain Interaction (DDI) information but also satisfying the characteristics of the PPIN as a complex network, such as a small-world network, a network without rich club. Parsimony principle is used to find a spanning DDI structure through solving an integer linear programming.

3 - Minimal Information for Automated Protein Function Prediction

Daniel Faria, Informatics, Faculty of Sciences, University of Lisbon, Campo Grande, Edifício C6, 1749-016, Lisboa, Portugal, dfaria@xldb.di.fc.ul.pt

The BLAST algorithm has become the de facto standard for protein function prediction from sequence. However, its applicability is limited and its widespread use promotes the propagation of errors. Several machine learning approaches have been tested as alternatives to BLAST, but the main focus has been on accuracy rather than speed. However, these approaches can't expect to rival BLAST unless they are extremely efficient. In this work we assess the discriminatory power of several simple representations of protein sequences by testing them with simple machine learning approaches. Our goal is to obtain very efficient classifiers that can rival BLAST in terms of both accuracy and speed.

4 - A guide through the labyrinth of gene prioritization tools

Francisco Bonachela Capdevila, KU Leuven, campus Kortrijk, B-8500, Kortrijk, Belgium, Francisco.BonachelaCapdevila@kuleuven-kortrijk.be, Léon-Charles Tranchevent, Daniela Nitsch, Bart De Moor, Patrick De Causmaecker, Yves Moreau

Finding the most promising genes among large lists of candidate genes has been defined as the gene prioritization problem. In the last decade, several different computational approaches have been developed to tackle this challenging task. We review 18 computational solutions for human gene prioritization that are freely accessible as web tools and illustrate their differences. In addition we have developed a website containing detailed information about these and other tools, which is regularly updated. Web: <http://www.esat.kuleuven.be/gpp>

■ MA-25

Monday, 9:00-10:20

6.2.48

Financial Mathematics and OR 1

Stream: Financial Mathematics and OR

Invited session

Chair: Koray Simsek, Faculty of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, ksimsek@sabanciuniv.edu

1 - Robust portfolio construction for downside risk control

Woo Chang Kim, Industrial and Systems Engineering, KAIST, #3107, E2-2, KAIST, 335 Gwahangno, Yuseong-gu, 305-701, Daejeon, Korea, Republic Of, wkim@kaist.ac.kr

In this paper, we propose an alternative way to construct a robust portfolio of financial product. We utilize the market information under the stressful times and estimate the parameters directly from the data. The empirical analysis indicates that the performance could be improved much compared to other approaches, while our model requires less parameters to estimated.

2 - Stochastic Diffusion Processes and High Frequency Sampling Data

Ahmet Can Inci, College of Business - Finance, Bryant University, 1150 Douglas Pike, 02917, Smithfield, RI, United States, ainci@bryant.edu

Studies propose that higher frequency data provide a more accurate separation of continuous and jump components of a dynamic process. Stochastic processes may not be fully utilized for low frequency monthly/quarterly data since processes such as jumps may be smoothed out. In this study, the empirical performance of a sophisticated multi-country multi-state quadratic stochastic model is explored in the context of sampling frequency for the same sample period. Differences in the coefficient estimates of the parameters and the empirical performance of the model are documented.

3 - Mathematical Programming Approaches for Generating p-Efficient Points

Nilay Noyan, Manufacturing Systems/Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, nnoyan@sabanciuniv.edu, Miguel Lejeune

The concept of p-efficiency is widely used to develop efficient methods to solve probabilistically constrained problems, such as the cash-flow matching problem. Those methods require the generation of p-efficient points (pLEPs). We consider a random vector characterized by a set of scenarios and generate pLEPs by solving a mixed integer programming problem. We propose to solve this challenging problem by a new mathematical programming framework, which involves solving a series of outer approximations. We present numerical results showing the computational efficiency of the proposed framework.

4 - Performance Enhancements for Defined Benefit Pension Plans

Koray Simsek, Faculty of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, ksimsek@sabanciuniv.edu, John Mulvey

Over the next 30-50 years, traditional corporate and government pension plans will encounter severe problems in many countries. Contributing factors include: demographic trends, low savings rates, and inefficient investment strategies. This paper takes up the last point, showing that a forward-looking asset liability management model can improve performance across many reward and risk measures. We approximate a multi-stage stochastic program via a set of robust policy rules. Empirically, we show that a duration enhancing overlay strategy improves performance during economic contractions.

■ MA-26

Monday, 9:00-10:20

3.1.11

Mathematical Programming Approaches for Classification Problems

Stream: Machine Learning and Its Applications

Invited session

Chair: Gurkan Ozturk, Industrial Engineering, Anadolu University, AU-MMF-Industrial Engineering, Iki Eylul Campus, 26480, Eskisehir, Turkey, gurkan.o@anadolu.edu.tr

1 - A New Contribution to Mean Shift Outlier Model with Continuous Optimization

Pakize Taylan, Mathematics, Dicle University, 21280, Diyarbakir, Diyarbakir, Turkey, ptaylan@dicle.edu.tr, Fatma Yerlikaya Ozkurt, Gerhard-Wilhelm Weber

The outlier detection problem is one of the important problems in statistics since observation of outliers negatively affects the estimation and the inference. There are several outlier detection methods. One of these methods is given by Mean Shift Outlier model. In our study, Mean Shift Outlier model is constructed with Tikhonov Regularization. Here, our new model is solved by continuous optimization techniques, in particular, via the elegant framework of conic quadratic programming which becomes an important complementary technology and alternative to the outlier detection methods.

2 - A Mixed-Integer Programming Approach to Multi-Class Data Classification Problems

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

In this study, a novel MILP based hyper-box enclosure approach is presented for multi-class data classification problems. In order to deal with large data sets, a three-stage mathematical programming based approach is developed for training part. The efficiency of the method is tested by the simple distance based testing algorithm. The computational results on the UCI Repository data sets show that the simplicity and accuracy of the proposed method provides scientific insight into the multi-class data classification problems.

3 - A heuristic classification algorithm for large scale problems

Mehmet Tahir Ciftci, Logistics, Eczacibasi Vitra, 11300, Bilecik, Bozuyuk, Turkey, tahir.ciftci@eczacibasi.com.tr, *Gurkan Ozturk*

In last years, polyhedral conic functions are used in developing successful classification algorithms. The performance of the classification algorithm highly depends on the parameters of function used. One of the these parameters is the vertex point of the graph of polyhedral conic function under consideration. In this study, several heuristic approaches based on different center point determination strategies are proposed. These approaches are then used in algorithms for solving large scale classification problems. Classification performances are reported for the literature test problems.

4 - A novel mathematical programming approach for classification based on linear and conic functions

Gurkan Ozturk, Industrial Engineering, Anadolu University, AU-MMF-Industrial Engineering, Iki Eylul Campus, 26480, Eskisehir, Turkey, gurkan.o@anadolu.edu.tr, *Refail Kasimbeyli*

Mathematical programming approaches for classification problems are generally based on linear functions. Conic functions are defined by expanding linear functions with different norms. In this study we use a two-step approach. In the first step, linear and conic functions are obtained by solving linear programming problems. Then in the second step, an integer programming model is constructed and solved. Eventual separating function is defined as a point-wise minimum of selected functions. The performance of the proposed method is shown on test problems.

■ MA-27

Monday, 9:00-10:20

8.2.06

Financial Optimization 1

Stream: Financial Optimization

Invited session

Chair: *Cesarone Francesco*, La Sapienza Universita' di Roma, Facolta' di Economia, 00161, Roma, francesco.cesarone@uniroma1.it

1 - Log-Robust Portfolio Management

Aurelie Thiele, Industrial and Systems Engineering, Lehigh University, 200 West Packer Ave Room 329, 18015, Bethlehem, PA, United States, aurelie.thiele@lehigh.edu, *Ban Kawas*

We present a robust optimization approach to portfolio management under uncertainty that (i) builds upon the well-established Lognormal model for stock prices while addressing its limitations, and (ii) incorporates the imperfect knowledge on the true distribution of the continuously compounded rates of return, i.e., the increments of the logarithm of the stock prices, in an intuitive manner. We derive theoretical insights into the worst-case uncertainty and the optimal allocation. We also consider extensions to short sales and discuss risk-return trade-offs.

2 - Pension Fund ALM with multiple asset classes

Katharina Schwaiger, Economics and Finance, Brunel University, Kingston Lane, Brunel University, UB8 3PH, Uxbridge, Middlesex, United Kingdom,

katharina.schwaiger@brunel.ac.uk, *Gautam Mitra*, *Nicola Spagnolo*

Asset and Liability Management models for pension funds have been recently recast as Liability Driven Investment models. The industry has interpreted this as different allocation strategies: i.e. 100% fixed income, fixed proportions of equities and fixed income plus overlay strategies. We propose asset allocation strategies of two-stage stochastic programming and integrated chance-constrained programming models and compare their performance to static fixed mix strategies. The stochastic programming models trade-off initial injected cash and PV deviations between assets and liabilities.

3 - Enhanced indexation using SSD

Diana Roman, Mathematics, Brunel University, UB8 3PH, Uxbridge, United Kingdom, diana.roman@brunel.ac.uk, *Gautam Mitra*, *Csaba I. Fabian*

We analyse the effectiveness of SSD models in the context of enhanced indexation. Enhanced indexation models are strategies for asset allocation that seek to outperform an index. Most of the index tracking / outperforming models aim to tackle the computational difficulty posed by limiting the number of stocks (which leads to MIP or QMIPs). We show that the SSD-based models naturally select a small number of stocks, which makes unnecessary the imposition of cardinality constraints. The effectiveness in over-performing the index is shown using 3 datasets drawn FTSE100, Nikkei 225 and SP500.

4 - A new portfolio selection approach: Models and Algorithms

Cesarone Francesco, La Sapienza Universita' di Roma, Facolta' di Economia, 00161, Roma, francesco.cesarone@uniroma1.it, *Andrea Scozzari*, *Fabio Tardella*

In this paper we present a comparison study between different portfolio models. We focus on the Markowitz, the Mean Absolute Deviation, and the CVaR models, with the introduction of quantity and cardinality constraints. In particular, we provide a new solution method for the limited asset Markowitz model based on a reformulation as a Standard Quadratic Program and on some recent theoretical results. We report optimal solutions of some unsolved test problems from Beasley's OR Library. Finally, we present a new model based on CVaR minimization with constraints on the correlation among stocks.

■ MA-28

Monday, 9:00-10:20

8.2.10

Stochastic Integer Programming

Stream: Stochastic Programming 1

Invited session

Chair: *Gloria Perez*, Applied Mathematics and Statistics and Operational Research, Universidad del País Vasco, Science and Technology Faculty, Barrio Sarriena s/n, 48940, Leioa, Spain, Spain, gloria.perez@ehu.es

1 - On BFC-MSMIP strategies for Twin Node Family branching selection and bounding for multistage stochastic mixed integer programming

Gloria Perez, Applied Mathematics and Statistics and Operational Research, Universidad del País Vasco, Science and Technology Faculty, Barrio Sarriena s/n, 48940, Leioa, Spain, Spain, gloria.perez@ehu.es, *Laureano Fernando Escudero*, *María Araceli Garín*, *María Merino*

In the Branch-and-Fix Coordination (BFC-MSMIP) algorithm for solving multistage stochastic mixed integer programming problems, we find it crucial to decide the stages where the nonanticipativity constraints are explicitly considered in the model. We present a scheme for obtaining strong bounds and branching strategies for the Twin Node Families to increase the efficiency of BFC-MSMIP. Also we explain the computational description using the free optimization software COIN-OR, Computational Infrastructure for Operations Research and it is reported some computational experience.

2 - FRC: A heuristic extension of the Branch-and-Fix Coordination approach for solving very large multistage mixed 0-1 stochastic problems

Celeste Pizarro Romero, Dpto. de Estadística e Investigación Operativa, Universidad Rey Juan Carlos, Escuela de CC. Experimentales y Tecnología, 28933, Móstoles, Spain,

celeste.pizarro@urjc.es, Antonio Alonso-Ayuso, Laureano Fernando Escudero, Pablo Olaso

We present a Branch-and-Fix Coordination (BFC) framework for solving large-scale multistage mixed 0-1 stochastic problems. A mixed 0-1 model for each scenario cluster is considered plus the non-anticipativity constraints that equate the 0-1 and continuous so-called common variables from the same group of scenarios in each stage. We propose the heuristic extension of BFC, so-called Fix-and-Relax Coordination (FRC) algorithm, to exploit the characteristics of the non-anticipativity constraints of the stochastic model for solving very large-scale instances. Computational results are reported.

3 - Subgradient scheme, Volume algorithm, Progressive Hedging algorithm and Dynamic Constrained Cutting plane scheme in Lagrangean Decomposition Models

María Araceli Garín, Applied Economy III, UPV/EHU, Lehendakari Aguirre 83, 48015, Bilbao, Bizkaia, Spain, mariaaraceli.garin@ehu.es, Laureano Fernando Escudero, Gloria Perez, Aitziber Unzueta

We represent the two stage stochastic mixed 0-1 problem by a splitting variable representation of the DEM. In order to satisfy the non-anticipativity constraints, we consider the Lagrangean decomposition and compare the solution given by different schemes based on dual Lagrangean problems, where the Lagrange multipliers are updated by using the subgradient method, the volume algorithm, the progressive hedging algorithm and the dynamic constrained cutting plane scheme. Lagrangean decomposition is proposed for satisfying the non-anticipativity constraints. Computational results are reported.

4 - Multistage Stochastic Programming Problem: Decomposition, Stability and Empirical Estimates

Vlasta Kaňková, Econometrics, Institute of Information Theory and Automation of ASCR, Pod Vodárenskou věží 4, Praha 8, CZ 18208, Prague, Czech Republic, Czech Republic, kankova@utia.cas.cz

A multistage stochastic programming problem can be mostly introduced as a system of parametric one stage optimization problems. Consequently, results (achieved for one stage problems) can be employed to investigate stability and empirical estimates of the multistage problems. The aim of the contribution is to investigate assumptions under which this approach is suitable and the convergence rate of empirical estimates is acceptable. The introduced assumptions cover heavy tailed distributions and conditions guaranteeing nonempty constraints set of decomposed problems.

MA-30

Monday, 9:00-10:20

8.2.13

MCDA II: Multicriteria ranking and classification vs portfolio decision analysis (Panel)

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

Panel 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 - Multicriteria ranking and classification vs portfolio decision analysis

Alec Morton, Management/ Operational Research, London School of Economics, Houghton St, London, wc2a2ae, London, England, United Kingdom, a.morton@lse.ac.uk, Christian Stummer, Valerie Belton, Ahti Salo, José Rui Figueira, Theodor Stewart

Three very similar problems are as follows: rank n multiattributed items; classify the items as "yes", "no" and "maybe"; and select a number of these items such that the total cost of the selected items is less than some budget. The former two sorts of problems have been studied under the heading of ranking and classification, and the last sort of problem has been studied under the heading of portfolio decision analysis. Are these problems as similar as they appear, and if so, why do we think about them differently?

MA-31

Monday, 9:00-10:20

8.2.15

Societal Complexity and Climate

Stream: Methodology of Societal Complexity

Invited session

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Sustainability assessment for solar plant and wind power projects in the con co island, quang tri province, vietnam

Le Trinh Hai, Human Ecology, Vrije Universiteit Brussel, 103 Laarbeeklaan, 1090, Brussels, Viet Nam, letrinhhai@gmail.com, Pham Hoang Hai, Nguyen Ngoc Khanh, Jan Kuilman, Dinh Thi Phuong Loan, Luc Hens

Background: Clean Development Chemical Programme mentioned in Article 12 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change is a hot issue, in particular in developing countries (e.g. Vietnam) to limit or reduce their greenhouse gas emissions. Solar plant and wind power are two important aspects in this programme.

Aim: To assess sustainability of the planning projects on solar plant and wind power on the island of Con Co Quang Tri, Vietnam as a case study.

Methods: The analytic hierarchy process and multi-criteria/indicator assessment are applied to evaluate the planning projects.

Results: Scenario I provides the sustainability scores of composite sustainable development index (ICSD: 0.509) for the solar plant and of for the wind plant (ICSD: 0.490). In Scenario II both power projects score high (the solar plant ICSD: 0.86 and the wind power ICSD: 0.838).

Conclusions: The multi-criteria/indicator assessment allows to evaluate the two planning projects on the Con Co island. Based on the results, the projects are not only help to reduce the environmental pollution in particular in Scenario II and also to improve the local life, especially in Con Co as a poor island and important district of the province of Quang Tri. In addition, it will possibly help the decision-makers are able to understand the values of the energy systems as part of Clean Development Mechanism.

2 - Online web based solution for environmental sustainable development

Unal Akyuz, Software Engineering, Bahcesehir University, Bahcesehir University, Faculty of Engineering, 34353, Istanbul, Turkey, unal.akyuz@stu.bahcesehir.edu.tr, Onur Yazici, Okan Kilic, Gizem Akturk, Erkan Mert, Boran Uzunlu, Buse Ozturk, Sureyya Ozogur-Akyuz

The aim of this multidisciplinary research is to help reducing the green house effect by constituting an online web solution with a mathematical programming approach which calculates Co2 emission and evaluates the necessary number of trees to recover Co2 emission, and further calculates the area of the land needed with respect to the region and the type of the tree by the help of Integer Linear Programming (ILP).

3 - Eco-dimension of Tourist Service Quality

Majda Bastic, Faculty of Economics and Business, University of Maribor, Razlagova 14, 2000, Maribor, Slovenia, majda.bastic@uni-mb.si

Tourism has not only contributed to increase of service export but also to climate changes. Climate changes and their impact on a quality of our life emerged a new increasing segment of tourists who demonstrate a particular sensitivity to the environment. An eco-component has not been included in the existing scales such as SERVQUAL, SERVPERF or ECOSERV. The objective of this paper was to investigate the service quality expectations of the ecotourists in order to develop eco-scale refers to environmentally responsible behaviour of hotels' management.

4 - Compram Method for Handling Societal Problems - Case Study in a Brazilian Research and Development (R&D) Program for the electric sector

André Bacellar, Research and Development and Efficiency Superintendence (SPE), Brazilian Electricity Regulatory Agency (ANEEL), SQN 403 Bl.M apto.107, 70835130, Brasília, DF,

Brazil, ambacellar@yahoo.com.br, *Aurelio Calheiros de Melo Junior*

The Brazilian Electricity Regulatory Agency — ANEEL establishes guidelines and instructions that regulate investments made by companies in R&D Program for the Brazilian Electric Energy Sector. The main problem in ANEEL's point of view is to reduce the utilities R&D financial risk as they develop research projects and at the same time reduce bureaucratic procedures, especially to the expenditures control. More control means less risk, but with more transaction costs. Lots of other variables increase the complexity.

■ MA-32

Monday, 9:00-10:20

8.2.17

Transportation planning in forest products industry

Stream: OR in Agriculture and Forest Management

Invited session

Chair: *Manfred Gronalt*, Institute of Production and Logistics, University of Natural Resources and Applied Life Sciences, Feistmantelstr. 4, A-1180, Vienna, Austria, Manfred.Gronalt@boku.ac.at

1 - Combining logs and biomass transportation planning in a Portuguese integrated pulp and paper company

Alexandra Marques, Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Tapada da Ajuda, 1349-017, Lisboa, Portugal, alexmarques@isa.utl.pt, *Jose Borges*

The high economical impact of transportation over total wood production cost fosters the development of innovative optimization approaches. In this article we propose a heuristic approach for combined logs and biomass transportation scheduling in a vertically integrated pulp and paper company. It is a particular case of the Log-truck scheduling problem aiming to find minimum cost routes for transporting all product assortments from the forest to transformation centers or terminals, according to the wood delivery plan defined beforehand. Innovative time windows constraints are considered.

2 - OR in support of forest products management and supply

Alexandra Marques, Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Tapada da Ajuda, 1349-017, Lisboa, Portugal, alexmarques@isa.utl.pt, *Mikael Rönnqvist*, *Sophie D'Amours*, *Jose Borges*

Optimization models and methods are extensively used for wood procurement planning, encompassing forest planning, harvesting, transportation, storing and plant supply. They foresee the optimal sustainable use of forest resources and available equipments, thus ranging from strategic planning to equipments allocation and operations daily scheduling. Their role in forest decision making is perceived, as they integrate individual supply chain agents' goals. This paper discusses models and solution approaches applied for wood procurement. The data flows among the supply chain are also addressed.

3 - The impact of using foldable containers in wood transport

Manfred Gronalt, Institute of Production and Logistics, University of Natural Resources and Applied Life Sciences, Feistmantelstr. 4, A-1180, Vienna, Austria, Manfred.Gronalt@boku.ac.at, *Patrick Hirsch*, *Jan Zazgornik*

In this study the impact of two different transport modes on vehicle routing is reported for cases in forest wood supply chains. The daily routing of vehicles with traditional round log trucks is compared to a more flexible concept of using foldable containers as unified loading equipment. Test instances are solved by a modified nearest neighbor insertion heuristic and improved by a metaheuristic called dynamic Tabu Search with Alternating Strategy, where neighborhoods are changed dynamically. The efficiency of both modes is measured in terms of duration and costs, respectively.

4 - Design of a biomass supply chain — an integrated approach

Tiago Gomes, Universidade do Minho, Portugal, tiago.gomes@dps.uminho.pt, *Filipe Alvelos*, *Sameiro Carvalho*

Successful biomass supply chain management requires many decisions relating to the supply of raw material, such as, the harvest of raw material, wood chipping, facility location, transportation and inventory decisions. The definition of an integrated approach to deal with such a diversity of problems aims to raise the supply chain surplus. In this research work, an integer programming model to support tactical and operational decisions in a biomass supply chain is proposed with the objective of minimizing total costs and satisfies the customers demand.

■ MA-33

Monday, 9:00-10:20

8.2.19

Energy Modeling

Stream: Energy, Environment and Climate [c]

Contributed session

Chair: *Reinhard Madlener*, Faculty of Business and Economics / E.ON Energy Research Center, RWTH Aachen University, Mathieustrasse 6, 52074, Aachen, Germany, rmadlener@eonerc.rwth-aachen.de

1 - A Multi-Sector Energy-Economy Model for Turkey

Bora Kat, The Scientific and Technological Research Council of Turkey, Atatürk Bulvarı No:221, Kavaklıdere, 06100, Ankara, Turkey, borakat@gmail.com, *Caglar Güven*, *Ebru Voyvoda*

In this study, an energy-economy model within the optimization framework is proposed. The model consists of a detailed representation of the energy activities and disaggregates the rest of the economy into five main sectors unlike the conventional energy-economy optimization models in which the rest of the economy is represented in an aggregated fashion. Besides the ability of representing the energy-economy interactions, the model is extended as it can assess the impacts of each scenario on the environmental variables, specifically on the GHG emissions.

2 - Sustainable Development Goals and the Use of Modern Portfolio Theory for Optimizing the Power Generation Mix at the Company Level

Barbara Glensk, Faculty of Business and Economics, E.ON Energy Research Center, RWTH Aachen University, Institute for Future Energy Consumer Needs and Behavior, Mathieustr.6, 52074, Aachen, North Rhine-Westphalia, Germany, bglenk@eonerc.rwth-aachen.de, *Reinhard Madlener*

Most countries and energy providers have plans to change their power generation mix, aiming at the development and pursuance of sustainable energy strategies, which typically imply the reduction of CO₂ emissions and an increased share of power from renewable energy sources. These goals ought to be guided through optimal capacity investment planning based on risk-return considerations. In this paper, by using variants of modern portfolio theory, we investigate the impact of new investments on the efficiency of the power generation mix of E.ON, one of the largest energy companies in Europe.

3 - A coupled geo-spatial energy - air quality assessment model for the region of Luxembourg

Laurent Drouet, CRTE, CRP Henri Tudor, Technoport Schlassgoart, 66, rue de Luxembourg, 4221, Esch-sur-Alzette, Luxembourg, ldrouet@gmail.com, *Daniel Zachary*, *Ulrich Leopold*, *Lara Aleluia Reis*

We present a general method to couple an energy model and an air-quality model. The energy model (MARKAL-like) aims to minimize the energy cost at a given level of emissions. The air quality model simulates the chemical reactions to produce ozone for worst-case episodes. We build a decomposition problem to find the optimal energy system with a constraint on the ozone concentrations. An oracle-based optimization method is implemented to solve the coupled model using the cutting plane algorithm (Proximal-ACCPM). We report on preliminary results of a prototype version developed for Luxembourg.

4 - Energy visions, resource allocation and multi-criteria assessment for a stakeholder discourse

Evelina Trutnevyte, Institute for Environmental Decisions (IED), Natural and Social Science Interface (NSSI), ETH Zurich, Universitätstrasse 16, CHN J 70.1, 8092, Zurich, Switzerland,

evelina.trutnevyte@env.ethz.ch, Michael Stauffacher, Alexander Scheidegger, Roland W. Scholz

Decisions for the future energy system are influenced by discourses among stakeholders. These discourses must be informed by analytical expertise on the allocation of scarce energy resources and the assessment of implications. We present a methodology, which links (i) visions (overall preferences) of stakeholders, (ii) representative sets of resource allocation options for the visions, and (iii) multi-criteria assessment to appraise implications. Such analysis improves support for strategic discourses among multiple stakeholders. The methodology is applied on a case of a Swiss community.

■ MA-34

Monday, 9:00-10:20

8.2.23

Solution Approaches for Lot-sizing Problems I

Stream: Lot-sizing and Scheduling, Economic Order Quantity

Invited session

Chair: *Marco Caserta*, Economics, University of Hamburg, Von-Melle-Park, 5, 20146, Hamburg, Germany, marco.caserta@uni-hamburg.de

1 - Genetic Algorithm Based Approaches for the Capacitated Lot Sizing Problem with Set-up Carryover and Backordering

Hacer Guner Goren, Department of Industrial Engineering, Dokuz Eylul University, Buca Campus, Buca, Izmir, Turkey, hacer.guner@deu.edu.tr, *Semra Tunali, Raf Jans*

This production planning problem deals with multiple products produced on a single machine. A setup is assumed to be carried over from one period to the next and the partial sequencing of the first and last product is incorporated. When the demand of a period can not be satisfied, it is backordered. In this study, a heuristic hybrid approach combining Genetic Algorithms (GAs) and Fix-and-Optimize heuristic is proposed to solve capacitated lot sizing problem with set-up carryover and backordering. The performance of the proposed approach is compared with pure GAs by generating various problem instances.

2 - An exact solution approach for the discrete lot-sizing and scheduling problem with identical parallel resources

Céline Gicquel, Laboratoire Genie Industriel, Ecole Centrale Paris, Grande Voie des Vigines, 92290, Chatenay-Malabry, France, celine.gicquel@ecp.fr, *Laurence Wolsey, Michel Minoux*

We consider the discrete lot-sizing and scheduling problem with identical parallel resources. We propose to solve this optimization problem using a tight MILP formulation and a commercial solver. We first study two alternative formulations of the problem: one involving machine-specific binary variables and one using system-wide integer variables. We then derive a new family of valid inequalities and use it to devise a Cut & Branch algorithm. Our computational experiments show that the proposed approach is effective at solving large instances of the problem within a reasonable computation time.

3 - Lower bounds for the capacitated lot sizing problem with setup time

Silvio Araujo, Departamento de Ciências da Computação e Estatística-DCCE, Universidade Estadual Paulista-UNESP, R. Cristovao Colombo, 2265 - Jd Nazareth, 15054-000, São José do Rio Preto, São Paulo, Brazil, saraujo@ibilce.unesp.br, *Zeger Degraeve, Raf Jans*

We study the Capacitated Lot Sizing Problem with Setup Times (CLST) and present some theoretical results regarding the quality of the lower bounds obtained by simultaneous per item and per period decompositions of the problem. Moreover, we develop and compare, by presenting some computational results, different algorithms based on column generation and Lagrange relaxation for finding lower bounds for the problem.

4 - Capacitated Lot Sizing with Setup Times: Decompositions of the Simple Plant Location Formulation

Bert De Reyck, Management Science & Operations, London Business School, Regent's Park, NW1 4SA, London, United Kingdom, bdereyck@london.edu, *Zeger Degraeve, Ioannis Fragkos*

Implementing Dantzig—Wolfe Decomposition (DW) and Lagrange Relaxation (LR) in extended formulations may be computationally challenging due to the inherent degeneracy these formulations often exhibit. We apply DW/LR to the Simple Plant Location formulation of the capacitated lot sizing problem with setup times. Its per—period decomposition gives rise to a series of subproblems that do not have the integrality property. Thus, we obtain an improved lower bound. We discuss the subproblem solution and show that cutting off some alternative optimal solutions improves computational efficiency.

■ MA-35

Monday, 9:00-10:20

6.2.46

Teaching Soft OR and PSMs

Stream: Soft OR and Problem Structuring Methods

Invited session

Chair: *Leroy White*, Management, University of Bristol, Social Science, 8 Woodland RD, BS8 1TN, Bristol, United Kingdom, leroy.white@bris.ac.uk

Chair: *John Mingers*, Kent Business School, Kent University, CT2 7PE, Canterbury, Kent, United Kingdom, j.mingers@kent.ac.uk

1 - Soft Systems Methodology (SSM): a reconfiguration

Ion Georgiou, IMQ, Fundação Getulio Vargas, Rua Itapeva 474 (9 andar), Bela Vista, 01332000, Sao Paulo, Sao Paulo, Brazil, iongeorgiou@gmail.com, *Maria Fernanda Mendes*

Teaching Soft Systems Methodology (SSM) is a non-trivial exercise due to a number of reasons. There is no textbook approach currently available, although illustrative case studies of varying pedagogical utility do exist. The methodology introduces elaborate conceptual novelty and technical language, although some of its tools are arguably but formalizations of decision making processes that might otherwise receive scant attention. The methodology emerged through an intricate historical and philosophical background, although one that weaved theoretical developments with perceived practical necessities. The literature presents the methodology as available in two distinct modes, although only one has received the most scholarly attention. And, perhaps most challenging of all, its inherent flexibility renders it difficult to categorize: it can be taught as an exploratory approach, a formal decision making approach, an organizational learning vehicle, and it may even be used in part, in whole, iteratively or not, and even in conjunction with other methods. Indeed, the very question of whether SSM is a methodology or a method is debatable and will influence the pedagogic approach taken. Finally, it is an approach designed to help decision makers tread through the complexity and uncertainty generated by systems of interrelated problems. Where a usual recourse in such situations is to computerized decision support systems, none are available to accompany a process led by SSM. A formal pedagogical approach to SSM will be presented. The aim is to provide teachers and trainers with the confidence to communicate the relevance of the approach in a transferable manner that students/clients can then use in their careers. The focus will be on the so-called Mode 1 of SSM, this being the one most heavily discussed in the literature. However, based on recent research, a complete reconfiguration of the structure of this Mode will be presented. As such, one novelty lies in how SSM may be understood through a new configuration, one that emphasizes decision making, but also one that emphasizes the interrelated logic between all the tools and concepts used in the methodology. In addition, a useful multimethodological input will be provided with the use of cognitive mapping in one particular part of SSM. In sum, the paper concentrates on teaching SSM as a formal decision making approach which simultaneously enables understanding of the entire methodology and its related parts. From such a foundation, the methodology's facilitative potential for exploratory and organizational learning purposes, as well as its multimethodological flexibility, can be appreciated.

2 - Teaching supporting strategy: a multimethodological perspective using 'soft' and 'hard' tools

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, Martin Kunc

The development of a course promoting the use of tools to support a strategy process is described. Tools, from a number of disciplines, including OR/MS, cover both the soft & hard spectrum & can be used either individually or in combination.

The content of the course will be presented along with how delivery differs across student groups. A noticeable feature of the course has been the development of multimethodological approaches; examples will be presented to illustrate some of the soft tools taught. The paper ends with reflections on the current challenges faced by course designers.

3 - Teaching Soft OR: Role Play Simulation and Social Learning

Leroy White, Management, University of Bristol, Social Science, 8 Woodland RD, BS8 1TN, Bristol, United Kingdom, leroy.white@bris.ac.uk

This paper describes the use of role play simulation (RPS) in teaching soft OR methods. RPS provides an opportunity for active learning. The paper will describe the use of a simulation designed for teaching soft OR and will provide reflections to show the efficacy of simulations as active learning techniques. The reflections will also provide an outline of how the knowledge of Soft OR builds on itself over time and that people learn from one another, via observation, imitation, and modelling. The process of social learning (learning from the learning of others) will be described.

4 - Can Problem Structuring Methods be taught?

Ashley Carreras, Leicester Business School, De Montfort University, Marketing, The Gateway, LE19BH, Leicester, United Kingdom, acarerras@dmu.ac.uk, Parmjit Kaur

This paper examines the idea that because the techniques included under the umbrella heading of Problems Structuring Methods might best be considered as crafts, then the most effective way for a student to understand and be able to apply such techniques is for them to experience these techniques in a real workshop as a participant. It will draw upon empirical data gathered from a series of student membership workshops carried out on behalf of the OR society at three UK universities, and the qualitative data generated in these Causal Mapping workshops.

■ MA-36

Monday, 9:00-10:20

3.1.05

Fuzzy expert systems

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence

Invited session

Chair: Heinrich Rommelfanger, Economics and Business Administration, Goethe University, Niebergallweg 16, 65824, Schwalbach a. Ts., Hessen, Germany, Rommelfanger@wiwi.uni-frankfurt.de

1 - Employer Awards: Fuzzy Ratings and Rankings

Jessica Naundorf, Department of Economics & Management, Otto-von-Guericke-University Magdeburg, Chair of Strategic Management and Organisation, P.O. Box 41 20, 39 016, Magdeburg, Germany, jessica.naundorf@ovgu.de, Thomas Spengler

The participation in employer awards has evolved into a major topic so as to be the candidate's first choice in increasing "War for Talents". Given this managerial interest, the present article discusses the aims of employer awards from the employer's viewpoint in addition to the instruments, which need to be used within the rating and ranking process regarding the "100 Best Companies to Work For". Due to vagueness, the current ratings and rankings are not applicable to mitigate the valuations of experts. Hence, fuzzy logic seems particularly suitable to model this decision-making process. The corresponding procedures are based on fuzzy sets as well as on a fuzzy rule-based expert system.

2 - Dynamics of Diffuse Information Processing: The Example of Stock Price Movements

Andreas Uphaus, Faculty of Economics and Management, Otto-von-Guericke University Magdeburg, Universitaetsplatz 2,

Chair of Empirical Economics Research, 39106, Magdeburg, Sachsen-Anhalt, Germany, auphaus@online.de, Bodo Vogt

We explore the idea that stock prices are not known exactly. Traders normally know a range of possible prices which we call range of reasonable alternatives. In former studies we have shown how to model the process for one point in time. This procedure is closely related to fuzzy intervals. Now we analyze sequences of stock prices with respect to the question how diffuse information is dealt with over several points in time. We present a model which is based on an iterated application of the Numerical Response Process over time. The model predicts price movements for short time intervals well.

3 - Operational Risk Assessment: A Fuzzy Logic Approach

Sebastian Hain, Economic and Business Administration, Goethe University Frankfurt, Seckbacher Landstr. 30, 60389, Frankfurt am Main, Hessen, Germany, shain@stud.uni-frankfurt.de, Heinrich Rommelfanger

This paper presents an integrated approach to evaluating operational risk based on a hierarchical system of risk factors. Employing a fuzzy logic expert system both quantitative and qualitative data can be aggregated to the total operational risk. The procedure is explained by the subsystem IT security. For selected risk categories the expert rule maps and the fuzzy inference process are described in detail. A numerical example illustrates the course of the fuzzy expert system using the new developed software tool Visual Fuzzy.

4 - Optimization of Fuzzy Models Obtained From Typicality and Membership Partitions

Rui Jorge Almeida, Department of Econometrics, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, rjalmeida@ese.eur.nl, Uzey Kaymak

We study how to simplify, combine and optimize the fuzzy rule-based model derived using either Fuzzy Possibilistic C-Means or Possibilistic Fuzzy C-Means algorithms, where multiple rules per cluster are extracted from both the membership partition matrix and the typicality matrix. We make use of a three-step approach to obtain fuzzy models. An initial rule-based model is obtained by product space clustering. Then we perform simplification of the fuzzy sets in the rule base and rule reduction. Finally the parameters of the model are optimized using genetic algorithms or a neuro-fuzzy system.

■ MA-37

Monday, 9:00-10:20

3.1.09

OR Applications in the Health Field

Stream: OR for Development and Developing Countries

Invited session

Chair: Habib Chabchoub, LOGIQ, Institut Supérieur de Gestion Industrielle, 3018, Sfax, Tunisia, Habib.chabchoub@fsegs.rnu.tn

Chair: Youssef Masmoudi, Sfax University, Hight School of Commerce of Sfax, BP 954, 3018, Sfax, Tunisia, youssef_m_tn@yahoo.fr

1 - Predicting cancer risk group of countries based on oecd health data 2005 - 2007

İdil Erte, Medical Informatics, METU, Orta doğu Teknik Üniversitesi, Rektörlük 6.kat, 06531, Ankara, Turkey, idilerte@gmail.com, Elif Cakir, Pinar Koseoglu, Özlem Özkan

The study aims to use classification and clustering algorithms for different health related problems and compare the results of these. This study includes discovering knowledge from OECD Health Data 2007 and 2005 which includes data related to many attributes about thirty countries all over the world such as life expectancy, tobacco usage, cancer and aids. We tried to generate a model for predicting the cancer risk levels of countries by using some attributes of training data set. The main knowledge we want to discover is "cancer risk group of the countries according to OECD Health Data 2007"

2 - Breast cancer prognosis based on Bayesian Networks

Arij Mkaouar, ENIS, 3018, Sfax, Tunisia, arij.mkaouar@yahoo.fr, Hekma Louati, Ahmed Rebai

The aim of this study is to use a database of real examples of 84 patients to model a system of prognosis of breast cancer. We have adapted for the resolution of this issue the Bayesian networks. Our network is formed of a set of medical measures corresponding to the nodes of the network. The arcs describe the relations between these measures as conditional probabilities. We used the implicit approach for the estimation of parameters. When a new case arrives, it is inserted into the network and is propagated to all nodes and arcs to obtain a final prediction of good quality.

3 - Emergency Department Performance Measures: Multi Class Queuing Networks

Jihen Jlassi, LOGIQ, 3018, Sfax, Tunisia,
jihene2000tn@yahoo.fr

Emergency department becomes a useful way to the access to hospital and it is a subject of study for many researchers. The research developed in this paper aims to improve the performance of the emergency department (ED) of Sfax Hospital by analytical method. So, a network of queues with multiple customer types is proposed. Different indicators of performance are used.

4 - The menu planning problem: a formal study and a practical study

Amine Lamine, LOGIQ, Institut Supérieur de Gestion Industrielle de Sfax, 3018, Sfax, Tunisia,
amine.lamine@yahoo.fr, *Mahdi Khemakhem*, *Habib Chabchoub*

The healthy choice of food can help people to reduce the risk of chronic diseases like heart disease, diabetes, etc. We study in this work the menu planning problem MPP which determines the appropriate composition of meal's menus. Theoretically, we present this problem as a new NP-hard optimization problem called the MD-GUBMKP which is an extension of variants of the knapsack problem KP. We propose a formulation for the MD-GUBMKP and its direct application to the MPP. Next, we show how we can, formally and practically, transform the MD-GUBMKP to the others variants of KP and inversely.

■ MA-38

Monday, 9:00-10:20
6.2.44

Experimental Economics and Game Theory

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

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Simulation Results of Nash-Cournot Equilibrium

Amnon Gonen, Management of Technology, Holon Institute of Technology - HIT, 52, Golomb St., 58102, Holon, Israel,
agonen1@gmail.com

In this study, duopoly market equilibrium is tested by a group of players using a special business simulator that was adopted specifically for this task. The results showed that the players' decisions were mainly influenced by the difference in quantities and price, rather than the actual prices and quantities, as was expected. Moreover, if the prices and quantities of both firms were quite similar, they believed they had achieved a state of equilibrium, although they were sometimes quite far from it.

2 - Analysis of Serbian development indicators and calculation of the competitiveness index

Aleksandra Marcikic, University of Novi Sad, Faculty of Economics Subotica, Mihaila Pupina 32, 24000, Subotica, Serbia, amarcikic@ef.uns.ac.rs, *Boris Radovanov*

Economic changes in most of transition countries, such as Serbia, often lead to inequality in income distribution, high inflation rate and reduction of real gross domestic product. The paper presents actual position of Serbia by quantitative analysis of basic development indicators, which is followed by comparative analysis of development factors in surrounding countries. Furthermore, factor analysis is used to create the index of competitiveness, as an integral indicator that represents influences of ten variables, and finally the position of Serbia is compared with other European countries.

3 - Global division problems with preferences

Miguel A. Hinojosa, Universidad Pablo de Olavide, Cta. Utrera s/n, 41013, Seville, Spain, mahinram@upo.es, *Amparo Mármol*, *Francisca Sanchez*

We address a multi-dimensional extension of classical division problems to situations in which several goods have to be divided simultaneously among a set of agents, and both references points for the division of each good, and preferences of the agents on the shares they obtain of the various goods, have to be taken into account.

We analyse the implications of the agents exhibiting additive preferences and also address the case in which the preferences of the agents are maximin and leximin.

4 - A Simulation Study of an Iterated Prisoners' Dilemma Experiment

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

We study the development of cooperation in a repeated prisoner's dilemma experiment with unknown length and unknown continuation probability. Players are rematched with a new team twice. We found that players use prior experience to anticipate the end of a matching. There is a dramatic restart effect. Stability of mutual cooperation crucially depends on the initial move of both players. In the simulation study we raise the question whether all the effects can be shown by simulated situations.

■ MA-39

Monday, 9:00-10:20
6.2.45

Optimal Control in Economics and Economic Demography

Stream: Optimal Control

Invited session

Chair: *Raouf Boucekkine*, Université catholique de Louvain, B-1348, Louvain-La-Neuve, Belgium, Raouf.Boucekkine@uclouvain.be

1 - Forest Management, Carbon Sequestration and Biodiversity in the Presence of Climate Change

Renan Goetz, Department of Economics, University of Girona, Campus Montilivi, s/n, 17071, Girona, Spain, renan.goetz@udg.edu, *Natali Hritonenko*, *Rubén Javier Mur Torrentó*, *Yuri Yatsenko*, *Àngels Xabadia*

This paper determines the optimal forest management for timber and carbon sequestration in the presence of climatic changes. It does not only focus on mitigation costs for carbon sequestration but also includes the cost and benefits of adaption of the management regime to climate change. Furthermore, the paper compares the flow method and the rental value approach for the valuation of carbon sequestration. It shows that they are only equivalent under very specific conditions. Finally, the paper determines the optimal forest management regime if biodiversity is also considered as an objective.

2 - Optimal Population Problem and endogenous Growth: Re-assessing the Parfits repugnant Conclusion

Giorgio Fabbri, Department of Economic Studies, University of Naples "Parthenope", Via Medina 40, 80133, Napoli, Italy, giorgio.fabbri@uniparthenope.it, *Raouf Boucekkine*, *David de la Croix*

Recently some authors have tried to evaluate Parfit's repugnant conclusion within a neoclassical growth model (see Arrow et al., 2009). Here we consider an AK model with a broad concept of capital. A planner maximizes a social welfare function depending on consumption per capita and population size. In this framework, we characterize optimal population dynamics and optimal consumption per capita paths. Parfit's repugnant conclusion is shown to arise under some precise conditions on the preference and technological parameters of the model.

3 - Spatial dynamics and convergence: The spatial AK model

Carmen Camacho, Economics Department, Université catholique de Louvain, Place Montesquieu 3, 1348, Louvain la Neuve,

Belgium, carmen.camacho@uclouvain.be, Raouf Boucekkine, Giorgio Fabbri

We study the optimal dynamics of an AK economy where population is uniformly distributed along the unit circle. Locations only differ in initial capital endowments. Despite constant returns to capital, we prove that transition dynamics will set in. In particular, we prove that the spatio-temporal dynamics, induced by the willingness of the planner to give the same (detrended) consumption over space and time, lead to convergence in the level of capital across locations in the long-run.

4 - Happiness due to Consumption and its Increases, Wealth and Status

Andreas Novak, Business Administration, Bruennerstrasse 72, A-1210, Vienna, andreas.novak@univie.ac.at, Franz Wirl

This paper departs from the standard open-economy Ramsey model and introduces additional concerns for wealth, status and Easterlin's hypothesis that consumption changes, in particular increases, are important and not only the level. These extensions induce first of all interior steady states, multiple steady states and limit cycles. Surprisingly, introducing status conferred by private wealth or conspicuous consumption has no effect despite the involved externalities as long as the social influence associated with the status externalities remains moderate.

■ MA-40

Monday, 9:00-10:20
6.2.52

Wireless and sensor networks

Stream: Network Optimization

Invited session

Chair: Bernard Fortz, Département d'Informatique, Université Libre de Bruxelles, CP 210/01, Bld du Triomphe, 1050, Bruxelles, Belgium, bfortz@euro-online.org

1 - Stochastic Second Order Cone Programming in Mobile ad hoc networks

Francesca Maggioni, Dept. of Mathematics, Statistics, Computer Science and Applications, University of Bergamo, Via dei Caniana n. 2, 24127, Bergamo, Italy, Italy, francesca.maggioni@unibg.it, Florian Potra, Marida Bertocchi, Elisabetta Allevi

We propose a two-stage stochastic second-order cone formulation of a stochastic location-aided routing (SLAR) model for mobile ad-hoc network. The aim is to provide a sender node S , with an algorithm for optimally determining a region that contain a destination node D . The movements of D are given by random ellipsoid scenarios. A stochastic second order cone model allows to solve problems with a much larger number of scenarios (20250) than is possible with semidefinite models (500). Sensitivity analysis to reveal the stochasticity is included.

2 - Exact models for the k-connected wireless survivable network problem

Christina Burt, Mathematics and Statistics, University of Melbourne, 139 Barry St, 3053, Carlton, Victoria, Australia, c.burt@ms.unimelb.edu.au, Yao-ban Chan

Survivable wired networks have been extensively studied up to 2-connected. More recently, 1-connected wireless networks have been addressed, but k-connected networks remain an open problem.

We prove that, in contrast to the wired case, the minimum transmission k-connected optimisation problem is NP-hard even for $k = 1$.

We construct a multi-commodity flow model, making use of preprocessing and valid inequalities from the literature; and develop a new warm start heuristic to improve computation time.

3 - Sensor Network Lifetime Maximization with Mobile Sink Routing

M. Emre Keskin, Industrial Engineering, Bogazici University, Bogazici Universitesi Endustri Muhendisligi, Hisarustu / Besiktas, 34470, Istanbul, Turkey, m.emre.keskin@gmail.com, I. Kuban Altinel, Necati Aras, Cem Ersoy

It is a known phenomenon of the WSNs that the sensors located near to the sink deplete their energies faster than the rest of the network. This causes the sink to be disconnected from the rest of the network while most of the sensors are still functional. To remedy this weakness, moving the sink toward different regions of the network area can be offered. In this study, we attempt to find an optimal path for the sink with and without optimal data flow decisions in order to maximize the network lifetime. We also take sink travel time and the data accumulated during that time into consideration.

■ MA-41

Monday, 9:00-10:20
3.1.06

Recent Advances in Revenue Management

Stream: Revenue Management

Invited session

Chair: Joern Meissner, Management Science, Lancaster University Management School, Room A48, LA14YX, Lancaster, United Kingdom, j.meissner@lancaster.ac.uk

1 - Decomposition Techniques in Large-Scale Network Revenue Optimization

Arne Karsten Strauss, Management Science, Lancaster University Management School, Lancaster, LA1 4YX, Lancaster, United Kingdom, a.strauss@lancaster.ac.uk

Many service providers need to optimize the availability of products over a large network of resources. A heuristic solution approach is to somehow decompose the network optimization problem into a collection of small problems corresponding to the individual resources. However, most recent approaches are tested only on very small problems (<10 resources) and appear too slow to be applied to large-scale problems. In this research project, I develop and test a new decomposition scheme on real data of large-scale flight networks in collaboration with the R&D team at Lufthansa Systems.

2 - Expected future value decomposition based bid price generation for large-scale network revenue management

Dolores Romero Morales, Said Business School, University of Oxford, Park End Street, OX1 1HP, Oxford, United Kingdom, dolores.romero-morales@sbs.ox.ac.uk, Laureano Fernando Escudero, Juan Francisco Monge, Jingbo Wang

We apply the stochastic dynamic programming approach to the network revenue management problem, where the so-called Expected Future Value (EFV) curves estimate the impact of the decisions made at a given stage on the objective function value related to the future stages. Because of the EFV approach, we can define bid prices for combination of resources directly, generating non-linear bid prices, as opposed to the more restrictive additive bid prices. We will show numerical results illustrating that we can solve large-scale problem instances very efficiently.

3 - A revenue management policy for railway container transportation

Ioana Bilegan, LAMIH-DIM, University of Valenciennes, Université de Valenciennes, ISTV2, Le Mont Houy, 59313, Valenciennes, France, ioana.bilegan@univ-valenciennes.fr, Luce Brotcorne, Dominique Feillet, Yezekael Hayel

We consider a container railway transportation network functioning on a reservation system basis. Each punctual demand has to be accepted or rejected, with respect to the expected revenue estimated over a certain time period. The approach proposed to make the accept/reject decision is based on a revenue management policy. For each punctual demand, estimations of future demands are taken into account, within a well-defined time window, and a probabilistic mathematical program is solved. Extensive simulation results, for different demand profiles and different types of network are presented.

4 - Improved Bid Prices for Choice-Based Network Revenue Management

Joern Meissner, Management Science, Lancaster University Management School, Room A48, LA14YX, Lancaster, United Kingdom, j.meissner@lancaster.ac.uk, Arne Karsten Strauss

In many implemented network revenue management systems, a bid price control is being used. Yet it is still unknown how well a bid price control actually performs. We propose a simple and fast heuristic that iteratively improves on an initial guess for the bid price vector. We demonstrate that using these dynamic marginal capacity values directly as bid prices can lead to significant revenue loss as compared to using our heuristic. Finally, we investigate numerically how much revenue performance is lost due to the confinement of product combinations that can be represented by a bid price.

■ MA-42

Monday, 9:00-10:20

3.1.07

Bilevel Programming

Stream: Variational Inequalities, Complementarity Problems and Bilevel Programming

Invited session

Chair: *Stephan Dempe*, Mathematics and Computer Sciences, Technische Universität Freiberg, 09596, Freiberg, Germany, dempe@math.tu-freiberg.de

1 - An improved exact method for the discrete (r, p)-centroid problem

Yury Kochetov, Information Technology Department, Novosibirsk State University, Pirogova str., 2, 630090, Novosibirsk, Russian Federation, jkochet@math.nsc.ru,
Ekaterina Alekseeva, Nina Kochetova, Alexander Plyasunov

In the discrete (r, p)-centroid problem two decision makers, a leader and a follower, compete to attract clients from a given market. The decision makers try to maximize their own profits. So, we deal with a noncooperative Stackelberg game. We present the game as a mixed integer linear program with a large number of constraints and variables. An exact iterative method based on the column generation technique is proposed. A feasibility problem is solved in each iteration by metaheuristics. Computational results for benchmarks from the library "Discrete Location Problems" are discussed.

2 - Interval uncertainty in the context of bilevel fractional programs

Carmen Galé, Métodos Estadísticos, Universidad de Zaragoza, CPS, Edificio Torres Quevedo, María de Luna,3, 50015, Zaragoza, Spain, cgale@unizar.es, *Herminia I. Calvete*

This work focuses on linear fractional bilevel programming problems in which the coefficients are only approximately known. In particular, the proposed approach considers that the coefficients of the problem are specified as intervals. We analyze methods that find the best optimum and the worst optimum, as well as the coefficient settings which achieve these two extremes. The range of the upper level objective function between the best and the worst optima gives an insight into the possible results and the risk involved in the decision process.

3 - Resolution of bilevel problems using Inexact Restoration

Ana Friedlander, Applied Mathematics, Institute of Mathematics, Statistics and Scientific Computing, Rua Sergio Buarque de Holanda 651, Cidade Universitária, 13083859, Campinas, São Paulo, Brazil, friedlan@ime.unicamp.br

Inexact restoration methods are used in general nonlinear programming problems. Their appeal is greatly due to the freedom of choice of the algorithms that can be used to solve the subproblems defined in a typical iteration. Bilevel programming problems present characteristics that suggest situations when this approach could be promising. In this presentation we discuss this topic and present examples. Theory and practice will be commented.

■ MA-43

Monday, 9:00-10:20

8.2.02

Algorithmic Decision Theory 1

Stream: Algorithmic Decision Theory

Invited session

Chair: *Ulrich Junker*, ILOG, An IBM Company, 1681, route des Dolines, 06560, Valbonne, France, uli.junker@free.fr

1 - A calibration-based approach to combine experts prior information

María Jesús Rufo Bazaga, Mathematics, University of Extremadura, Avda de la Universidad s/n, 10071, Cáceres, Spain, mrufo@unex.es, *Carlos Javier Pérez Sánchez, Jacinto Martín*

This work proposes a Bayesian approach based on a log-linear pooling to aggregate experts' information. It uses an expected Kullback-Leibler divergence to obtain the weights in the combined prior distribution. Specifically, the combined prior distribution that minimizes the expectation with respect to the corresponding predictive prior distribution is found. Therefore, a pooled prior distribution is achieved for which the expected calibration is the best one. This proposal is based on a criterion that can be used as calibration tool when subjective prior distributions are used. This approach can be used in several decision making contexts as it is shown with an illustrative application.

2 - Scaling Invariance and a Characterization of Linear Objective Functions

Sasa Pekec, Fuqua School of Business, Duke University, 1 Towerview Road, 27708-0120, Durham, NC, United States, pekec@duke.edu

A decision-maker who aims to select the "best" collection of alternatives from the finite set of available ones might be severely restricted in the design of the selection method. If the representation of valuations of available alternatives is available to linear scaling, such as the choice of the unit of measurement, the only sensible way to compare choices is to compare weighted sums of individual valuations corresponding to these choices. This scaling invariance also provides a characterization of linear 0-1 programming objective functions. The problem of finding an optimal subset of available data to be aggregated, allowing for use of different aggregation methods for different subsets of data, is also addressed.

3 - Invariants of Decision Problems and impacts onto methods

Alexis Tsoukiàs, CNRS - LAMSADE, Université Paris Dauphine, 75775, Paris Cedex 16, France, tsoukias@lamsade.dauphine.fr, *Alberto Colomi, Wassila Ouerdane*

In this presentation we continue the exploration of "what is a decision problem". We generalise the concepts of optimisation and constraint satisfaction and we then discuss the problem generated by the presence of multi-dimensional information (multiple stakeholders, multiple states of the nature, multiple criteria). In the presentation we explore the general problem where independence among such dimensions is not set. Among the possible uses of such an analysis we focus on the problem of constructing explanations and justifications for the end user of the model using argumentation theory.

4 - Effects of hierarchical weighting in preference programming

Jyri Mustajoki, Department of Automation Science and Engineering, Tampere University of Technology, P.O.Box 692, 33101, Tampere, Finland, jyri.mustajoki@tut.fi

Preference programming is an approach to incorporate imprecision in multi-attribute value trees with interval judgments. We study how the hierarchical model structure affects the overall imprecision in the results, and in which level of the hierarchy it is most efficient to give more precise judgments. The aim is to find out good practices for carrying out the weighting process in practice. The simulation experiment provides theoretical results, which are discussed with respect to practical issues. The results suggest paying attention to increasing precision in the lower level judgments.

■ MA-44

Monday, 9:00-10:20

8.2.03

Portfolio Decision Analysis I

Stream: Portfolio Decision Analysis

Invited session

Chair: *Juuso Liesiö*, Systems Analysis Laboratory, Aalto University, P.O.Box 11100, 00076Aalto, Espoo, Finland, juuso.liesio@tkk.fi

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@tkk.fi

1 - A PROMETHEE-based approach to portfolio selection problems

Rudolf Vetschera, Dept. of Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, rudolf.vetschera@univie.ac.at, *Adiel Teixeira de Almeida*

Multi-attribute decision methods like PROMETHEE cannot be directly applied to portfolio selection problems because they require pairwise comparisons of alternatives and the number of potential portfolios is usually huge. We introduce a simplified approach to portfolio selection based on PROMETHEE net flows of individual items rather than portfolios. We develop an equivalence theorem for mathematical programming formulations of the problem and present results of a computational study comparing our approach to a PROMETHEE ranking of portfolios, which shows very promising results.

2 - Optimal revision of uncertain estimates in project portfolio selection

Eeva Vilkkumaa, Department of mathematics and systems analysis, Aalto University, School of science and technology, Systems analysis laboratory, Aalto University, P.O.Box 11100, 00076 Aalt, Espoo, Finland, eeva.vilkkumaa@tkk.fi, *Juuso Liesiö*, *Ahti Salo*

Organizations typically select projects based on uncertain point estimates about the projects' future values. In this paper, we analyze how the explicit consideration of uncertainties in these estimates helps improve decision quality. Specifically, we develop a Bayesian adjustment approach where the sum of revised estimates for the selected projects will, on average, coincide with that of the projects' actual values. Decisions based on adjusted estimates are also shown to yield a higher expected portfolio value and a greater number of correctly selected projects.

3 - Measurable Multiattribute Value Functions for Project Portfolio Selection and Resource Allocation

Juuso Liesiö, Systems Analysis Laboratory, Aalto University, P.O.Box 11100, 00076Aalto, Espoo, Finland, juuso.liesio@tkk.fi

The linear-additive value model (i.e. portfolio value is the sum of additive multi-attribute project values) is widely employed to support multiobjective project portfolio selection. Motivated by empirical evidence, we relax the assumption of mutually preference independent projects underlying the additive-linear model and derive corresponding multilinear value models. We show that the elicitation of a multilinear value function can be decomposed into scoring each project with regard to each attribute and develop optimization models to maximize portfolio value subject to resources constraints.

4 - Comparison of two approaches for evaluating a portfolio of R&D projects with a budget

Anabela Costa, Quantitative Methods, ISCTE - Instituto Universitário de Lisboa, Av. das Forças Armadas, 1649-026, Lisboa, Portugal, anabela.costa@iscte.pt, *José Paixão*

The Real Options approach has proved to be a suitable methodology for the financial evaluation of R&D projects since it captures the value of flexibility in R&D projects. Based on a dynamic programming model, presented in the literature, we present two approaches to valuing a portfolio of R&D projects with a budget: one approach makes an extension of the model above mentioned, and the other one, estimates the value of the projects by simulation. Computational experiments are discussed.

■ MA-45

Monday, 9:00-10:20
8.2.12

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

Chair: *Moshe Sniedovich*, Dept. of Mathematics and Statistics, University of Melbourne, Parkville, 3010, Melbourne, Victoria, Australia, m.sniedovich@ms.unimelb.edu.au

1 - Operational optimization as a part of a bi-level optimization problem

Mikko Linnala, Department of Physics and Mathematics, University of Eastern Finland, Yliopistoranta 1 F, 70210, Kuopio, Finland, mikko.linnala@uef.fi

A bi-level optimization problem covering design and operational levels is defined. The problem is solved using dynamic multiobjective optimization, i.e. values of state and control variables change over a time horizon, and competing criteria are optimized simultaneously. Moreover, interaction between the design and operational levels is analyzed. Benefits of bi-level dynamic multiobjective optimization are illustrated by giving an operational optimization example of a paper mill in which process design is optimized simultaneously in order to maintain efficiency of the mill.

2 - Dynamic Programming Approach for Arrivals Scheduling at Heathrow Airport

Stanislava Armstrong, School of Computer Science & IT, The University of Nottingham, Jubilee campus, Wollaton rd, NG8 1BB, Nottingham, Nottinghamshire, United Kingdom, saw@cs.nott.ac.uk, *Jason Atkin*, *Edmund Burke*

Busy airports experience periods when demand exceeds runway capacity, which leads to an accumulation of aircraft circling in nearby stacks. This could cause delays that can adversely affect ground resource utilisation and may have implications for connecting flights. An accurate estimation of landing times could contribute to better resource allocation and time management. The arrival stacks can limit the possible landing sequences. Their effects upon the sequences and on the delays will be shown and potential benefits from operating mode changes will be detailed.

3 - Dynamic and group decision-making model for optimal management of natural resources

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

Sustainable management of natural resources requires not only satisfying specified sustainability criteria, but also the perception of these criteria by the various segments of society, and involves a long-term perspective. We generated a dynamic, multi-criteria model involving several decision-makers to address these issues. Specifically, our model is based on a network which presents a Bellman multi-stage iterative decision process, and a DEA and weighted geometric mean method modified ANP for deriving a group priority at each stage of the process. An application of the model is presented.

4 - Lot-sizing model with dynamic safety inventories

Jinhua Zheng, Maritime Technology and Logistics, Tokyo University of Marine Science and Technology, Tokyo University of Marine Science and Technology, 4-5-7, Konan, Minato-ku, Tokyo, Japan, 108-8477, Tokyo, Japan, jinhua@logopt.com, *Mikio Kubo*

In this paper we introduce an extended model of the classical lot-sizing model in which demand parameters are stochastic. One characteristic of our model is to determine lot-sizes and safety stocks simultaneously. We develop a new dynamic programming algorithm for the single item uncapacitated model, and prove an extended planning horizon theorem that accelerates the dynamic programming algorithm. Numerical experiments suggest the efficacy of the proposed algorithm and the extended planning horizon theorem.

■ MA-46

Monday, 9:00-10:20
8.2.14

OR Challenges Related to the Recent and Future Disasters I

Stream: OR for Madeira (and related challenges)

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - A model for high-speed railway planning optimization considering risk analysis and management

Ana Costa, Civil Engineering, University of Coimbra, Rua Luís Reis Santos, Polo II da UC, 3030 - 788, Coimbra, Coimbra, Portugal, alcosta@dec.uc.pt, Maria Cunha, Paulo Coelho

Planning of High-Speed Railways must consider multiple and uncertain future conditions under which to perform (e.g. floodings, earthquakes). Options in corridors and technical solutions to adopt exist and different solutions may yield different overall performance. This paper discusses the main issues to consider in developing a systematic tool to support the decision process with risk analysis and management through scenario descriptions of uncertainty. A methodology for alignment optimization using Simulated Annealing is proposed and an overview of obtainable results is presented.

2 - Infrastructures in Natural Disasters

Huey-Kuo Chen, Civil Engineering, National Central University, No. 300, Jung-Da Road, 320, Chung-Li City, Taoyuan, Taiwan, ncutone@ncu.edu.tw

When a natural disaster occurs, the transportation infrastructures in the affected area are often seriously damaged. The fatalities and property losses will get worsened if the damaged transportation infrastructures cannot be repaired in a reasonable time. We address the task of repairing damaged infrastructure as the real-time vehicle routing problem with time windows that is repetitively solved in a time rolling frame. The results show that the proposed solution metaheuristic is comparable to Wang et al. (2008) but the idea of our heuristic is more to our intuition.

3 - Emergency Transportation Decisions for the Post-Disaster Istanbul Earthquake Case

Emin Ahmet Tanrioven, Industrial Engineering, Graduate School of Science and Engineering, Koc University, Rumeli Feneri Yolu, 34450, Sariyer, Istanbul, Turkey, etanrioven@ku.edu.tr, Sibel Salman, Esma Gel

This study develops a decision support tool for dispatching ambulances and transporting casualties to hospitals or temporary emergency units in a mass-casualty incident. Specifically, post-earthquake case for six crowded districts in Istanbul is studied. The ambulance dispatching problem is inherently large scale in the context of disaster response, with a surge in transportation needs that changes over time in the post-disaster time frame. Dispatching strategies are studied while considering injury types of patients and fairness among six districts in a dynamic and stochastic environment.

4 - Emergency medical systems: a stochastic generalized assignment case study

Susana Baptista, CMA, FCT - UNL, Campus de Caparica, 2829-516, Caparica, Portugal, sbb@fct.unl.pt

The assignment problem in an emergency ambulance system can be formulated as a stochastic on-line generalized assignment problem: an ambulance must be assigned to a service request as soon as its location is known, service time and assignment costs are stochastic, and workshift final time should not be exceeded. In order to evaluate solutions found by alternative assignment rules of ambulances belonging to the National Institute for Medical Emergency and serving the city of Lisbon, off-line solutions are obtained using a scenario analysis approach and applying a stochastic recourse model.

■ MA-47

Monday, 9:00-10:20

8.2.16

Various Aspects of Sustainable Living in Developing Countries

Stream: Sustainable Living: Cognitive, Social, Economical, Ecological and World View

Invited session

Chair: *Pedamallu Chandra Sekhar*, Department of Medical Oncology, Dana-Farber Cancer Institute, Boston, 02115, Ipswich, MA, United States, pcs.murali@gmail.com

Chair: *Ali Gökmen*, Department of Chemistry, Middle East Technical University, 06531, Ankara, Turkey, agokmen@metu.edu.tr

Chair: *Inci Gokmen*, Chemistry, Middle East Technical University, METU Department of Chemistry, 06531, Ankara, Turkey, igokmen@metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Canan Pehlivan*, Industrial Engineering, Hacettepe University, Beytepe Campus, 06800, Ankara, Turkey, cananp@hacettepe.edu.tr

1 - Maximum entropy in land use change - a methodology for an urban sustainability model

Daniel Zachary, CRTE, CRP Henri Tudor, 66, rue de Luxembourg, L-4421, Esch sur Alzette, Luxembourg, dan.zachary@tudor.lu

This paper explores the use of informational entropy as a guide to land use selection for urban and regional planning. The Maximum Entropy Allocation Land Use model (METALU) is constructed around the paradigm that cost can be represented in terms of available energy and land use choice as populated states. These analogies have allowed for the formulation of a planning model to be describe in terms of Boltzmann statistics and state population properties have been exploited using the concept of maximum entropy.

2 - Incentives of no-lose targets for developing countries

Vicki Duscha, Fraunhofer Institute, Germany, v.duscha@isi.fraunhofer.de

For an international environmental agreement to be effective industrialized as well as developing countries like China and India need to agree to significant emission reductions. One idea to integrate developing countries are no-lose targets. Three factors directly affect the emission reduction incentive of a no-lose target: the target setting, the price for emission allowances and the costs for emission reductions. The price for emission allowances and the costs for emission reductions are highly influenced by future technology development which is, however, extremely uncertain.

3 - A location-routing problem for the municipal solid waste management system

Canan Pehlivan, Industrial Engineering, Hacettepe University, Beytepe Campus, 06800, Ankara, Turkey, cananp@hacettepe.edu.tr, *Sedef Meral, Can Ayanoglu*

This study deals with a municipal solid waste management system in which the strategic and tactical decisions are addressed simultaneously. We formulate this system as a location-routing problem with two facility layers. Mathematical models are presented, an iterative capacitated-k-medoids clustering-based heuristics proposed and a sequential clustering-based method is presented. We apply the clustering-based algorithm to a real life application. Our algorithm developed gives consistent results within acceptable running time.

■ MA-48

Monday, 9:00-10:20

8.2.04

III-posed Variational Problems I

Stream: III-posed Variational Problems - Theory, Methods and Applications

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Proximal Auxiliary Problem Principle with Logarithmic-Quadratic Functions for Solving Variational Inequalities

Christina Jager, Mathematics, University of Trier, Universitätsring 15, 54286, Trier, Germany, christina.jager@uni-trier.de

Variational inequalities with operators that are the sum of a maximal monotone, set-valued operator and a single-valued, continuous operator are considered. Our solution scheme extends the auxiliary problem principle by using a logarithmic-quadratic regularization function that provides an interior point effect. Operator approximations and an inexact solving of the auxiliary problems are allowed. Convergence is proved under mild assumptions and numerical examples with nonsmooth optimization problems are given where a bundle technique is used to approximate the set-valued part of the operator.

2 - The exponent of Hölder calmness for level sets of polynomials

Jan Heerda, Institut für Mathematik, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099, Berlin, Germany, janjh@math.hu-berlin.de

Hölder calmness is a tool to describe stability of constraint set mappings. Hoffman error bounds yield proper calmness for systems of affine functions. Using the Hörmander-Lojasiewicz inequality Luo/Luo and Luo/Pang showed Hölder calmness for systems of polynomials and even analytic functions. But this result is based on the Tarski-Seidenberg principle, so one only has existence of some exponent for Hölder calmness. Here we show that for one quadratic polynomial the exponent is one-half. Also some further relations between polynomial degree and exponent of Hölder calmness will be given.

3 - On the cutting plane property and the Bregman Proximal Point Algorithm

Nils Langenberg, FB IV - Mathematik, Universität Trier, Universitätsring, 54286, Trier, Germany, langenberg@uni-trier.de

The well-known Bregman PPA for variational inequalities is studied. Under the assumption of the cutting plane property (CPP, e.g. paramonotonicity) a constrained ill-posed problem can efficiently be solved by means of well-posed unconstrained subproblems. Motivated by the fact that the CPP fails to hold in saddle problems and Nash games, we deal with the method's behaviour for problems without the CPP.

We show that if the generated sequence is convergent, then its limit is a solution and give a large class of (nonlinearly constrained) feasible sets for which the sequence indeed converges.

Monday, 10:40-12h00

■ MB-01

Monday, 10:40-12h00

Aula Magna

Keynote Talk 2

Stream: Keynote Speakers

Invited session

Chair: *Gerhard J. Woeginger*, Department of Mathematics and Computer Science, Eindhoven University of Technology, 5600 MB, Eindhoven, Netherlands, gwoegi@win.tue.nl

1 - The combinatorics of Social Choice

Noga Alon, Tel Aviv University, Israel, nogaa@post.tau.ac.il

The early work of Condorcet in the 18th century, and that of Arrow and others in the 20th century, revealed the complex and interesting mathematical problems that arise in the theory of Social Choice, showing that the simple process of voting leads to strikingly counter-intuitive paradoxes. I will describe some of these, focusing on several recent intriguing examples whose analysis combine combinatorial and probabilistic ideas with techniques from Discrete Optimization and the theory of the VC dimension of range spaces.

■ MB-02

Monday, 10:40-12h00

3.2.14

Advanced Combinatorial Optimization 1

Stream: Combinatorial Optimization

Invited session

Chair: *Paolo Toth*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

1 - On the Geometry of Lift-and-Project

Egon Balas, GSIA, Carnegie Mellon University, Pittsburgh, PA, United States, eb17@andrew.cmu.edu

We give geometric interpretations to several aspects of the lift-and-project procedure executed on the LP simplex tableau. They are meant to deepen our understanding of the procedure and to explain how and why the procedure works.

2 - A New Lagrangean Based Branch and Bound Algorithm for the 0-1 Knapsack Problem

Cid de Souza, Institute of Computing, University of Campinas, Cidade Universitária, Barão Geraldo, Caixa Postal 6176, 13083-970, Campinas, São Paulo, Brazil, cid@ic.unicamp.br, *Alexandre Cunha, Laura Bahiense, Abílio Lucena*

This paper describes a new Branch and Bound algorithm for the 0-1 Knapsack Problem (KP). The algorithm is based on the use of a Lagrangean Relax-and-Cut procedure that allows exponentially many Fractional Gomory Cuts and Extended Cover Inequalities to be candidates to Lagrangean dualization. In doing so, the upper bounds thus obtained are stronger than the standard Linear Programming relaxation bound for KP. The algorithm is aimed at solving instances with coefficients as large as 1015, a class of KP instance for which existing solution algorithms might not be directly applicable.

3 - Local search inequalities

Paolo Serafini, Dept. of Mathematics and Computer Science, University of Udine, Via delle Scienze 206, 33100, Udine, Italy, serafini@dimi.uniud.it, *Giuseppe Lancia, Franca Rinaldi*

We describe a general method for deriving new inequalities for integer programming formulations of combinatorial optimization problems. The inequalities, motivated by local search algorithms, are valid for all optimal solutions but not necessarily for all feasible solutions. These local search inequalities can help in either pruning the search tree at some nodes or in improving the bound of the LP relaxations. In particular we apply this idea to the TSP and to the max-cut problems.

4 - An Exact Method for the Multi-Trip Vehicle Routing Problem

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, *Roberto Roberti*, *Paolo Toth*

The Multi-Trip Vehicle Routing Problem (MTVRP) is an extension of the Capacitated Vehicle Routing Problem where vehicles are allowed to perform more routes during the working period.

To our knowledge, only heuristic algorithms but none exact methods have been proposed for the MTVRP so far. We present an exact method based on two different set partitioning formulations of the problem and a sequence of bounding procedures.

The computational results show that benchmark instances with up to 120 customers can be consistently solved to optimality within acceptable computing times.

■ MB-03

Monday, 10:40-12h00

3.2.15

VRP

Stream: Metaheuristics

Invited session

Chair: *Sandra Ulrich Ngueveu*, LOSI (Laboratory of Industrial Systems Optimization), University of Technology of Troyes, 12, rue Marie Curie, 10010, Troyes, France, sandra_ulrich.ngueveu@utt.fr

1 - A Genetic Algorithm for Capacitated Vehicle Routing Problem

Lai-Soon Lee, Laboratory of Applied and Computational Statistics, Universiti Putra Malaysia, Institute for Mathematical Research, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia, lee@math.upm.edu.my, *Habibeh Nazif*, *Hsin-Vonn Seow*

A genetic algorithm is proposed for capacitated vehicle routing problem. The proposed algorithm uses an optimised crossover operator designed by a complete undirected bipartite graph to find an optimal set of delivery routes satisfying the requirements and giving minimal total cost. The algorithm is tested with benchmark instances and compared it with other known heuristics in the literature. Computational results showed that the proposed algorithm is competitive in terms of the quality of the solutions found.

2 - A novel decoding algorithm to solve Vehicle Routing Problem by Particle Swarm Optimization

Babak Farhang Moghaddam, Industrial Engineering, Islamic Azad University -parand branch, no.131- mokhberi st.- satari st.- Tehran - Iran, 1447174646, Tehran, Tehran, Iran, Islamic Republic Of, farhang@iust.ac.ir, *Seyed jafar Sadjadi*, *Elham Farhash*

In this paper, A Particle Swarm Optimization (PSO) approach is applied to solve the CVRP. Since PSO solves the problems with continues variables and VRP is a mix-integer problem, a decoding method is needed to apply PSO for VRP. In this way, designing an effective decoding algorithm can empower the PSO. So we develop a novel decoding method for interpreting PSO solutions to VRP. Also, some heuristic methods are used as local search to have better solution. This fact is demonstrated by comparing PSO with the optimal solution. Furthermore, our PSO results are compared with some other methods in the literature.

3 - A GRASP ELS Metaheuristic for the Vehicle Routing Problem with Conflicts

Khaoula Hamdi, ROSAS, UTT, 12 rue Marie Curie, 10010, Troyes, France, khaoula.hamdi@utt.fr, *Labadi Nacima*, *Alice Yalaoui*

The Vehicle Routing Problem (VRP) is a classical problem for which several exact and approximation methods were proposed. In real life applications, such as in Hazardous Material transportation, transported items may be incompatible. This variant of routing problems represents a new problem for which only few algorithms have been developed. In a previous work we introduced the mathematical model and proposed some heuristics and an Iterated Local Search to resolve the Vehicle Routing Problem with Conflicts (VRPC). In this study a hybrid GRASP-ELS is designed to improve the previous results.

4 - A new GRASPxELS approach to solve Vehicle Routing Problems with Backhauls

Raksmey Phan, LIMOS, Université Blaise Pascal, Complexe scientifique des Cézeaux, 63173, Aubière, France, phan@poste.isima.fr, *Christophe Duhamel*, *Philippe Lacomme*

The Vehicle Routing Problem with Backhaul is a classical extension of the VRP where two types of customers are considered: linehauls and backhauls. On each route, linehauls have to be served before the backhauls. Several efficient ways to solve this problem have been proposed recently: tabu search, LNS and MACS. We propose a hybrid metaheuristic scheme called GRASPxELS. Two search spaces are used alternatively: the giant trip space and the VRP tour space. The numerical results show that GRASPxELS outperforms both three methods in the same experimental context.

■ MB-04

Monday, 10:40-12h00

3.2.13

Scheduling with metaheuristics (2)

Stream: Metaheuristics

Invited session

Chair: *André Rossi*, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr

Chair: *Marcin Siepak*, Institute of Informatics, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370, Wroclaw, Poland, marcin.siepak@pwr.wroc.pl

1 - A scatter search method for uncertain P||Cmax problem with interval processing times

Marcin Siepak, Institute of Informatics, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370, Wroclaw, Poland, marcin.siepak@pwr.wroc.pl, *Jerzy Jozefczyk*

It is assumed that processing times for P||Cmax problem are not known a priori, but they belong to intervals of known bounds. The worst-case absolute regret is used to evaluate resulting uncertain problem. The deterministic counterpart is NP-hard. Moreover, no approximate algorithm is possible to develop for the uncertain case. Therefore, an heuristic solution algorithm, based on scatter search, is applied. It is compared with another heuristic algorithm based on LPT and middle values of uncertain processing times as well as with B&B based exact algorithm which is proposed for small instances.

2 - A Multi Period Model for Multi-Stage Multi-Product Production Planning with Random Yield and Compressible Processing Time

A. Soudi, IE, IUST, Narmak, 1684613114, Tehran, Tehran, Iran, Islamic Republic Of, asie_soudi@ind.iust.ac.ir, *M.b. Aryanezhad*, *M. Karimi-Nasab*

This paper discusses about imperfect production planning in the case of process compressibility for each product type at each production stage in every planning period. Each product type should pass a series of sequential production stages and due to process imperfectness, after each production stage a 100% inspection is carried out to screen defective items from non-defectives. As the rework is not allowed at all, defective items are scrapped. On the other hand, in the presence of random yield, production plans are unreliable rather than perfect yield. Consequently, we encounter with more numbers of shortage times. The production manager aims at minimizing total costs of setups, production, finished items inventory holding, work-in-process inventory holding, shortages (in the term of backorders) for a set of product types over a finite number of planning periods under given constraints. The problem is formulated and analyzed via mathematical modeling and the model is solved on a set of random test problems by particle swarm optimization (PSO). Computational experiences report that the PSO and the model together lead to better solutions in a reasonable CPU time than other previous approaches.

3 - Lot Sizing Problem with Production Compressibility for Deteriorating Items

A.h. Ebrahimian, Industrial Engineering, Islamic Azad University, no. 61, Mir-Emad st., Beheshti ave., 1587853539, Tehran, Tehran, Iran, Islamic Republic Of,

brahimian_amirh@yahoo.com, *M.b. Aryanezhad, Seyed Mohammad Ghoreyshi, M. Karimi-Nasab, E. Noorollahi*

Real life production planning is involved in considering many complicating factors. In this paper a new mathematical analysis is investigated for determining optimal production-inventory policies in the case of dealing with multiple deteriorating products with dynamic demands. The deterioration of each product type occurs at a randomly distributed rate. Production rates for each product type are decision variables, such that process compressibility is assumed to be existed. In other words, there is a time/cost trade-off in producing each product type, where mathematical function has been used to show the relation between time and cost of production. A new particle swarm optimization (PSO) algorithm is developed based on the problem's structure for obtaining near-optimal solution of the problem by considering the proved theorems. The proposed approach is run on a set of random test problem. The results are then compared with Lingo 8.0 for small size instances. Computational experiences show that both the model and the PSO algorithm have excellent performance even in the worst cases. This is illustrated via finding the best tuning relations for different parts of the PSO algorithm by using design of experiments' techniques.

4 - A Meta-heuristic Approach for the Design and Scheduling of Multipurpose Batch Plants - An exploratory study

Nelson Chibeles-Martins, Dep. de Matemática, FCT, FCT-UNL, Quinta da Torre, 2829-516, CAPARICA, Portugal, npm@fct.unl.pt, *Tânia Pinto_Varela, Ana Paula Barbósa-Póvoa, Augusto Novais*

Multipurpose industrial facilities involve the production of a range of products through different recipes, hence optimal facility design must also include production scheduling aspects. Research in this area has been focused on the use of MILP/MINLP models that might become intractable when applied to real problems. A contribution is presented, based on a Simulated Annealing approach, to overcome this drawback. Examples are solved and the performance of SA and exact algorithms compared, with sensitivity analysis on parameters undertaken. In all cases, design and scheduling are determined.

■ MB-05

Monday, 10:40-12h00

3.2.16

Genetic algorithms

Stream: Metaheuristics

Invited session

Chair: *Alexander Plyasunov*, Information Technology Department, Novosibirsk State University, Pirogova str. 2, 630090, Novosibirsk, Russian Federation, apljas@math.nsc.ru

Chair: *Hwai-En Tseng*, Department of Industrial Engineering and Management, National Chin-Yi University of Technology, 35, Lane215, Section 1, Chung-Shan Road, 411, Taiping City, Taichung County, Taiwan, hwai_en@seed.net.tw

1 - Grouping genetic algorithms for green product modular design

Hwai-En Tseng, Department of Industrial Engineering and Management, National Chin-Yi University of Technology, 35, Lane215, Section 1, Chung-Shan Road, 411, Taiping City, Taichung County, Taiwan, hwai_en@seed.net.tw

Recently, people all over the world paid much attention to green and environmental design. Under the consideration of economy, the green recycle of a product depends upon the profit/cost relationship of the discarded product. This study attempted to build up appropriate algorithms for product modular design in three stages. At Stage 1, the liaison intensity was used to quantify the connection relations among parts. At Stage 2, the product to be recycled was modularized by the grouping genetic algorithms. At Stage 3, the disassembly cost and recycle profit of the modules were evaluated.

2 - Reliability Optimization of Series-k-out-of-M Systems Using a Genetic Algorithm

Ceki Franko, Mathematics, Izmir University of Economics, 1488 sokak No:1 Daire 12 Alsancak/Izmir, 35520, Izmir, Turkey, ceki.franko@ieu.edu.tr, *Cemal Murat Özkut, Cihangir Kan*

Series-parallel systems are commonly used in optimal design problems. This paper presents a generalization of the series-parallel system. Since it is difficult to obtain the exact solution for series-k-out-of-M system, a heuristic method is developed for solving a multi-objective model in which system reliability and costs are considered. A mathematical model is provided by transforming the multi-objective model into single-objective model. Also, a modified genetic algorithm is proposed in order to solve this model. Finally, the numerical example is provided and the result is illustrated.

3 - Genetic local search algorithm for the mill pricing problem

Alexander Plyasunov, Information Technology Department, Novosibirsk State University, Pirogova str. 2, 630090, Novosibirsk, Russian Federation, apljas@math.nsc.ru

In the mill pricing problem we are given two finite sets of facilities and customers. Each customer has a budget, a demand and patronizes the facility providing the lowest price and travel cost. The objective is to maximize the overall profit for the facilities. We present the problem as a Stackelberg-type leader-follower game and show that it is NP-hard in the strong sense. Genetic local search algorithm is developed for finding near optimal solutions. Computational results are discussed.

4 - A Preference Based Genetic Algorithm For Bi-Objective Capacitated Facility Location Problem With Partial Coverage

Berk Orbay, Industrial Engineering, Middle East Technical University, Turkey, berkorbay@gmail.com, *Esra Karasakal*

In this study, we address the problem of locating minimum number of capacitated facilities in order to maximize total coverage of the demand points. We assume that a facility fully covers the demand points that are located within its critical distance and after that distance coverage level of the facility decays linearly. We develop a preference based interactive multi-objective genetic algorithm to solve the problem. We test the performance of the algorithm on randomly generated problems of different sizes.

■ MB-06

Monday, 10:40-12h00

8.2.30

DEA Methodology II

Stream: DEA and Performance Measurement

Invited session

Chair: *Yannis Smirlis*, University of Piraeus, 80 Karaoli - Dimitriou Str, 18534, Piraeus, Greece, smirlis@unipi.gr

1 - Piecewise linear virtual inputs/outputs in Interval DEA

Yannis Smirlis, University of Piraeus, 80 Karaoli - Dimitriou Str, 18534, Piraeus, Greece, smirlis@unipi.gr, *Dimitris Despotis*

Recent publications relax the DEA assumption of single weights for inputs/outputs and deal with cases that virtual inputs/outputs exhibits diminishing/increasing marginal functions between specified threshold values. This concept has been studied only for crisp data sets. In this work we extend this concept of diminishing/increasing returns to Interval DEA. We model nonlinear value functions in a piece-wise linear fashion and we transform the original data set to an augmented data set, compliant with the Interval DEA methodology. Numerical and empirical data sets illustrate this approach.

2 - Ranking DMUs by Using Stochastic MAJ Model

Mohammad Hassan Behzadi, Statistics, Science and Research Branch, Islamic Azad University, Tehran, Iran, Tehran, Iran, Islamic Republic Of, behzadi@srbiau.ac.ir, *Farhad Hosseinzadeh Lotfi, Mahnaz Mirbolooki*

Using traditional DEA models, many decision making units (DMUs) are classified as efficient. These models works with deterministic data. Considering stochastic data in DEA is one of the important methods to deal with imprecise data. Therefore, in this research studies we provide an additive model for ranking efficient DMUs with stochastic data condition. To solve the stochastic model, a deterministic equivalent is obtained. Although the deterministic equivalent is non-linear, it can be converted to a quadratic program. Using numerical example, we will demonstrate how to use the result.

3 - A DEA based approach for solving the multiple objective shortest path problem

Alireza Davoodi, Mathematics, Islamic Azad University, Neyshabur Branch, ———, Neyshabur, Khorasan, Iran, Islamic Republic Of, alirzd@yahoo.com

Finding the shortest path in a network is one of the important and interesting subjects in network flow problems. When each arc has just one type of cost, there exist some simple methods to find the shortest path. But if there are more than one type of cost (vector of cost), the non-dominated path plays the role of the best path. In this case a Multiple Objective problem is created to find the non-dominated path. In this paper a DEA based approach is introduced to find the non-dominated path(s) in a multiple cost network. This method can determine all efficient paths and the best one.

4 - Fractional regression models for second stage DEA efficiency analyses

Esmeralda Ramalho, Economics, Universidade de Evora, Largo dos Colegiais, 2, 7000-803, EVORA, Portugal, ela@uevora.pt, *Joaquim Ramalho, Pedro Henriques*

Data envelopment analysis (DEA) is commonly used to measure the relative efficiency of decision-making units. Often, in a second stage, a regression model is estimated to relate DEA efficiency scores to exogenous factors. In this paper, we argue that the traditional linear or tobit approaches to second-stage DEA analysis do not constitute a reasonable data-generating process for DEA scores. Under the assumption that DEA scores can be treated as descriptive measures of the relative performance of units in the sample, we show that using fractional regression models are the most natural way of modeling bounded, proportional response variables such as DEA scores. We also propose generalizations of these models and, given that DEA scores take frequently the value of unity, examine the use of two-part models in this framework. Several tests suitable for assessing the specification of each alternative model are also discussed.

■ MB-07

Monday, 10:40-12h00
8.2.47

New Achievement in Mathematical Programming

Stream: Mathematical Programming [c]
Contributed session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Domingos Cardoso*, Departamento de Matematica, Universidade de Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, dcardoso@ua.pt

1 - Algorithmic strategies for the recognition of graphs with convex quadratic stability number

Maria F Pacheco, Instituto Politécnico de Bragança - ESTiG, Quinta de Santa Apolónia, Gab. 112, 5301-857, Bragança, Portugal, pacheco@ipb.pt, *Domingos Cardoso, Carlos J. Luz*

A major difficulty in the recognition of graphs with convex quadratic stability number is the existence of adverse subgraph(s) (subgraph such that the smallest eigenvalue of its adjacency matrix doesn't change when a (neighbourhood of) any vertex is deleted). It is a challenge to find adverse graphs without convex quadratic stability number. We present the main results about graphs with convex quadratic stability number and conclusions about the existence of adverse subgraphs belonging to this family in certain classes of graphs.

2 - A new hybrid cryptosystem based on the satisfiability problem

Sadek Bouroubi, Faculty of Mathematics, Dept of Operations research, USTHB University, Laboratory LAID3, BP32 Bab Ezzouar 16111, 16111, Algiers, Algeria, bouroubis@yahoo.fr

With the development of the mathematical methods which ensure safe electronic communication, more sophisticated techniques emerged which allow to attack codes on increasingly powerful computers. Modern cryptosystems are based on number theory, commutative group theory, or algebraic geometry. This paper presents a simple hybrid cryptosystem whose security is based upon the satisfiability problem well known NP-complete. Its execution is finally illustrated by an example to understand better how it processes.

3 - A two-phase heuristic for the K Clusters with Fixed Cardinality Problem

Lidia Lourenço, Dept. de Matemática, Centro de Investigação Operacional, FCT - Universidade Nova de Lisboa, Monte de Caparica, 2829-516, Caparica, Portugal, ll@fct.unl.pt, *Margarida Pato, Graça Gonçalves*

Given an undirected graph, the K Clusters with Fixed Cardinality Problem consists of finding K subsets of nodes with fixed cardinality maximising the total similarity of nodes in the same cluster. We propose a two-phase heuristic procedure designed to obtain a feasible solution for this NP-hard problem. First a greedy rule is used to build a solution which is improved in the next phase by an exchange-based heuristic. A computational experiment is designed to evaluate the performance of this heuristic.

4 - A combinatorial approach to assess the separability of clusters

M. Joao Martins, Dep. Matematica, Inst. Superior Agronomia, Tapada da Ajuda, 1349-017, Lisboa, Portugal, mjmartins@isa.utl.pt, *J. Orestes Cerdeira, Pedro C. Silva*

Given a set of entities, to what extent a particular subset is separated from the other entities? This is a common question that arises in different relevant areas. We propose to assess the separability of a set of entities X based on the following notion of intrusion associated to some aggregation criterion. An entity y is a k-intruder if every (k+1)-partition where y is singleton is not an optimal (k+1)-partition of X U y. We study the optimization problems resulting from different aggregation criteria, and develop this approach further to evaluate the overall separability of a partition.

■ MB-08

Monday, 10:40-12h00
6.1.36

Scheduling at Container Terminals

Stream: Project Management and Scheduling
Invited session

Chair: *Florian Jaehn*, Business Administration, Management Information Science, Hoelderlinstrasse 3, 57068, Siegen, Germany, florian.jaehn@uni-siegen.de

1 - Positioning freight trains in rail container terminals

Malte Fliedner, Wirtschaftswissenschaftliche Fakultät, Friedrich-Schiller-Universität Jena, Carl-Zeiss-Strasse 3, 07743, Jena, Thuringen, Germany, malte.fliedner@uni-jena.de, *Nils Boysen*

Modern rail container terminals are an essential node of intermodal transportation networks. In such a terminal, several gantry cranes transship containers simultaneously from incoming trains to their designated destinations on the yard. In this work, we investigate the decision problem of positioning freight trains on the tracks of a terminal in order to balance workload among gantry cranes. We propose mathematical formulations of the core decision problem, provide complexity results and develop heuristic and exact algorithms to solve the problem and several extensions.

2 - Parking Freight Trains in Rail-Rail Transshipment Yards: The Train Location Problem

Nils Boysen, Lehrstuhl für ABWL/ Operations Management, Friedrich-Schiller-Universität Jena, Carl-Zeiß-Str. 3, 07743, Jena, Germany, nils.boysen@uni-jena.de, *Malte Fliedner*

In modern rail-rail transshipment yards huge gantry cranes spanning all railway tracks allow for an efficient consolidation of containers among freight trains. An important decision problem during daily operations is the train location problem, which assigns each train to a railway track (vertical position) and decides on each train's parking position on the track (horizontal position), so that the train processing time is minimized. For this problem different solution procedures are described and tested in a comprehensive computational study.

3 - Truck Scheduling Problem in Intermodal Container Transportation

Jenny Nossack, Management Information Sciences, University of Siegen, Hölderlinstraße 3, 57068, Siegen, North

Rhine-Westphalia, Germany, jenny.nossack@uni-siegen.de,
Erwin Pesch

We address a truck scheduling problem that arises in intermodal container transportation, where containers need to be transported between customer places (shipper or receiver) and container terminals (rail or maritime) and vice versa. The transportation requests are handled by a trucking company which operates several depots and a fleet of homogeneous trucks that must be assigned and scheduled to minimize the total truck operating time under hard time window constraints imposed by the customers and terminals. Empty containers are considered as transportation resource and are provided by the trucking company for transportation. The truck scheduling problem at hand is formulated as Full Truckload Pickup and Delivery Problem and is solved by a 2-stage heuristic solution approach. Computational results for randomly generated instances are presented.

4 - New bounds and algorithms for the Transshipment Yard Scheduling Problem

Florian Jaehn, Business Administration, Management
Information Science, Hoelderlinstrasse 3, 57068, Siegen,
Germany, florian.jaehn@uni-siegen.de, Nils Boysen, Erwin
Pesch

In modern rail-rail transshipment yards huge gantry cranes transship containers between different freight trains, so that hub-and-spoke railway systems are enabled. In this context, we consider the transshipment yard scheduling problem (TYSP) in which trains have to be assigned to bundles, which jointly enter and leave the yard. Although feasible solutions can easily be obtained, the problem is NP-hard if certain, realistic objectives are chosen. We present several heuristics as well as one exact algorithm for solving the problem. The presentation concludes with some computational results.

■ MB-09

Monday, 10:40-12h00
6.2.53

Optimization of Transport Problems on Networks I

Stream: Mathematical Programming

Invited session

Chair: Simone Göttlich, Mathematics, TU Kaiserslautern, Post Box 3049, 67653, Kaiserslautern, Germany, goettlich@mathematik.uni-kl.de

1 - A measure theoretic approach to continuous and discrete flows over time

Ebrahim Nasrabadi, Mathematics, Technische Universität Berlin, Institut für Mathematik, Sekr. MA 5-2, Straße des 17. Juni 136, 10623, Berlin, Germany, nasrabadi@math.tu-berlin.de, Ronald Koch, Martin Skutella

Network flows over time form a fascinating area of research. They model the temporal dynamics of network flow problems occurring in a wide variety of applications. Research in this area has been pursued in two different and mainly independent directions with respect to time modeling: discrete and continuous time models.

In this talk we deploy measure theory in order to introduce a general model of network flows over time combining both discrete and continuous aspects in only one model. We focus on the maximum flow problem and extend the famous MaxFlow-MinCut Theorem to this setting.

2 - An Adaptive Model Switching and Discretization Algorithm for Gas Flow on Networks

Pia Domschke, Mathematics, TU Darmstadt, Dolivostr. 15, 64293, Darmstadt, Germany, domschke@mathematik.tu-darmstadt.de, Oliver Kolb, Jens Lang

The equations describing the transport of gas in pipeline networks are based on the Euler equations. Compressor stations and valves increase the complexity. We present a hierarchy of models that describe the flow of gas qualitatively different. Using adjoint techniques, we may specify model and discretization error estimators. We present a strategy that adaptively applies the different models in different regions of the network in order to reduce the complexity of the problem while maintaining the accuracy of the solution. This approach is suitable to be used within an optimization framework.

3 - Approximate Parametric Dynamic Programming in Inventory Management

Marco Laumanns, IBM Research Zurich, 8803, Rueschlikon, Switzerland, mlm@zurich.ibm.com, Stefan Woerner, Apostolos Fertis, Rico Zenklusen

We present an approximation method for inventory management under multiple suppliers and stochastic lead times. The method is based on parametric dynamic programming using convex piecewise linear approximations of the differential cost function in approximate relative value iteration steps and works for a range of stochastic control problems with linear dynamics and convex piecewise linear immediate costs. The obtained differential cost approximation not only defines a policy that performs well in practice, it also yields valid lower bounds that are useful to judge the quality of heuristics.

4 - Solution techniques for time-continuous network problems

Simone Göttlich, Mathematics, TU Kaiserslautern, Post Box 3049, 67653, Kaiserslautern, Germany, goettlich@mathematik.uni-kl.de

Many phenomena appearing in economics can be described by continuous models consisting of ordinary and partial differential equations. Typical application areas include supply chain management, scheduling problems and network flow problems in general. The focus is on the mathematical modelling as well as on techniques for simulation and optimization purposes. In fact, in various cases those models can be related to mixed-integer programming models. To ensure feasibility and to reduce the computational effort of large-scale instances, there is evidently need for suitable algorithms.

■ MB-10

Monday, 10:40-12h00
6.2.56

Graphs and Networks II

Stream: Graphs and Networks

Invited session

Chair: Jean Fonlupt, Maths, Université de Paris 6, 175 Rue du Chevaleret, F 75013, Paris, France, jean.fonlupt@math.jussieu.fr

1 - The sandwich line graph

Denis Cornaz, LAMSADE, Université Paris-Dauphine, Pce Mal Lattre de Tasigny, 75016, Paris, France, cornaz@lamsade.dauphine.fr

A sandwich function is one that computes a bound which dual both for the chromatic number and for the clique number of any given graph G . In an orientated graph D , two arcs form a simplicial pair if they share the same tail vertex and if the two distinct head vertices are linked by an arc. The sandwich line graph $S(D)$ of an orientated graph D is the line graph $L(G)$ of the underlying undirected graph G minus the edges of $L(G)$ corresponding to simplicial pairs of arcs of D . If D is any acyclic orientation of a graph G , both following sums are equal (as they are both equal to the number of vertices of G): The sum of the clique covering number of G and of the stability number of $S(D)$; The sum of the stability number of G and of the clique covering number of $S(D)$. From these relations one can use any sandwich function in $S(D)$ in order to produce another sandwich function for G . Numerical experiments show that the quality of (polynomial) Lovasz Theta (sandwich) function is significantly improved for the chromatic number.

2 - Computing solutions of the Paintshop-Necklace problem

Frédéric Meunier, LVMT, Ecole Nationale des Ponts et Chaussées, 6-8 avenue Blaise Pascal, Cité Descartes, 77455, Marne-la-Vallée, France, frederic.meunier@enpc.fr

How assign colors to occurrences of cars in a car factory ? How divide fairly a necklace between thieves who have stolen it ? These two questions are two facets of a same combinatorial problem, which has for now attracted attention from a theoretical point of view. The main purpose of our work is to make a step in a more operational direction by discussing practical ways to compute solutions for instances of various sizes. Approaches, such as linear programming, valid inequalities, greedy algorithms, path-following methods, will be discussed.

3 - Non-stable pairs in the Stable Marriage problem and multi-index configurations

Pavlos Eirinakis, Management Science & Technology, Athens University of Economics & Business, 76 Patision Str., 10434, ATHENS, Greece, peir@aueb.gr, *Dimitris Magos*, *Yiannis Mourtos*, *Panayiotis Miliotis*

In a Stable Marriage (SM) line-graph, some of the nodes corresponding to man-woman pairs that do not participate in any stable marriage cannot be removed, since the set of solutions would then get larger. We provide an algorithm that utilizes the rotation poset graph (a graph underlying the set of SM solutions) to identify all such nodes, thus deriving the minimal marriage graph. This allows us to determine the dimension and the facets of the SM polytope. Further, we explore the possibility of applying our work on a multi-index Supply Chain Network configuration and present some special cases.

■ MB-11

Monday, 10:40-12h00
8.2.38

Technical Communication

Stream: Emerging Applications of OR
Invited session

Chair: *Stig C Holmberg*, Information Technology and Media, Mid Sweden University, Mid Sweden University, ITM - Q351, 83125, Östersund, Sweden, shbg@ieec.org

Chair: *Lena-Maria Öberg*, ITM, Mid Sweden University, 831 25, Östersund, Sweden, lena-maria.oberg@miun.se

1 - Viable learning organizations — continuous change in a changeable world

Lena-Maria Öberg, ITM, Mid Sweden University, Akademigatan 1, 83125, Östersund, Sweden, lena-maria.oberg@miun.se, *Christina Nyström*, *Hanna Olsson*

Organizations dealing with technical communication must be well prepared due to changes in the surroundings. Changes put new demands on competence, technology in use, routines as well as the existing doctrine. In this paper, we present a model which supports an organization's continuously development of competence, doctrine, technology and routines. The know-how in the organization is gathered in an organizational memory (OM) — the Business Intelligence System. This BIS must be continuously updated in order to support identified business potentials.

2 - XML-thinking for Technical Communication

Stig C Holmberg, Information Technology and Media, Mid Sweden University, Mid Sweden University, ITM - Q351, 83125, Östersund, Sweden, shbg@ieec.org, *Lena-Maria Öberg*

All technical devices require adequate technical information (TI) in order to optimally serving us. The production and management of the necessary TI, however, often tend to be very cumbersome. Here XML-technologies (XML, XSLT, CSS and so on) are seen as a panacea. The problem, however, is that TC companies often oversee the need for an initial, careful and systemic information modelling and planning. Without such a planning the expectations of introducing XML often fall short. Hence, we here introduce XML-thinking as a set of guidelines for applying the XML-technologies to their full force.

3 - Queueing Modeling and Analysis for a Web-Server System with Proxy Servers

Yoshitaka Takahashi, Faculty of Commerce, Waseda University, 1-Chome 6-1, Nishi-Waseda, 169-8050, Shinjuku, Tokyo, Japan, yoshitak@waseda.jp, *Yoshiaki Shikata*, *Andreas Frey*

It is an important queueing issue to evaluate the delay in a web-server system with proxy servers handling real-time services. However, there exists almost no literature on the queueing models and analyses for the web-server system. The goal of this paper is to provide a queueing model and analysis. Using the diffusion approximation, we derive a mean-delay approximate formula. Our formula is validated by simulation results and is shown to be consistent with the previously-obtained exact result for a special case (single proxy-server and Poisson-arrival model).

4 - Churn Analysis with Bayesian Belief Network in Telecommunication Industry

Y. Ilker Topcu, Industrial Engineering, Istanbul Technical University, Istanbul Teknik Üniversitesi, İletme Fakültesi, Macka, 34367, Istanbul, Turkey, ilker.topcu@itu.edu.tr, *Pınar Aykanat*

In this study, a Bayesian Belief Network (BBN) model is applied to find out the most important factors that have effects on customer churn in telecommunication industry. Since BBN depends on the conditional probabilities between variables, it is used to show the casual relations between variables. Average minutes of calls, average billing amount, the frequency of calls to people from different providers, and tariff type are found as the most important variables that explain churn. Finally, a number of scenarios are discussed and promotions are suggested to save the customers.

■ MB-12

Monday, 10:40-12h00
8.2.39

AHP 02

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Erdem Aksakal*, Industrial Engineering, Engineering Faculty, Gazi University Engineering Faculty, Maltepe, 06570, Ankara, Turkey, eaksakal@gazi.edu.tr

1 - Evaluations of Vessel Registration Alternatives after the Direct Shipping across Taiwan Strait Applying Fuzzy AHP

Cheng-Chi Chung, Shipping and Transportation Management, National Taiwan Ocean University, No.2, Beining Rd., Jhongjheng District, Keelung City 202, Taiwan (R.O.C.), 202, Keelung, Taiwan, jackie@mail.ntou.edu.tw, *Shih-Hao Yang*

Confronted by the competition of open registry nations and regions, the flagging out of vessels is getting more serious in the world; therefore the traditional maritime countries are all aggressively making relative shipping policies and arrangements in order to increase the tonnage of national fleet. Apart from economic considerations, the political reasons of the restriction of direct shipping across Taiwan Strait and forbidding the national fleet of the opposite side come into each own ports in the past have resulted in vessels' flagging out among Taiwanese shipping corporations. After signing the shipping agreement across Taiwan Strait on 15 December 2008, the only qualification of "the vessel, which is registered in Taiwan, China, or Hong Kong, owned by above regions' shipping corporations' could sail across Taiwan Strait directly. Therefore, shipping corporations in Taiwan who operate cross Strait business have to decide vessel's registration in Taiwan or in Hong Kong, or registering in China through joint venture. The change of operational environment together with the implication of tonnage tax system and the loose of employing foreign seafarers' restrictions in Taiwan, all influential factors, will impact shipping corporations in Taiwan to evaluate the alternatives of vessel registration among Taiwan, Hong Kong, or China. This study will construct an evaluation framework of vessel's registration by using Fuzzy AHP, and find out the optimal alternative among Taiwan, Hong Kong, or China. The results of this paper can serve as a good strategic reference on vessel registrations to the shipping corporations in Taiwan.

2 - A hybrid approach to personnel selection problem: AHP and Weighted Fuzzy Axiomatic Design

Erdem Aksakal, Industrial Engineering, Engineering Faculty, Gazi University Engineering Faculty, Maltepe, 06570, Ankara, Turkey, eaksakal@gazi.edu.tr, *Metin Dagdeviren*, *Ergun Eraslan*

The aim of this study is to describe a hybrid model for supporting the personnel selection process in service business. Selecting the right personnel is like having an ahead step for the future in the name of the organization. On the other hand selecting the wrong or improper personnel affects the organizations in a negative way. Selecting a new personnel under these conditions make the condition difficult and because of its composition, the personnel selection process creates its own alternatives. Selecting the proper personnel among those alternatives is a multi-criteria decision making problem. In this study the use of analytic hierarchy process and weighted fuzzy axiomatic design in personnel selection process investigated.

3 - A Hybrid Fuzzy Approach for a Point-Factor Job Evaluation System

Ahmet Can Kutlu, Industrial Engineering, Istanbul Technical University, Istanbul Technical University Management Faculty Industrial Engineering Department, Macka Istanbul, 34367, Istanbul, Turkey, kutluahm@itu.edu.tr, *Hülya Behret*

In this study, a fuzzy approach is developed for job evaluation which is defined as the methods and practices of ordering jobs or positions with respect to their value or worth to the organization. The most comprehensive method used in job evaluation is the Point-Factor Method where a set of compensable factors are identified as determining the worth of jobs. In this paper, factors are weighted by using Fuzzy Analytical Hierarchy Process (FAHP) method. After determining the factor weights, the evaluated jobs are grouped by using Fuzzy Rule Based System (FRBS) to be a base for a waging system.

4 - Selecting the software that will be developed for the purchasing department using fuzzy AHP

Nurgül Demirtaş, Yildiz Technical University, 0090, Istanbul, nurguldemirtas@gmail.com, *Özge Nalan Alp*, *Hayri Baraçlı*

Software applications are very important to follow operations in a company. These applications are influenced by many factors when they are being developed. This situation is result in using MCDM technique. MCDM techniques are the most effective techniques to achieve the most appropriate decision when there are lots of criteria. In this study, firstly lacks of the software application which is used in purchasing department will be determined and then the most effective software application platform will be selected to developed applications by Fuzzy AHP which is the one of MCDM techniques.

■ MB-13

Monday, 10:40-12h00

2.2.21

Facility Location and Supply Chain Management

Stream: Location Analysis

Invited session

Chair: *Isabel Correia*, New University of Lisbon, Lisbon, Portugal, isc@fct.unl.pt

1 - Robust models for dynamic multilevel facility location

Marina Gebhard, Chair of Business Administration and Logistics, University Erlangen-Nuremberg, Lange Gasse 20, 90403, Nürnberg, Germany, marina.gebhard@wiso.uni-erlangen.de, *Jens Wollenweber*

We study a strategic capacity planning and facility location problem in supply chains operating under uncertainty. Our focus lies on the uncertainty of the customer demands which are modeled by alternative future scenarios. We present a new formulation for a robust dynamic multilevel capacitated facility location problem that minimizes the expectation of the relative regrets associated with the given scenarios. We compare our formulation to both a deterministic and an alpha-reliable mean-excess regret model formulation and analyze their differences in terms of robustness and effectiveness.

2 - Optimal development of a national supply system in Germany and its geo-economic impact on the states and regions of it

John Karkazis, Business School, University of the Aegean, Chios, GR-82100, Chios, Greece, ikarkazis@aegean.gr, *Vassilis Angelis*, *Christina Chalimourda*, *Maria Mavri*

In this paper the concept of regional efficiency is introduced and the role of geo-economic gravity centers in regional development is analyzed. In the above context, the paper focuses on the geo-economic ability of administrative units to act as supply centers covering regional demand for products and services with the minimum operational and transportation cost. This theoretical framework is applied to the case of Germany in order to evaluate the optimal location of supply centers in a single, double and triple national supply system on the road network of the country.

3 - A Heuristic to Locate Distribution Centers in Large Supply Chains

Jean-Sébastien Tancrez, Operations Management, EPFL, Ecole Polytechnique Fédérale de Lausanne, EPFL - TOM, Odyssea

2.19, Station 5, 1015, Lausanne, Switzerland, jean-sebastien.tancrez@epfl.ch, *Jean-Charles Lange*, *Pierre Semal*

Designing supply chain networks is crucial for companies but remains challenging. In this work, we study the location of distribution centers in a three layer network, with single commodity and single period. We include both transportation and inventory costs and allow direct flows from factories to customers. A continuous model is proposed, which decomposes into a simple problem (batch sizes) and a linear-like program (locations and flows). An iterative heuristic is then built on this, allowing to solve large realistic problems. The approach is exemplified on the case of a glass manufacturer.

4 - A two-echelon supply chain network design problem with facility sizing decisions and variable operating costs

Francisco Saldanha-da-Gama, CIO/DEIO, University of Lisbon, FCUL-DEIO, Bloco C6, Piso 4, 1749-016, Lisbon, Portugal, fsgama@fc.ul.pt, *Isabel Correia*, *Teresa Melo*

A two-echelon supply chain network design problem is considered. In each echelon and at each potential site, a new facility can be set up for a group of product families. The size of the storage area occupied by a product family is to be selected from a discrete set of available sizes. Operating costs depend on the type of storage area installed in a given location and are charged to the total product quantity that is stored. A minimal cost network is to be determined. Several formulations are discussed and the results of a computational study based on randomly generated data are presented.

■ MB-14

Monday, 10:40-12h00

2.2.15

Lotsizing and Supply Chain Planning

Stream: Supply Chain Planning

Invited session

Chair: *Herbert Meyr*, Chair of Production and Supply Chain Management, Technical University of Darmstadt, Hochschulstr. 1, 64289, Darmstadt, Germany, Meyr@bwl.tu-darmstadt.de

1 - Simultaneous lotsizing and scheduling for time-dependent production speeds: dual reoptimization revisited

Herbert Meyr, Chair of Production and Supply Chain Management, Technical University of Darmstadt, Hochschulstr. 1, 64289, Darmstadt, Germany, Meyr@bwl.tu-darmstadt.de

The GLSPPL determines lotsizes and production schedules for a given deterministic dynamic demand in a capacitated, 1-stage production system consisting of heterogeneous production lines. Meyr (2002) proposed a dual reoptimization heuristic for the GLSPPL, where generalized network flow problems are solved as embedded subproblems. In order to tackle a practical application requesting time-dependent productions speeds, it was necessary to adapt the principle of dual reoptimization to general LPs. The paper shows experiences with this adaptation and computational tests with different LP solvers.

2 - Heuristics for the General Lotsizing and Scheduling Problem for Multiple production Stages

Florian Seeanner, Rechts- und Wirtschaftswissenschaften, Fachgebiet Produktion & Supply Chain Management, Hochschulstr. 1, 64289, Darmstadt, Germany, seeanner@bwl.tu-darmstadt.de

The General Lotsizing and Scheduling Problem for Multiple production Stages determines simultaneously lotsizes and setup sequences for a two or three-level continuous production system as can be found in the consumer goods industry. Unfortunately, this model can hardly be solved by standard MIP solvers, even for small problem instances. Therefore heuristic approaches have to be developed. As corresponding real-world-problems are quite large in data terms, scalability is a special requirement for those heuristics. In this talk scalable heuristics and preliminary computational results are shown.

3 - Supply Chain Planning in Grocery Retail - An Operations Planning Framework

Michael Sternbeck, Logistics, Catholic University of Eichstaett Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, michael.sternbeck@ku-eichstaett.de, *Alexander Hübner*, *Heinrich Kuhn*

In our presentation we develop a consumer-back demand planning framework for grocery retailing to exemplify the interrelated planning issues. This integrates retail specifics, consumer interaction, and hierarchical and sequential decision aspects. We use two case examples to exemplify the interrelated planning issues. The first will demonstrate the intertwined impact of warehousing, distribution and instore logistics. The second will show hierarchical planning aspects for integrated assortment, shelf space and price management.

4 - A hierarchical planning approach to physical and financial supply chain management

Gerd J. Hahn, Chair of Production and Operations Management, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, Germany, gerd.hahn@kuei.de, *Heinrich Kuhn*

The physical and the financial perspective of the supply chain are inextricably interlinked. However, hierarchical approaches to supply chain planning mainly focus on material flows and omit financial flows as well as their impact on shareholder value creation. In this presentation, we introduce an integrated approach to hierarchical supply chain planning optimizing Economic Value Added (EVA) as a prevalent mid-term indicator of value-based financial performance. Robust optimization methods are utilized to manage operational supply chain risk due to the uncertainty of future events.

■ MB-15

Monday, 10:40-12h00
2.2.12

Rich routing problems

Stream: Vehicle Routing

Invited session

Chair: *David Pisinger*, DTU Management, Produktionstorvet 424, 2800, Kgs. Lyngby, Denmark, pisinger@diku.dk

1 - Reliability in Vehicle Routing Problem with Time Windows

Duygu Tas, Industrial Engineering and Innovation Sciences, TU/e Eindhoven University of Technology, Technische Universiteit Eindhoven P.O. Box 513, 5600 MB, Eindhoven, Netherlands, d.tas@tue.nl, *Nico Dellaert*, *Tom Van Woensel*, *Ton de Kok*

In the Vehicle Routing Problem with Time Windows (VRPTW), a time window can be considered as a service requirement set by the customer. Routing schedules need to meet these requirements to provide adequate delivery reliability. We consider the VRPTW with stochastic travel times with a known probability distribution and the reliability for all customers via an objective function which minimizes the weighted sum of the total expected delay calculated with respect to the TWs and the total distance. We will describe our model and present our results.

2 - Dynamic routing in congested networks using real-time ITS information

Ratna Babu Chinnam, Industrial & Manufacturing Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, r_chinnam@wayne.edu, *Ali Guner*, *Alper Murat*

Growing congestion on transportation networks is impacting the effectiveness of just-in-time (JIT) logistics through increased delays and variability. We propose compact yet effective models for characterization of congestion and offer stochastic dynamic models and methods for routing under real-time information. We illustrate applications and methods for single as well as milk-run deliveries subject to time windows. Results from a simulated network of Southeast-Michigan freeways using historical data from Michigan ITS are presented.

3 - Driver-Pooling for Vehicle Routing Problems

Christian Doppstadt, IT-based Logistics, Goethe University Frankfurt, Grueneburgplatz 1, 60323, Frankfurt, Germany,

doppstadt@wiwi.uni-frankfurt.de, *Michael Schwind*, *Michael Schneider*

Most research done on vehicle routing problems (VRPs) considers drivers as a homogeneous set. This does not reflect the real world situation, where travel and service times are highly driver dependent e.g. due to learning effects. If inhomogeneous drivers are considered, a decision on which drivers to employ for a given problem instance is required. To our knowledge, we are the first to investigate this issue. We develop a method to determine the optimal set of drivers out of a driver pool. The results are used as input for an existing VRP heuristic supporting driver dependent times.

4 - Order batching and routing with time windows in warehouse picking

Katja Prnaver, Theoretical computing, Institute of Mathematics, Physics and Mechanics, Jadranska 19, 1000, Ljubljana, Slovenia, katja.prnaver@imfm.uni-lj.si, *David Pisinger*

In warehouses, effective consolidating of order into batches may result in significant reduction of total warehouse costs. Past research has mainly been focused on reducing traveled time of pickers, with some recent analytical results for single- or 2-block warehouses. We will present an optimization algorithm for order batching with time windows, minimizing the number of pickers required and the total traveled distance. The algorithm works for block structured warehouses of arbitrary size. Experimental results, showing that 5-10% savings can be obtained, will be presented.

■ MB-16

Monday, 10:40-12h00
2.2.14

Robust optimization in public transport

Stream: Public Transport

Invited session

Chair: *Laura Galli*, DEIS, University of Bologna, Viale Risorgimento, 2, 40136, Bologna, Italy, l.galli@unibo.it

1 - Robust Aircraft Rotation Planning

Ivan Dovica, Department of Applied Mathematics, Charles University, Malostranske namesti 25, 11800, Prague, Czech Republic, ivan@kam.mff.cuni.cz, *Ralf Borndörfer*, *Ivo Nowak*, *Thomas Schickinger*

This talk addresses the robust aircraft rotation planning problem, for which we propose a novel column generation method. It is based on a stochastic model of the operation of an airline. The algorithmic core is a method to compute delay distributions on legs along individual aircraft rotations. To investigate the practical relevance of the method, a Monte-Carlo simulation including standard recovery actions is applied.

2 - A Lagrangian Heuristic for Robust Train Timetabling

Valentina Cacchiani, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, valentina.cacchiani@unibo.it, *Alberto Caprara*, *Matteo Fischetti*

Lagrangian heuristics approximately solve a relaxation of the problem at hand through an iterative optimization scheme and apply several times a heuristic driven by the Lagrangian dual information. We present a simple modification of this scheme so as to deal with robustness: we modify the problem formulation by introducing artificial parameters to control robustness and we dynamically change their weights so as to produce subproblems where robustness becomes more important. The approach is illustrated on the Train Timetabling Problem and tested on real-world instances.

3 - Recoverable Robustness for Railway Rolling Stock Planning

Laura Galli, DEIS, University of Bologna, Viale Risorgimento, 2, 40136, Bologna, Italy, l.galli@unibo.it, *Valentina Cacchiani*, *Alberto Caprara*, *Leo Kroon*, *Gabor Maroti*, *Paolo Toth*

In this paper we apply the notions of Recoverable Robustness and Price of Recoverability to railway rolling stock planning using a Benders decomposition approach. We evaluate the approach on real-life rolling stock planning problems of NS, the main operator of passenger trains in the Netherlands. We present a successful heuristic leading to robust solutions, whose value is very close to the continuous lower bound. Finally, we show the practical effectiveness of our method by proposing an evaluation framework and showing extensive computational results on a very large number of scenarios.

4 - Robust train platforming and routing

Gabor Maroti, Department of Decision and Information Sciences, Rotterdam School of Management, Erasmus University Rotterdam, Burg Oudlaan 50, 3062 PA Rotterdam, The Netherlands, 3062 PA, Rotterdam, Netherlands, gmaroti@rsm.nl, *Alberto Caprara, Laura Galli, Leo Kroon, Paolo Toth*

Train Platforming and Routing is a problem of assigning to each train of a given timetable a platform and a conflict-free route through a railway node. The problem appears both in early planning stages and in real-time operations. In this work we focus on the robustness of the problem.

We extend an existing platforming model to robustness considerations, and we design an optimization-based rescheduling algorithm. Further, we evaluate the algorithm in a simulation framework. The computational tests are based on real-life instances of the Italian train operator FS.

■ MB-17

Monday, 10:40-12h00

1.3.14

Collaborative Planning II

Stream: Transportation Planning

Invited session

Chair: *Karl-Heinz Küfer*, Optimization, Fraunhofer ITWM, Fraunhofer-Platz 1, 67663, Kaiserslautern, Germany, kuefer@itwm.fhg.de

Chair: *Herbert Kopfer*, Department of Business Studies & Economics, Chair of Logistics, University of Bremen, Wilhelm-Herbst-Strasse 5, 28359, Bremen, Germany, kopfer@uni-bremen.de

1 - Limit and Degree of Autonomy in Groupage Systems

Herbert Kopfer, Department of Business Studies & Economics, Chair of Logistics, University of Bremen, Wilhelm-Herbst-Strasse 5, 28359, Bremen, Germany, kopfer@uni-bremen.de, *Heiko Kopfer, Xin Wang*

Groupage systems enable collaborating forwarders to exchange transportation requests in order to harmonize their transportation plans. This contribution describes several approaches for collaboration in groupage systems. It assigns the described approaches to different stages of collaboration intensity. For each stage it analyses the resulting degrees of autonomy of the cooperating partners. The main distinguishing features of the presented approaches are illustrated and their influence on the degree of autonomy is discussed.

2 - A Collaboration Platform for Freight Carriers

Heiner Ackermann, Abteilung Optimierung, Fraunhofer ITWM, Fraunhofer-Platz 1, 67663, Kaiserslautern, Germany, heiner.ackermann@itwm.fraunhofer.de, *Hendrik Ewe, Herbert Kopfer, Karl-Heinz Küfer*

We present a collaboration platform for cooperating freight carriers that encourages complex exchanges of requests by means of an auction. The platform's design goals are threefold: maximize the collaboration's profit, keep participants' autonomy regarding offering and bidding and giving maximal planning reliability concerning the exchange. We also discuss several decision support problems increasing the platform's usability and present first results gathered using a prototypic implementation.

3 - Profit Sharing Among Collaborating Freight Carriers

Hendrik Ewe, Department of Optimization, Fraunhofer Institute for Industrial Mathematics (ITWM), Fraunhofer-Platz 1, D-67663, Kaiserslautern, Germany, ewe@itwm.fhg.de, *Heiner Ackermann, Herbert Kopfer, Karl-Heinz Küfer*

Sharing the jointly generated profit is a fundamental issue when it comes to collaboration among independent freight carriers. However standard profit sharing schemes such as the core or the Shapley value fail to be applicable due to several reasons. Based on a monetary flow network we characterize the set of feasible profit shares having a desirable locality property. We then discuss several specific sharing schemes derived from the network model.

4 - A Combinatorial Auction Framework and Models for Carriers' Collaboration in Less Than Truckload Transportation

Chen Haoxun, 12, rue Marie Curie - BP 2060, 10010, TROYES, haoxun.chen@utt.fr, *Bo Dai*

In collaborative logistics, multiple carriers or shippers may form an alliance to optimize their transportation operations by sharing vehicle capacities and delivery tasks for eliminating empty backhaul, raising vehicle utilization rate, increasing each actor's profit. We propose a combinatorial auction framework and models for carriers' collaboration in less than truckload transportation. It consists of 5 steps: Outsourcing Request Selection by each carrier, Price Setting by auctioneer, Bid Generation of each carrier, Winner Determination by auctioneer, Profit Allocation among carriers.

■ MB-18

Monday, 10:40-12h00

1.3.15

Stochastic Modeling and Simulation I

Stream: Stochastic Modeling and Simulation

Invited session

Chair: *Alexander Grusho*, Probability theory, Moscow State University, GSP-2, GSP-2, GSP-2, Moscow, grusho@yandex.ru

1 - Fractal dimension cluster validation criteria

Dvora Toledano-Kitai, Haifa University, 21982, Karmiel, Israel, dvora@braude.ac.il, *Renata Avros, Zeev Barzily, Zeev (Vladimir) Volkovich*

We propose a new standpoint to the cluster validation problem based on a fractal dimension cluster quality model. Clusters dimension values in a partition are repeatedly assessed by means of simulated samples occurrences in groups such that the proximity of the result obtained is interpreted as partition goodness. Most concentrated at the origin empirical distribution of the calculated dimensions differences indicates an estimated number of clusters. Numerical experiments presented for different fractal dimensions exhibit capability of the offered method in artificial and real datasets.

2 - On Goodness-Of-Fit Tests For Random Combinatorial Objects

Alexander Kolodzey, Institution of Russian Academy of Sciences Dorodnicyn Computing Centre of RAS, Shokalskogo proezg, 1/1 - 68, 127229, Moscow, Russian Federation, kolodzey@mtu-net.ru

We consider the random combinatorial objects which possess the decomposition property of the individual components. The weight of the object equals to the sum of the components weights, and joint distribution of the number of components with a given weight can be represented as the joint conditional distribution of several independent Poisson random variables. A theorem about large deviations probabilities is proved, and Bahadur efficiency criteria of fit for random combinatorial objects are studied.

3 - Learning Parameter Optimization of Stochastic Gradient Descent with Momentum for a Stochastic Quadratic

Memmedaga Memmedli, Statistics, T.C. Anadolu University, T.C. Anadolu University, Faculty of Science, Department of Statistics, 26470, Eskisehir, Turkey, mmammadov@anadolu.edu.tr, *Engin Tas*

Stochastic gradient descent (SGD) with momentum is a competitive optimization method in particular classification problems with large and redundant data sets. Learning rate and momentum factor parameters should have to be carefully tuned. We propose to determine learning rate and momentum adaptively using the second-order information embedded in the Hessian. Convergence speed of stochastic gradient descent with adaptively tuned learning parameters (eSGD) compared with standard SGD on rosenbrock performance function with noisy measurements. Results show that eSGD outperforms standard SGD.

4 - Identification of Local Distortions in Random Sequences

Alexander Grusho, Probability theory, Moscow State University, GSP-2, GSP-2, GSP-2, Moscow, grusho@yandex.ru, *Elena Timonina, Zeev (Vladimir) Volkovich*

We consider a sequence of consistent distributions $P(0, n)$ with supports $D(0, n)$ on the product X^n of a finite set X . The distortion is defined by functions $f(m, n)$, mapping X^n in X^n which does not change last $n-m$ coordinates, and define a consistent sequence of distributions. Here, the consistent sequence of tests for the hypothesis $H(0, n): P(0, n)$ against $H(1, n): P(1, n)$ exists iff there exists $n > m-1$, where intersection $D(0, n)$ and $D(1, n)$ is the empty set. That specifies the ability to find local distortions in a random sequence, which distribution is well defined.

■ MB-19

Monday, 10:40-12h00

1.3.20

Modelling the Human Decisions

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Helena Ferreira*, Rua Dr. José Sampaio n° 861, 4810-275, Guimarães, helenaisafer@gmail.com

Chair: *Abdelrahim Mousa*, Mathematics, University of Minho, Eshpinho, Eshpinho, PhD Student, Portugal, abedmousa2000@yahoo.com

1 - Collaborative Dominance: When Doing Unto Others as You Would Have Them Do Unto You Is Rational

Leandro Rego, Statistics, Universidade Federal de Pernambuco, Rua Muniz Tavares 25, apt. 902, Jaqueira, 52050-170, Recife, PE, Brazil, leandro.ufpe@gmail.com, *Filipe Souza*

We discuss the intuition of mixed equilibria and analyze in what situations making the other players indifferent among their strategies is rational. We define the concept of stable collaborative dominance and, from it, we concluded that in 2×2 games, if there is a pair of stable collaborative dominant strategies, then the mixed equilibrium is not appropriate. Moreover, we show that there are situations in which the pair of collaborative dominant strategies is unstable, but players are able to cooperate via burning money agreements reaching a better situation than playing the mixed equilibrium.

2 - Modeling Human Behavior

Helena Ferreira, Rua Dr. José Sampaio n° 861, 4810-275, Guimarães, helenaisafer@gmail.com, *Leandro Almeida*, *José Cruz*, *Alberto A. Pinto*

We apply Game Theory concepts to the Theory of Planned Behavior that studies the decision-making mechanisms of individuals. We propose the Bayesian-Nash Equilibria as one, of many, possible mechanisms of transforming human intentions in behavior. This process corresponds to the best strategic individual decision taking in account the collective response. We show that saturation, boredom and frustration can lead to splitted strategies, in opposition to no saturation that leads to a constant strategy. Furthermore, we study the role of leaders in individual/group behavior and decision-making.

3 - Pinto's individuals decision bussola

Abdelrahim Mousa, Mathematics, University of Minho, Eshpinho, Eshpinho, PhD Student, Portugal, abedmousa2000@yahoo.com, *Alberto A. Pinto*, *Marta Faias*, *Mohammad Mousa*, *Rasha Samarah*, *Gabriela Goes*

Here, we introduce the Yes-No decision model that is a simplified version of the general decision models. In this model, there are just two possible decisions (Yes or No) that individuals can take. We note that this model has several applications in psychology, education and economics. This model already exhibits all the high complexity of the split and no-split Nash equilibria that is common in decision models. We completely characterize the split and no-split equilibria, through a usual concept of dynamical systems, introducing Pinto's thresholds in decision Nash equilibria. These thresholds describe hysteric-like behavior, as in dynamics, that it is responsible by the occurrence of catastrophes consisting in abrupt changes of individuals and collective behavior. The way these thresholds evolve and interact with parameter change, called bifurcations in dynamical systems, it is completely characterized by Pinto's bussola. These allow us to understand how small changes in psychological behavior or social behavior can create or annihilate possible individuals or collective behaviors to occur.

4 - Delayed Effects of Fiscal Policy Measures

Orlando Gomes, Economics, ISCAL - Instituto Politécnico de Lisboa, Av. Miguel Bombarda, 20, 1069-035, Lisboa, Portugal, omgomes@iscal.ipl.pt, *Ana Marques*

This presentation addresses the impact of fiscal policy changes over an economy resting on its long-term steady-state. The discussion, based upon a conventional intertemporal optimization setup, involves the consideration of a peculiar form of bounded rationality: it is assumed that only a small share of households is able to instantly recompute the optimal solution once the value of a tax rate is disturbed; all the other agents will then, gradually, follow the behavior of the first group (this can occur through contagion, social influence or social learning). As a result, the convergence towards the post-perturbation steady-state tends to follow a diffusion process and, consequently, policy measures will take time in affecting pervasively consumption-savings and labor-leisure choices.

■ MB-20

Monday, 10:40-12h00

1.3.33A

Cutting and Packing 2

Stream: Cutting and Packing

Invited session

Chair: *Andreas Bortfeldt*, Dept. of Information Systems, University of Hagen, Profilstrasse 8, 58084 Hagen, Germany, 58084, Hagen, FR Germany, Germany, andreas.bortfeldt@fernuni-hagen.de

1 - Ordering rules of the set of pieces in 2D- Open Orthogonal Dimensional Problem

Garcia Perez, Matemáticas Aplicadas, Universidad de Alcalá de Henares, C/ Camilo Jose Cela n° 63-A, 2° C, 28806, Alcalá de Henares, Madrid, Spain, fernando.garciap@uah.es, *Joaquín Aranda Almansa*, *Miguel Delgado Pineda*

We study the 2-Open Dimensional Orthogonal Problem. In this problem, it is usual to order the items by decreasing height or decreasing width to improve the best solution. We consider different ordering rules for the set of pieces and we analyze which one will probably be a good ordering depending on the objective, algorithm or set of pieces using 148 examples on the literature.

2 - Rect-TOPOS: A constructive heuristic for the rectangle packing area minimization problem

A. Miguel Gomes, Faculty of Engineering / INESC Porto, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465, Porto, Portugal, agomes@fe.up.pt, *Marisa Oliveira*, *Mª Eduarda Pinto Ferreira*

To solve the rectangle packing area minimization problem we use a variation of the TOPOS algorithm. In our adaptation, the layout is built by successively adding a new rectilinear piece to a partial solution while minimizing the enclosing rectangular area. Several criteria to choose the next piece and its orientation are proposed and compared. To evaluate and compare partial solutions different objective functions were used. Supported by Fundação para a Ciência e Tecnologia (FCT) project PTDC/GES/72244/2006.

3 - A superior piecewise linearization approach for assortment problems

Pei-Chun Wang, Graduate Institute of Industrial and Business Management, Taipei University of Technology, No. 1, Sec. 3, Chung Hsiao E. Road, Taipei 106, Taiwan, 106, Taipei, Taiwan, t5749005@ntut.edu.tw

The aim of the assortment problem is to seek the best way of placing a given set of rectangular pieces within a large rectangle with minimal area. Such problems are often formulated as a quadratic mixed-integer program. This study reformulates the assortment model as a mixed-integer linear program for finding the global optimum within tolerable error based on a superior piecewise linearization approach. Numerical examples also demonstrate that the presented method uses much less CPU time than that in current methods for reaching the global optimum.

4 - A two-stage approach for the rectangle packing area minimization problem

Andreas Bortfeldt, Dept. of Information Systems, University of Hagen, Profilstrasse 8, 58084 Hagen, Germany, 58084, Hagen, FR Germany, Germany, andreas.bortfeldt@fernuni-hagen.de, *Götz Goldacker*

The rectangle packing area minimization problem (RPAMP) requires packing a set of rectangles without overlaps while minimizing the enclosing rectangular area. We assume that the small rectangles have fixed dimensions. A two-stage generic approach is presented that is able to integrate different 2D container loading procedures. Results are reported for well-known RPAMP benchmark instances.

■ MB-21

Monday, 10:40-12h00

6.2.47

OR in Practice II

Stream: Software for OR/MS

Invited session

Chair: *Bernard Lamond*, Operations & Decision Systems, Université Laval, Pavillon Palasis-Prince, 2325, rue de la Terrasse #2634, G1V 0A6, Quebec, Quebec, Canada, bernard.lamond@fsa.ulaval.ca

1 - MES developing practice in tobacco manufacturing: A Case Study

Zhong Yao, Dept. of Information System, Beihang University, 37, Xueyuan, Haidian, 100191, Beijing, China, stiphen_zhong@126.com

Many firms in China had implemented the ERP systems, including the tobacco manufacturing firms. However, these firms found that traditional ERP systems like SAP and Oracle can not satisfied data requirements in their routine production management. Therefore, they seek new methods to support their production management. Manufacturing executive systems (MES) can be considered one of the most effective systems and sometimes it is described as the ERP system in process manufacturing industry. This talk briefly introduces the MES building process in one of tobacco manufacturing firm of China. We present the general system developing methods and tools used in the MES development via MES practice in a tobacco manufacturing firm. We hopefully provide a reference method for similar manufacturing firms.

2 - Comparing the Metaheuristics and Gradient Based Approaches in Multi-objective Urban Water Management

Mahdi Zarghami, Faculty of Civil Engineering, University of Tabriz, 29 Bahman Blvd., 51664, Tabriz, zarghaami@gmail.com, *Hassan Hajykazemian*, *Vahid Eghbaal*

In this paper, the efficiency of the evolutionary multi-objective optimization approaches are compared with respect to different gradient based methods. These methods are applied to an urban water problem in the large city of Tabriz, Iran. The evolutionary approaches include Genetic Algorithm, Particle Swarm Optimization and their new developed methods. According to the results, there are several trade-offs in selecting the most efficient methods and this paper will finally show the Pareto frontiers, which is needed to select the optimum solutions in uncertain conditions.

3 - Dynamic control of a flexible machine with stochastic tool life

Bernard Lamond, Operations & Decision Systems, Université Laval, Pavillon Palasis-Prince, 2325, rue de la Terrasse #2634, G1V 0A6, Quebec, Quebec, Canada, bernard.lamond@fsa.ulaval.ca

We present analytical results related to a tool management model for a flexible machine equipped with a tool magazine, variable cutting speed, and sensors to monitor tool wear, when tool life due to flank wear is stochastic. Under some regularity conditions, we derive the special structure of decision rules for adjusting the cutting speed as a function of remaining distance, each time a tool change occurs, in order to minimize the expected processing time (sum of cutting time and tool setup time). These are near-optimal and easy to compute.

■ MB-22

Monday, 10:40-12h00

3.1.10

Teaching with cases

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 - Workshop on Teaching OR using cases I

Peter Bell, Richard Ivey School of Business, University of Western Ontario, N6A 3K7, London, Ontario, Canada, pbell@ivey.ca, *Fredrik Odegaard*, *Mehmet Begen*

Workshop on Teaching OR using cases

This workshop will provide practical help for instructors who wish to provide their OR students with real world problem solving experience using cases. We aim to provide help with such questions as:

Where do I find OR cases?

How can I use one or more cases in my course?

What impact will the use of cases have on my students?

What do I (the instructor) have to do to use a case successfully?

2 - Workshop on Teaching OR using cases II

Fredrik Odegaard, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond Street North, N6A 3K7, London, Ontario, Canada, fodegaard@ivey.uwo.ca, *Mehmet Begen*, *Peter Bell*

Workshop on Teaching OR using cases

This workshop will provide practical help for instructors who wish to provide their OR students with real world problem solving experience using cases. We aim to provide help with such questions as: Where do I find OR cases? How can I use one or more cases in my course? What impact will the use of cases have on my students? What do I (the instructor) have to do to use a case successfully?

3 - Workshop on Teaching OR using cases III

Mehmet Begen, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond St. N., Ivey, N6A3K7, London, ON, Canada, mbegen@ivey.uwo.ca, *Peter Bell*, *Fredrik Odegaard*

Workshop on Teaching OR using cases

This workshop will provide practical help for instructors who wish to provide their OR students with real world problem solving experience using cases. We aim to provide help with such questions as: Where do I find OR cases? How can I use one or more cases in my course? What impact will the use of cases have on my students? What do I (the instructor) have to do to use a case successfully?

4 - Workshop on Teaching OR using cases IV

Antonia Carravilla, FEUP / INESC Porto, R. Dr. Roberto Frias, 378, 4200-465, Porto, Portugal, mac@fe.up.pt

Workshop on Teaching OR using cases

This workshop will provide practical help for instructors who wish to provide their OR students with real world problem solving experience using cases. We aim to provide help with such questions as: Where do I find OR cases? How can I use one or more cases in my course? What impact will the use of cases have on my students? What do I (the instructor) have to do to use a case successfully?

■ MB-23

Monday, 10:40-12h00

6.2.49

MOO: Algorithms for Multi-Objective Combinatorial Optimization II

Stream: Multi-Objective Optimization

Invited session

Chair: *José Santos*, Department of Mathematics, University of Coimbra, Department of Mathematics, FCTUC, Apartado 3008, 3001-454 Coimbra, 3001-454, Coimbra, Portugal, zeluis@mat.uc.pt

1 - Empirical study for the multi-objective shortest path problems using real data instances

José Santos, Department of Mathematics, University of Coimbra, Department of Mathematics, FCTUC, Apartado 3008, 3001-454

Coimbra, 3001-454, Coimbra, Portugal, zeluis@mat.uc.pt, José Paixão

The real data instances have, in general, a specific structure turning the multi-objective shortest path problem (MSPP) harder to solve than when randomly generated instances are used.

In this work, we study the number of Pareto optimal solutions on this kind of networks and compare it with the results obtained in randomly instances. Additionally, we compare the performance of the labelling and ranking algorithms to solve the MSPP when real data instances are considered.

2 - Dynamic Location-Allocation Facility Modeling using a GIS-based Multiobjective Approach

Lino Tralhão, INESC Coimbra, Rua Antero de Quental, 199, 3000-141, COIMBRA, Portugal, linotralhao@gmail.com, João Coutinho-Rodrigues, José Paulo Almeida, Luís Alçada

This work introduces a dynamic, multiobjective, mixed integer programming approach to deal with facility location-allocation problems. Aspects such as the planning in different time periods, the attractiveness of the facilities, and the population changes along the time, are addressed by a methodology encompassing economic, operational, and social objectives. Given the spatial nature of these problems, GIS technology is used; the comparison of the scenarios generated is performed in the objectives' space along with adequate graphical representations. An application illustrates the approach.

3 - Automated Schematic Maps: Point Positioning Enhancement Strategies

João Mourinho, Instituto de Engenharia Mecânica e Gestão Industrial, Faculdade de Engenharia da Universidade do Porto, Campus da FEUP, Rua Dr. Roberto Frias, 400, 4200-465 Porto, 4200-465, Porto, joamourinho@gmail.com, Teresa Galvão Dias, João Cunha

Schematic Maps are simplified maps used mainly for depicting transportation maps. The schematization process has a multiobjective combinatorial nature and involves the simplification of geographic information, such as stops and lines. We propose an algorithm for generating enhanced solutions for the initial stage of the schematization process, related to the alignment of transportation stops and lines to a grid. The algorithm merges knowledge from the fields of the human cognitive psychology, mathematics and computing. Preliminary results on real word instances are presented and discussed.

4 - A Multi-objective Approach for High Quality Virtual backbones in Mobile Ad-Hoc Networks

Pascal Bouvry, Univ. of Luxembourg, 5600, Luxembourg, Luxembourg, pascal.bouvry@uni.lu, Apivadee Piyatumrong, Frederic Guinand, Kittichai Lavangnananda

Topology management for mobile ad-hoc networks is usually based on the notion of virtual backbones. The notion of quality of such backbones as a multi-objective problem addressing quality of the mobiles composing the backbone and of the connection links. The approach using extensive simulation based on different mobility models and using backbones composed of spanning forests. We provide ways to address the global behavior of the algorithms by fine-tuning the greedy local decision policy and compare it to the solution quality that could be achieved using global knowledge and metaheuristics.

■ MB-24

Monday, 10:40-12h00

6.2.50

Bioinformatics II

Stream: Computational Biology, Bioinformatics and Medicine

Invited session

Chair: Jacek Blazewicz, Instytut Informatyki, Politechnika Poznańska, ul. Piotrowo 2, 60-965, Poznań, Poland, jblazewicz@cs.put.poznan.pl

Chair: Piotr Lukasiak, Institute of Computing Science, Poznań University of Technology, ul. Piotrowo 2, 60-965, Poznań, Poland, Piotr.Lukasiak@cs.put.poznan.pl

1 - Insights into Protein-RNA complex modeling on example of Dicer-Like proteins.

Maciej Milostan, Institute of Computing Science, Poznań University of Technology, ul. Piotrowo 2, 60-965, Poznań,

Poland, maciej.milostan@cs.put.poznan.pl, Piotr Lukasiak, Jacek Blazewicz

Dicer is an enzyme responsible for processing double-stranded RNAs and plays a key role in an RNAi mechanism. Only one crystal structure of dicer is available at the moment and it is structure of eukaryotic Dicer from *Giardia intestinalis*. Dicer-Like proteins are also present in many higher eukaryotes including *Arabidopsis thaliana*. We would like to present results obtained by application of homology modeling, based on combination of multiple sequence and structural alignments, followed by Molecular-Dynamics (MD) simulations, Normal Mode Analysis (NMA) and docking experiments.

2 - Generation of enriched gene sets from independent component analysis sources: an alternative for the identification of biologically relevant molecular signatures

Adrien Six, CNRS UMR 7211 - "Integrative Immunology" I2D3 team, University Pierre et Marie Curie, Bâtiment Cervi (Sce Biothérapies), 83, bd de l'Hopital, 75013, Paris, France, adrien.six@upmc.fr, Hang Phuong Pham, Nicolas Dérian, David Klatzmann

Transcriptome analyses often yield no gene signatures, due to no or too many differentially expressed genes. However, the underlying data structure may bear such information at a finer level of organization. We propose an original combination of Independent Component Analysis followed by Gene Set Enrichment Analysis to identify state-specific signatures that could not be deduced from direct gene expression analysis. With this strategy, we identify signatures for discrete cell subsets in whole spleen datasets and characterize vaccination vector-specific signatures.

3 - Assessment of protein structure models by systematic evaluation of local sequence-structure compatibility

Krzysztof Fidelis, UC Davis, 11111, Davis, United States, kfidelis@ucdavis.edu, Piotr Lukasiak, Maciej Antczak, Wojciech Biniński

Sequence — structure compatibility in proteins has been a subject of investigation ever since Christian Anfinsen's seminal work on the structure of ribonuclease (1954). Here we address the local structure version of the problem, with the immediate application to the evaluation of protein structure models. Model quality assessments (MQAs) are important as currently computational models outnumber experimentally derived structures by more than 100:1. We use the local descriptor of protein structure (LDPS) formalism and the corresponding shape libraries derived from known structures to assess the compatibility of any sequence with a known shape. This is undertaken with a learning approach, a support vector machine (SVM). Putative sequences and corresponding local structures are evaluated with several types of discriminatory functions (potentials), and SVM is trained to distinguish between these and native-like structures. We evaluate model quality by stringing local structure scores along the entire polypeptide chain of the model. This approach is particularly suited to assess the target sequence to template alignments in comparative modeling, a major source of modeling errors.

4 - Combinatorial Optimization to Predict Protein Structure, Function and Evolutionary Relationships

Susanne Pape, Mathematics, TU Darmstadt, Dolivostraße 15, Darmstadt, Germany, pape@mathematik.tu-darmstadt.de, Alexander Martin, Sebastian Pokutta

During the last decades, continuing advances in molecular bioinformatics (e.g. the Human Genome Project) have led to increased information about protein sequences. Predicting structure and function of proteins from these sequences is one of the most difficult problems in molecular biology. Many approaches dealing with protein sequences and structures are based on combinatorial optimization. Here, we present some novel strategies for minimizing a free energy function or aligning multiple sequences, that are both important tools in the analysis of protein relationships and structures.

■ MB-25

Monday, 10:40-12h00

6.2.48

Financial Modelling and Risk Management

Stream: Financial Mathematics and OR

Invited session

Chair: Omer Onalan, Faculty of Business Administration and Economics, Marmara University, Anadoluhisar, 34810, Istanbul, zittinonalan@gmail.com

1 - A multivariate approach to risk-return management within financial crisis environment

Marie Theres Gregus, Faculty of Economics, University of Split, Matice hrvatske 31, Makarska 4, 21 000, Split, Dalmatia, Croatia, mariagregus@yahoo.com, Elza Jurun

This paper is focused on multivariate risk-return management assuming time-varying estimation. The time-varying portfolio stocks are weighted by constraints on risk measure. Using assumption of bivariate Student's t-distribution, in multivariate GARCH(p,q) models, it becomes possible to forecast time-varying portfolio risk much more precisely. The complete procedure of analysis is established using real observed data by Zagreb Stock Exchange. It would be emphasize that the financial crisis environment makes the analysis challenging in methodological and practical sense.

2 - Hedging uncertainty in software development — A real option modeling approach

Emil Numminen, School of Management, Blekinge Institute of Technology, SE-371 79, KARLSKRONA, Sweden, emil.numminen@bth.se

This paper shows how real option theory is useful to manage uncertain-ties in software development projects. The paper show how the option to defer, the option to scale up and the option to abandon create flexibility and add value while decreasing the project uncertainty. The numerical modeling in this paper is done in a two-period discrete time setting using martingale measures to enforce risk-neutral expectations. The cash flow uncertainty is modeled via a multiplicative binomial process. The analysis is concluded with an empirical validation of the circumstances under which these options can be created in most software development projects. The paper ends with suggestions for further research.

3 - Pricing of foreign exchange options under the heston stochastic volatility model and the cir interest rates

Rehez Ahlip, School of Computing and Mathematics, University of Western Sydney, University of Western Sydney., 1797, Parramatta Campus, NSW, Australia, r.ahlip@uws.edu.au

Foreign exchange options are studied in the Heston stochastic volatility model for the exchange rate combined with the Cox, Ingersoll and Ross dynamics for the domestic and foreign stochastic interest rates. The instantaneous volatility is correlated with the dynamics of the exchange rate return, whereas the domestic and foreign short-term rates are assumed to be independent of the dynamics of the exchange rate. The main result furnishes a semi-analytical formula for the price of the foreign exchange European call option.

4 - The Use of Survival Analysis Techniques in studying a Bank's Attractiveness

Katerina Dimaki, Statistics, Athens University of Economics & Business, 76 Patission Street, 10434, Athens, Greece, dimaki@aueb.gr, Vassilis Angelis, Maria Mavri

Customers choose a bank on the basis of its attractiveness as expressed through what we have defined as the bank's Image. This paper uses Survival Analysis to monitor a bank's attractiveness over time. In this sense banks are considered as patients whose health status is given by the values of their Image whereas treatment is defined as the set of actions taken in order to improve their Image. A bank is considered as a survivor as long as its Image follows an increasing trend or remains constant. The moment of change in trend direction from increasing to decreasing indicates its failure.

■ MB-26

Monday, 10:40-12h00

3.1.11

Bioinformatics Applications of Machine Learning

Stream: Machine Learning and Its Applications

Invited session

Chair: *Burcu Gungor*, Computer Engineering, Bahcesehir University, 34353, Istanbul, Turkey, burcu.gungor@bahcesehir.edu.tr

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 - Application of advanced machine learning methods for tag snp selection in complex disease association studies

Gürkan Üstünkar, Information Systems, Middle East Technical University, METU Informatics Institute, Ankara, Turkey, ustunkar@gmail.com, Sureyya Ozogur-Akyuz, Gerhard-Wilhelm Weber, Nazife Baykal

In this study we propose two novel and efficient Tag SNP selection algorithms. Our proposed algorithms are motivated by prediction of Tagged SNPs and Pair-wise Association among SNPs. We also introduce Infinite Kernel Learning based binary classification scheme that can be used for SNP-Complex Disease Association studies. We evaluate the performance of our proposed models compared to previous studies in the literature that used the data sets we use in our study (Crohn's disease, Autoimmune disorder and Tick-borne encephalitis). We get competitive results within much more reasonable run times.

2 - Bioinformatics Approaches to Associate Single Nucleotide Polymorphisms with Human Complex Diseases According to Their Pathway Related Context

Burcu Gungor, Computer Engineering, Bahcesehir University, 34353, Istanbul, Turkey, burcu.gungor@bahcesehir.edu.tr, Ceyda Sol, Ugur Sezerman

Genome-wide association studies (GWAS) with millions of single nucleotide polymorphisms (SNPs) are popular strategies to reveal the genetic basis of human complex diseases. In this study, we use GWAS data provided by WTCCC for seven complex diseases and present how to derive SNP combinations associated with a specific disease, utilizing gene networks, protein protein interaction networks and pathway classification tools. With the whole-genome sequencing on the horizon, we show that the full potential of GWAS can only be achieved by integrating pathway-oriented analysis.

■ MB-27

Monday, 10:40-12h00

8.2.06

Financial Optimization 2

Stream: Financial Optimization

Invited session

Chair: *Roman Muraviev*, Mathematics, ETH Zurich, Hungerbergstrasse 5, 8046, Zurich, Switzerland, roman.muraviev@math.ethz.ch

1 - Optimal Control of Financial Derivatives by Chaotic Dynamics

Giacomo Patrizi, Statistica, Probabilita' e Statistiche Applicate, La Sapienza, University of Rome, Piazza Aldo Moro 5, 00185, Rome, g.patrizi@caspur.it, Laura Di Giacomo

A 'certainty equivalent' optimal control policy for a Dynamic financial Derivatives system based on chaotic theory will be formulated. The representation of stochastic processes as chaotic data improves the precision of the control of derivatives policies.

Theory and experimental results will be presented

2 - Dynamic management of multiple real options

Michi Nishihara, Graduate School of Economics, Osaka University, 1-7, Machikaneyama, Toyonaka, Osaka, 560-0043, Osaka, Japan, nishihara@econ.osaka-u.ac.jp

We develop a model for management of multiple real options. Simultaneous exercise of options has positive synergy effects such as economies of scale and scope, while separate exercise of options benefits from project flexibility. We consider two styles of management; static and dynamic management. A firm under static management determines whether real options are exercised simultaneously or separately ex ante. In contrast, a firm under dynamic management makes the decision at the time of exercise. We reveal characteristics of the policies and demonstrate differences among them.

3 - Utility Maximization with Additive Habits: Optimal Consumption and Wealth

Roman Muraviev, Mathematics, ETH Zurich, Hungerbergstrasse 5, 8046, Zurich, Switzerland, roman.muraviev@math.ethz.ch

Utility function with additive habits assigned to a financial agent, takes into consideration her addiction to certain levels of past consumption, and constitutes a significant neo-classical preference device, that enables to measure appropriately the satisfaction from consumption. Despite of its extensive recent study, almost nothing is known about the structure of the optimal consumption paths in the setting of incomplete markets and random endowments. We derive a recursive procedure for solving this utility maximization problem and uncover various economical features of the optimal consumption stream, such as monotonicity, concavity and asymptotics for large levels of wealth.

■ MB-28

Monday, 10:40-12h00

8.2.10

Applications of stochastic programming to the energy sector - electricity

Stream: Stochastic Programming 1

Invited session

Chair: *Maria Teresa Vespucci*, Department of Information Technology and Mathematical Methods, University of Bergamo, via Marconi, 5a, 24044, Dalmine (BG), Italy, mtvespucci@tin.it

1 - A multi-stage stochastic electricity portfolio model with forward contracts

Rosella Giacometti, Mathematics and Statistics, University of Bergamo, via dei Caniana 2, 24127, Bergamo, Italy, rosella.giacometti@unibg.it, *Maria Teresa Vespucci*, *Marida Bertocchi*

In this paper we develop a stochastic multi-stage portfolio model for a hydropower producer operating in a competitive electricity market. The portfolio includes its own production and a set of forward contracts for future delivery or purchase of electricity to hedge against risks. Our findings show that the use of forward contracts for hedging purposes results in a risk reduction and in a more efficient use of the hydroplant, taking advantage of the possibility of pumping water and ending up with a higher final value of the reservoir.

2 - Measures of performance of a stochastic model for the daily coordination of wind power plants and pumped storage hydro plants.

Maria Teresa Vespucci, Department of Information Technology and Mathematical Methods, University of Bergamo, via Marconi, 5a, 24044, Dalmine (BG), Italy, mtvespucci@tin.it, *Asgeir Tomasgard*, *Marida Bertocchi*, *Mario Innorta*

The integration in a power generation system of wind power plants and hydro plants with pumped storage allows to efficiently manage the uncertainty of wind power generation, as wind power in excess can be used for storing potential energy. A stochastic programming model is developed for the daily optimal coordination of this generation system. Approaches based on ARIMA models and on quantile regressions are used for constructing the scenario trees that represent the uncertainty of wind power production. Ex-ante and ex-post measures are used to evaluate the performance of the stochastic model.

3 - Optimal day-ahead bidding strategy with futures and bilateral contracts. Scenario generation through factor models.

Cristina Corchero, Estadística i Investigació Operativa, Universitat Politècnica Catalunya, c/Jordi Girona 31, Campus nord, Ed. C5, dspt 224, 08034, Barcelona, Spain, cristina.corchero@upc.edu, *F-Javier Heredia*, *M. Pilar Muñoz*

We propose a stochastic programming model that gives the optimal bidding, bilateral (BC) and futures contracts (FC) nomination strategy for a price-taker generation company in the MIBEL. The objective of the study is to decide the optimal economic dispatch of the physical FC and BC among the thermal units, the optimal bidding at day-ahead market (DAM) abiding by the MIBEL rules and the optimal unit commitment that maximizes the expected profits from the DAM. For the uncertainty characterization, we apply the methodology of factors models to forecast market prices in a short-term horizon.

4 - Single and multi-settlement approaches to market clearing mechanisms under demand uncertainty

Javad Khazaei, Engineering Science, University of Auckland, R215-70 symonds st-, 1010, Auckland, Auckland, New Zealand, j.khazaei@auckland.ac.nz, *David Young*, *Golbon Zakeri*

In the presence of uncertainty in generation or demand, there is a need that the market clearing mechanism deals with the deviations between the real and predicted quantities, and does so optimally. For this purpose, one or two settlement markets have been suggested in the literature. In this talk, we will discuss a single settlement stochastic programming mechanism and present its characteristics. We then compare this with some currently existing two settlement markets. The criterion is the social welfare obtained from these mechanisms at the equilibrium where we assume having rational players.

■ MB-29

Monday, 10:40-12h00

8.2.11

Global Optimization of Graph Partitioning

Stream: Boolean Programming

Invited session

Chair: *Frauke Liers*, Institut fuer Informatik, Universitaet zu Koeln, Pohligstrasse 1, 50969, Koeln, Germany, liers@informatik.uni-koeln.de

1 - An Effective Exact Algorithm for k-way Graph Partitioning

Frauke Liers, Institut fuer Informatik, Universitaet zu Koeln, Pohligstrasse 1, 50969, Koeln, Germany, liers@informatik.uni-koeln.de, *Miguel Anjos*, *Bissan Ghaddar*, *Angelika Wiegele*

We consider the task of partitioning the nodes of a graph into k subsets such that the sum of weights of the edges joining nodes in different partitions is maximum. Applications for this NP-hard problem arise, e.g., in VLSI design and in theoretical physics. Based on the work of Ghaddar et al. (Annals of OR, to appear), we present an SDP-based branch-and-cut approach for its solution. We show that suitably combining polyhedral insights with a bundle method for solving the positive semidefinite relaxations leads to an effective solution algorithm.

2 - Solving Non-convex Binary Quadratic Problems via Second-order Cone Programming

Bissan Ghaddar, Management Sciences, University of Waterloo, University of Waterloo, 200 University Avenue West, N2L 3G1, Waterloo, Ontario, Canada, bghaddar@uwaterloo.ca, *Miguel Anjos*, *Juan C. Vera*

We present a general framework based on polynomial programming for solving non-convex binary quadratic problems. Using this framework, we can re-derive previous relaxation schemes and provide new ones. In particular, we propose a second-order cone-based relaxation that can be strengthened by cut generation schemes. Computational results on the max-cut problem and the quadratic knapsack problem show that our second-order cone based-relaxation with valid inequalities is competitive in terms of bounds and time.

3 - Integer Linear Graph Partitioning

Matthias Peinhardt, Faculty of Mathematics (IMO), University Magdeburg, Universitätsplatz 2, 39106, Magdeburg, Germany, matthias.peinhardt@ovgu.de

We consider the problem of partitioning the vertices of a graph into at most k clusters, such that the weight of the edges in the multicut is maximized. We explore the capabilities of a linear integer programming formulation, with particular emphasis on the exploitation of the sparsity of graphs. The chosen formulation requires to deal with symmetrical solutions, which we approach with several different techniques. Both theoretical and computational results using this formulation are presented.

4 - On Handling Cutting Planes in Interior-Point Methods for Solving Semidefinite Relaxations of Binary Quadratic Optimization Problems

Alexander Engau, Mathematical and Statistical Sciences, University of Colorado Denver, Campus Box 170, PO Box 173364, 80217-3364, Denver, CO, United States, aengau@alumni.clemson.edu, *Miguel Anjos*, *Anthony Vannelli*

We describe an improved technique for handling large numbers of cutting planes when using an interior-point method for the solution of linear and semidefinite programming relaxations of combinatorial optimization problems. The approach combines an relaxed primal-dual interior-point algorithm with a cutting-plane scheme that does not solve successive relaxations to optimality but adds and removes cuts at intermediate iterates based on indicators for cut violation and feasibility of the associated slacks. The slack variables of added cuts are initialized using a recently proposed interior-point warm-start technique that relaxes the interiority condition on the original primal-dual variables and enables a restart from the current iterate without additional centering or correction steps. Our computational tests on relaxations of the maximum-cut and single-row facility layout problems demonstrate that this new scheme is robust for both unconstrained and constrained binary quadratic problems and its performance superior to solving only the final relaxation with all relevant cuts known in advance.

■ MB-30

Monday, 10:40-12h00

8.2.13

MCDA II: Health

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

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

Chair: *Mara Airoidi*, Management - OR group, London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, United Kingdom, m.airoidi@lse.ac.uk

1 - Multiple treatment multi-criteria drug benefit-risk assessment

Gert van Valkenhoef, Faculty of Economics and Business, University of Groningen, PO Box 800, 9700 AV, Groningen, Netherlands, g.h.m.van.valkenhoef@rug.nl, *Bert de Brock*, *Hans Hillege*, *Douwe Postmus*, *Tommi Tervonen*, *Tommi Tervonen*

Pharmaceutical decision making is based on assessing benefits and risks of alternative drugs, ideally by considering all available clinical evidence. In practice this is not achieved as the assessments are based on meta-analytical methods that allow only single criterion pair-wise comparisons. The recently proposed Mixed Treatment Comparison (MTC) models enable indirect comparisons within a set of alternative treatments. In this presentation we show how MTC can be used to construct stochastic multi-criteria models that allow to compare multiple treatments in terms of multiple criteria.

2 - International perspectives on priority setting in health care using Multi-Criteria Decision Analysis (MCDA)

Stuart Peacock, Canadian Centre for Applied Research in Cancer Control (ARCC), University of British Columbia, 675 West 10th Avenue, V5Z 1L3, Vancouver, BC, Canada, speacock@bccrc.ca

Priority setting in health care involves managers and doctors making decisions about which drugs and health technologies to fund from their limited budgets. This paper will review the burgeoning use of Multi-Criteria Decision Analysis (MCDA) within the Program Budgeting and Marginal Analysis priority setting framework. Particular attention will be given to international consistencies and controversies in: the decision criteria used in priority setting; the methods used to elicit criteria weights; and, the type of aggregation rule used to combine criteria scores.

3 - Design of Appointment Systems for Outpatient Clinics with Scheduled and Unscheduled Arrivals

Maartje Zonderland, Stochastic Operations Research, University of Twente, Citadel H-127, Postbox 217, 7500AE, Enschede, Netherlands, m.e.zonderland@utwente.nl, *Nikky Kortbeek*, *Richard Boucherie*, *Nelly Litvak*

Outpatient clinics and diagnostic testing facilities traditionally provide patients with individual appointments to balance workload. Disadvantages however, include patients needing to revisit the hospital, an involved planning process and potentially long access times. This study explores the viability of various walk-in based policies. We present a stochastic method that finds the mixed strategy that optimally balances the benefits and drawbacks of pure appointment and walk-in policies.

■ MB-31

Monday, 10:40-12h00

8.2.15

Societal Complexity, City and Economy

Stream: Methodology of Societal Complexity

Invited session

Chair: *Cathal Brugha*, Management Information Systems, University College Dublin, Quinn School of Business, Belfield, 4, Dublin 4, Ireland, Cathal.Brugha@ucd.ie

1 - The identity of a city

Zbigniew Kesk, Architecture, University of Technology, Podchorznych1, Krakow, Poland, zbigniewkesek@interia.pl

This paper will be concerned with the event considered as a creation of new opportunities for experiencing urban space; with the transition from the concept of a city as a static entity to the vision of a city as a kinetic entity. The main shift in thinking of town planners and architects, inspired by the theories of physicists and philosophers, consists in the belief, that apart from the flow of people and images, also architecture is a kinetic component of the city; that it is the event — and not form or style — that is the basis for thinking about architecture.

2 - A multivariate study of social change in Canterbury

Ajije Xie, Kent Business School, University of Kent, F4/G, The Pavilion, Woolf College, Giles Lane, CT2 7BQ, Canterbury, Kent, United Kingdom, ax3@kent.ac.uk, *Cecilio Mar Molinero*

In 1979, a new government in the UK decided to allow tenants of council houses to buy their properties. Many took up mortgages and bought their houses, only to be caught by increased interest rates, and were forced to sell the houses they had just bought. This resulted in many social changes in urban areas. In this research we trace the changes that took place in Canterbury using the 1981 Census (before the changes), the 1991 Census (during the changes), and the 2001 Census (after the changes). We use three-way scaling techniques combined with regression analysis to deal with a large and complex data set.

3 - Why Bubble Economy Occur and Bubble Economy Destroy

Eizo Kinoshita, urban science, Meijo University, 4-3-3,nijigaoka, 509-0261, kani, gifu, Japan, kinoshit@urban.meijo-u.ac.jp

This paper shows that there are two different phases in economics. These are the primal and dual problems. In the primal problem phase, capital expenditures of private corporations grow, creating an impetus towards the maximization of profits (the spirit of capitalism, as explained by Max Weber). In this case, as Adam Smith once wrote, the "invisible hand of God" works to lead the economy to a significant growth. This paper defines the concept of Economic Growth, Bubble Economy and Destruction of Bubble Economy. And this paper describes that why bubble Economy occur and Bubble Economy Destroy. In the process, the paper shows that Primal Economy exists before Bubble Economy and Dual Economy exist after Destruction of Bubble Economy.

4 - The Actors of the Credit Crisis reflected by the Compram Methodology

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

The credit crisis is a complex societal problem in which many phenomena and actors are involved. If one wants to analyze the causes of this problem, try to stabilize the situation and prevent new fall backs, a multi-disciplinary approach is prescribed. A careful analysis based on the scientific methodology of societal complexity is needed in order to find how the credit crisis happened and how new crises can be prevented. Theories of multiple disciplines must be used by a multi disciplinary team to analyze the situation and to find sustainable options. This process can be accomplished by following the Compram Methodology of DeTombe. The Compram Methodology provides a framework for policy making which includes many methods and tools. The Compram Methodology is specialized to handle complex interdisciplinary world-wide problems and to offer a step-by-step approach of analyzing the problem, finding and implementing sustainable interventions and evaluating the effects. The Compram methodology offers a bird's-eye view on the complexity of the problem and gives direction to policy makers to build their decisions on using a multi-disciplinary, multi-actor approach. In this article the credit crisis is discussed in relation with the Compram Methodology. Aspects of the credit crisis are described with an emphasis on the role of the actors. Based on the Compram Methodology direction can be provided for handling the credit crisis and avoiding future similar problems.

■ MB-32

Monday, 10:40-12h00
8.2.17

OR in Forestry I

Stream: OR in Agriculture and Forest Management
Invited session

Chair: *Andrés Weintraub*, University of Chile, Santiago, Chile, aweintra@dii.uchile.cl

1 - Optimal weights in route distance generation

Mikael Rönnqvist, Department of Finance and Management Science, Norwegian School of Economics and Business Administration, NO-5045, Bergen, Norway, mikael.ronnqvist@nhh.no, *Patrik Flisberg*, *Bertil Lidén*

Contracts between transporters and forest companies are often based on the driven distance. However, this distance can often be hard to agree on because of many attributes e.g. length, quality, width, speed limits, etc. We present an approach to find a set of optimal weights for more than 30 attributes. An important part is a set of detailed "Solution routes" where the forest companies and transporters have agreed. Then an optimization model is formulated where the main variables are the weights on each attribute. Results and experiences from an industrial implementation are reported.

2 - Dynamic log yard designs for an improved coordination of sawmill and log yard operations

Luc LeBel, Sciences du bois et de la forêt, université laval, 2405 de la terrasse, g1v 0a6, Quebec, Quebec, Canada, luc.lebel@sbf.ulaval.ca, *Daniel Beaudoin*

Sawmills have traditionally kept high level of inventory in their yards for seasonal considerations. We attempt to find the optimal assortments to store through a Forward-Reserve Problem (FRP). The classical FRP was extended to a multi-period FRP in the context of a divergent process industry. The multi-period context allows for changes in assignments to the forward area as market conditions change. In order to account for the divergent nature of the industry, the FRP formulation has been extended to anticipate production at the mill based on known demands and market anticipation functions.

3 - A solution of the cable corridor layout problem for harvesting under steep slope conditions

Leo Bont, Institute of Terrestrial Ecosystems, CH-8092, Zürich, leo.bont@env.ethz.ch, *Hans Rudolf Heinemann*, *Richard Church*

The spatial layout of forest harvesting systems is a task which highly affects operational efficiency. Under steep slope conditions cable systems have been used for timber extraction, being laid out by rules of thumb, especially in Europe. Here we introduce a modelling approach for the cable corridor layout problem, assuming that the road network is given. We formulated the problem as a set cover mixed integer programming problem. Our approach will be useful for assessing layouts for different cable systems and to investigate the effectivity of road network layout for cable systems.

4 - Mixed Integer Programming Models to Evaluate Integrating Strategies for Value Chain Management: a Case Study of the Chilean Forest Industry

Andrés Weintraub, University of Chile, Santiago, Chile, aweintra@dii.uchile.cl, *Juan José Troncoso*, *Sophie D'Amours*, *Mikael Rönnqvist*

We present a mixed integer programming model to evaluate two different integration strategies in order to show the impacts of a fully demand driven integration of the value chain in the forest industry. To illustrate our thoughts, we use forest, economic and production information from a Chilean forest company. We compare two different integration strategies: the first one where the forest and the industry planning are decoupled and the second, where all parts of the value chain (forest, transportation, mills) are driven by final product demand.

■ MB-33

Monday, 10:40-12h00
8.2.19

Energy Policy and Planning

Stream: Energy, Environment and Climate [c]
Contributed session

Chair: *Sandrina Pereira*, IDMEC-IST, Avenida Rovisco Pais, Pav. Mecânica, 2º andar, 1049-001, Lisboa, Portugal, sandrinapereira@ist.utl.pt

1 - Decision Support System for Low Carbon Regions

Sandrina Pereira, IDMEC-IST, Avenida Rovisco Pais, Pav. Mecânica, 2º andar, 1049-001, Lisboa, Portugal, sandrinapereira@ist.utl.pt, *Anildo Costa*

This paper analyse the usefulness of Scenario Building and Analysis - SBA and simulation models such as Agent Based Models — ABM, as methods to develop energy policies and pathways towards Low Carbon Region - LCR. SBA can illustrate the influence of technology in GHG reduction but technology evolution by itself will not be enough to achieve LCR. Also, energy consumption is influenced by consumer's behaviour and social values which are better captured by ABM. A methodology to achieve LCR based on SBA (to assess technology) and ABM (to assess influence of society behaviour) will be described

2 - Energy Indicators for Sustainable Development

Athanasios Angelis-Dimakis, Chemical Engineering, National Technical University of Athens, Heron Polytechniou 9, Zografou Campus, 15780, Athens, Greece, angelis@chemeng.ntua.gr, *George Arampatzis*

Energy planning for sustainable development at regional and national level is a basic priority for every country. The scope of this paper is to develop a set of indicators in order to assess the economic, social and environmental aspects of an energy system's sustainable development. Those indicators give an overall picture of a country's energy system. Furthermore, as they fluctuate over time they will be good markers of progress and underlying changes and will guide decision-making on investments in energy. The set of indicators will be applied to the case of the Greek Energy System.

3 - An n-K Contingency-Constrained Unit Commitment Model via Robust Optimization

Fabrcio Oliveira, Industrial Engineering, PUC-Rio, Av. Marquês de S. Vicente s/n, Gávea, 22453-900, Rio de Janeiro, Rio de Janeiro, Brazil, fabrcio.carlos.oliveira@gmail.com, *Alexandre Street*, *José Manuel Arroyo*

This paper presents a new approach for the contingency-constrained unit commitment problem. The model incorporates an n-K security criterion by which power balance is guaranteed under any contingency state comprising the simultaneous loss of up to K units. Instead of considering all possible contingency scenarios, which would render the problem intractable, a novel scenario-free formulation based on robust optimization is proposed. Unlike scenario-based approaches, the robust model does not depend on the size of the set of contingencies, thus providing a computationally efficient framework.

■ MB-34

Monday, 10:40-12h00
8.2.23

Solution Approaches for Lot-sizing Problems II

Stream: Lot-sizing and Scheduling, Economic Order Quantity

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.loba@fe.up.pt

1 - An Efficient Computational Method for Non-Stationary (R,S) Inventory Policy with Service Level Constraints

Mustafa Dogru, Bell Labs, Alcatel-Lucent, BLANCHARDSTOWN INDUSTRIAL PARK, 15, DUBLIN,

Ireland, mustafa.dogru@alcatel-lucent.com, *Armagan Tarim, Ulas Ozen, Roberto Rossi*

This paper provides an efficient computational approach to solve a mixed integer programming (MIP) model developed for calculating the parameters of an (R,S) policy in a finite horizon with non-stationary stochastic demand and service level constraints. Given the replenishment periods, we characterize the optimal order-up-to levels for the MIP model and use it to guide the development of a relaxed MIP model, which can be solved in polynomial time. Extensive numerical tests show that our method dominates the MIP solution approach and can handle real-life size problems in trivial time.

2 - Multi-Product Single-Stage Lot Sizing with Random Yield, Imperfect Inspection, Process Compressibility, and Partial Backordering

D. Moradinezhad, industrial engineering, iran university of science and technology, no. 9, Zamani Alley, Nejatollahi Ave, Karimkhan St., Tehran, Tehran, Iran, Islamic Republic Of, dmcatonia@gmail.com, *M.b. Aryanezhad, E. Noorollahi, M. Karimi-Nasab, Seyed Mohammad Ghoreyshi*

Production planning with real world assumptions is a complicated issue for production managers. This paper develops an economic production quantity model for a multi-product single-stage production system under several working conditions / assumptions. The proposed model is proposed to determine decision variables such as cycle length, batch size of each product type for every production run, backorder, regular production rate, and rework rate simultaneously. Computational experiences induce that both model and the algorithm have high performance even in the worst cases.

3 - Heuristic approaches for a practical lot splitting and scheduling problem

Carina Pimentel, Departamento de Produção e Sistemas, Universidade do Minho, Campus de Gualtar, Portugal, 4710-057, Braga, Braga, Portugal, carina@dps.uminho.pt, *Filipe Alvelos, António Duarte, J. M. Valério de Carvalho*

In this talk we present some heuristic approaches for a real world lot splitting and scheduling problem of a Textile factory. The problem consists of finding a weekly production plan for the knitting section of the company, establishing the quantities to produce of each component (organized in one or several lots), and where and when (starting/completion times) to produce them. Two important objectives to achieve are on time delivery of products and minimum levels of work-in-process inventory. We present some results for a set of randomly generated instances based on real world data.

4 - Multi-plant, multi-period and multi-item capacitated lot-sizing problem in beverage industry

Luis Guimarães, DEMEGI, FEUP, Portugal, luis.santos.guimaraes@gmail.com, *Bernardo Almada-Lobo*

In some process industries joint lotsizing and scheduling is known to be vital in order to achieve feasible and effective production plans. Moreover, when facing a multi-plant scenario coordination between plants can make a substantial difference towards more efficient planning. Inspired by a real case-study in the beverage industry we develop a novel formulation and a new heuristic for the multi-plant, multi-period and multi-item capacitated lotsizing problem where transfers between plants are allowed and sequence dependent setup times and costs are considered in a rolling horizon approach.

■ MB-35

Monday, 10:40-12h00

6.2.46

Soft OR and Problem Structuring Methods I

Stream: Soft OR and Problem Structuring Methods

Invited session

Chair: *Colin Eden*, Management, University of Strathclyde, 199 Cathedral Street, G4 0QU, Glasgow, United Kingdom, colin@gsb.strath.ac.uk

1 - Enabling Politically Feasible Agreements: what is a group?

Colin Eden, Management, University of Strathclyde, 199 Cathedral Street, G4 0QU, Glasgow, United Kingdom, colin@gsb.strath.ac.uk, *Paul Nutt, Fran Ackermann*

Involving many group participants meets, (i) the need to tap into a range of different areas of expertise and perspectives, and (ii) the importance of gaining ownership for the outcome(s) among all those who can influence the implementation of agreements. This presentation discusses these issues.

2 - Problem structuring for investing in an uncertain future

Colin Eden, Management, University of Strathclyde, 199 Cathedral Street, G4 0QU, Glasgow, United Kingdom, colin@gsb.strath.ac.uk

Developing an appropriate problem structure for public policy issues that have very long term consequences (20-30yrs) has particular challenges. This presentation discusses the issues and possibilities in undertaking such a task.

3 - Using the Theory of Constraints to resolve conflicts in a large public hospital

Vicky Mabin, Victoria Management School, Victoria University of Wellington, PO Box 600, Wellington, 6140, Wellington, New Zealand, vicky.mabin@vuw.ac.nz, *Sally Babington, Vanessa Caldwell, Julie Yee*

Hospitals typically struggle to meet demand for services within limited budgets. Significant and long-standing tensions exist. This paper provides an analysis of a large public hospital using the Theory of Constraints, to build an understanding of the many cause and effect and necessity relationships that exist in such complex organisational settings. In this case, the root cause of the long-standing conflicts in the hospital system are mapped, solutions suggested, tested and implementation planned.

4 - Systematic and Comprehensive Supply Chain Environmental Management

Joana M. Comas Marti, TOM, EPFL, Station 5, 1015, Lausanne, Switzerland, joana.comas@epfl.ch, *Ralf W. Seifert*

Stakeholders are increasingly demanding businesses to manage environmental issues taking a supply chain or life cycle approach. Supply chain environmental management (SCEM) has arisen as a result. We contribute to the field with a framework for the systematic and comprehensive definition and assessment of SCEM strategies. We structure it in 3 dimensions: what, why and where, i.e. the action taken, the environmental impact being addressed with it, and the supply chain or life cycle stage where that impact takes place. We apply this framework to assess 12 sustainability leaders in 6 sectors.

■ MB-36

Monday, 10:40-12h00

3.1.05

Fuzzy Goal Programming 1

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence

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 - A Fuzzy Multi-objective Approach for Master Planning in Ceramic Tile Supply Chains

Josefa Mula, Business Management, Polytechnic University of Valencia, Escuela Politécnica Superior de Alcoy, Plaza Ferrándiz y Carbonell, 2, 03801, Alcoy, Alicante, Afghanistan, fmula@cigip.upv.es, *David Peidro, Mareva Alemany, Francisco Lario Esteban*

We propose a fuzzy multi-objective linear programming (FMOLP) approach to model a centralized replenishment, production and distribution problem for ceramic tile supply chains. We also present an interactive solution methodology to convert this FMOLP model into an auxiliary crisp single-objective linear model and to find a preferred compromise solution in an interactive fashion. For illustration purposes, an example based on modifications of real-world industrial problems is presented.

2 - An Application of Goal Programming in Personnel Selection Decisions

Lourdes Canos, Organizacion de Empresas, Universidad Politecnica de Valencia, Crtra. Nazaret-Oliva s/n, 46730, Grao de Gandia (Valencia), Spain, loucada@omp.upv.es, *Maria J. Canos*, *Vicente Liern*

The candidate selection process for a job can be seen as a decision problem in which some competences, valued under uncertainty, have to be optimized. When the number of candidates is high, the selection process has two or more phases. In the first stages of the process, establishing goals for some attributes makes a quicker and more effective election. In this paper we present some fuzzy logic based algorithms to solve this problem. We illustrate our approach with some numerical examples whose solution has been obtained by using software developed by the authors.

3 - Weight and Parameter Space Exploration in Fuzzy Goal Programming

Dylan Jones, Mathematics, University of Portsmouth, Lion Terrace, PO9 3HE, Portsmouth, Hampshire, United Kingdom, dylan.jones@port.ac.uk

Fuzzy goal programming model is characterised by a number of weights and parameters that need to be set by the decision maker. This seminar explores effective means for setting those weights and parameters. The nature of weight space in different goal programming variants is discussed. Means of effectiveness exploration and categorisation of weight and parameter space are given. Practical means of conducting weight and parameter sensitivity analysis in fuzzy goal programming are discussed.

4 - Ordinary Goal Programming with Fuzzy Aspiration Levels

Mariano Jimenez-Lopez, Economía Aplicada I, University of the Basque Country, Plaza de Oñati 1, 20018, San Sebastian, Spain, mariano.jimenez@ehu.es

Fuzzy sets help to express imprecise knowledge in a natural way. I mix ordinary goal programming with the representation of aspiration levels by fuzzy sets. I look for the minimum distance to these fuzzy sets, instead of, like in the case of fuzzy goal programming, looking for the better satisfaction degree. Therefore I accept solutions that surpass the tolerance thresholds. With this approach the shape of the penalty functions is generated intuitively and the membership degree of fuzzy aspiration levels can be used, in an interactive way, in order to look for a more equilibrated solution.

■ MB-37

Monday, 10:40-12h00

3.1.09

Humanitarian Logistics

Stream: OR for Development and Developing Countries
Invited session

Chair: *Begoña Vitoriano*, Estadística e Investigación Operativa I, Fac. CC. Matemáticas, Universidad Complutense de Madrid, Plaza de Ciencias, 3, Ciudad Universitaria, 28040, Madrid, Spain, bvitoriano@mat.ucm.es

1 - Rule-based assessment of disaster's consequences in a bipolar possibilistic framework

J. Tinguaro Rodriguez, Department of Statistics and Operational Research, Complutense University of Madrid, Plaza de Ciencias, 3, 28040, Madrid, Spain, jtrodrig@mat.ucm.es, *Javier Montero*, *Begoña Vitoriano*

A decision support system useful to assess consequences of disasters with the very first available information just after the strike, usually incomplete and not fully reliable, is presented in this work. This DSS is based on a rule-based learning model focused on interpretability. The output of the system is a bipolar possibility distribution assessing both the evidential support for and the plausibility (in the sense of not being excluded) of the available linguistic outputs. This enables a more expressive representation of uncertainty and knowledge about inferred consequences of disasters.

2 - Measuring Risk Factors in Humanitarian Aid Distribution

Begoña Vitoriano, Estadística e Investigación Operativa I, Fac. CC. Matemáticas, Universidad Complutense de Madrid, Plaza de Ciencias, 3, Ciudad Universitaria, 28040, Madrid, Spain, bvitoriano@mat.ucm.es, *M. Teresa Ortuno*, *Gregorio Tirado*

Natural disasters are phenomena that strike countries, which sometimes request help from the rest of the world. International organizations respond organizing relief operations, which usually have to be developed in an atmosphere of uncertainty which risks the operation success. Humanitarian aid distribution is usually performed with limited resources to know if it is possible to deliver the planned amount, or under uncertainty about the road state, or, sometimes, under low security conditions with some risk of being hijacked. A goal programming model including these criteria is presented.

3 - Combining distribution and recovery operations in Humanitarian Logistics

Federico Liberatore, Kent Business School, University of Kent, Annexe, CT2 7PE, Canterbury, United Kingdom, fl51@kent.ac.uk, *Begoña Vitoriano*, *M. Teresa Ortuno*, *Gregorio Tirado*, *Maria Paola Scaparra*

The distribution of emergency goods to a population affected by a disaster is one of the most fundamental operations in Humanitarian Logistics. In the case of a particularly disruptive event, parts of the distribution infrastructure (e.g. bridges, roads) can be damaged. This damage would make it impossible and/or unsafe for the vehicles to reach all the centers of demand (e.g. towns and villages). In this paper, we propose and solve the problem of planning for recovery of damaged elements of the distribution network, so that the consequent distribution scheme would be optimal.

4 - Infrastructure and good governance as key elements to equity and economic growth in Sub Saharan Africa

Moses Dowart, Department of Applied Mathematics, National University Of Science and Technology (NUST), 8327 unit k seke Chitungwiza Harare Zimbabwe, 263, Harare, Zimbabwe, Zimbabwe, mdowart@gmail.com

Africa, a continent endowed with immense natural and human resources as well as great cultural, ecological and economic diversity, remained underdeveloped. In this paper we analyse infrastructure and good governance as key elements to equity and economic growth in sub saharan Africa. We construct a simple endogenous growth model with an exhaustible natural resource element, read-dressing empirically the question of whether natural resources have a positive or negative effect on growth.

Key Words: Economic Growth, Infrastructure, Good Governance, Sub Saharan Africa.

■ MB-38

Monday, 10:40-12h00

6.2.44

Advances in Economical and Financial Theory

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

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - The visual exploration and grouping of EU member states according to Structural Indicators: a data-driven approach

Jasna Soldic-Aleksic, Department of Statistics, Faculty of Economics, Kamenicka 6, 11000, Belgrade, Serbia, Serbia, jasnasoldic@eunet.rs

This study applies Kohonen Self-Organizing Map for a visual exploration of the convergence of EU member states in the light of Structural Indicators for different economic and social domains. Currently the SIs set comprises 79 indicators. We want to acquire a general picture of the current status of EU member states. In this respect we have applied several standard univariate and multivariate data analysis techniques. The original SIs were replaced by fewer extracted factors. In addition, we produced six separate maps based on each SI dataset.

2 - The correlation risk premium in the recent financial turmoil

Chrysi Markopoulou, Management Science and Technology, Athens University of Economics and Business, 47A Evelidon str, Athens, Attica, Greece, cmarkopoulou@aueb.gr, *Spyros Xanthopoulos*, *Apostolos Refenes*

Accurate estimation of correlation risk premium is of paramount importance in asset allocation and risk management. There is growing literature that discusses the pricing of the correlation risk as well as the magnitude of the correlation risk premium. Moreover, a number of studies have provided evidence of increasing correlation during periods of high volatility. In this paper we examine and evaluate the behavior, the properties and the forecasting performance of the implied correlation risk premium using data on the Dow Jones Industrial Index options during the financial crisis of 2007-2009.

3 - The definition of customer churn in a non-contractual setting

Susana San Matías, Departamento de Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Edificio 7A, Camino de Vera, s/n, 46022, VALENCIA, Spain, ssanmat@eio.upv.es, *Mónica Clemente*

Churn is probably one of the most classical questions addressed by the field of marketing using data mining tools. The problem arises when a definition of churn has to be implemented in a non-contractual setting, because there is not a variable into the database that indicates when a customer is leaving. Several approaches to this issue can be found in the literature. Which is the most adequate definition of churn in such a context? In this paper we present, discuss and compare using objective criteria a large set of different definitions and we analyze the advisability of their application.

■ MB-39

Monday, 10:40-12h00
6.2.45

Set-Valued Analysis for Control Problems

Stream: Optimal Control

Invited session

Chair: *Robert Baier*, Department of Mathematics, University of Bayreuth, Chair of Applied Mathematics, D-95440, Bayreuth, Germany, robert.baier@uni-bayreuth.de

1 - Discrete Approximation of Differential Systems with Variable Time Impulses

Robert Baier, Department of Mathematics, University of Bayreuth, Chair of Applied Mathematics, D-95440, Bayreuth, Germany, robert.baier@uni-bayreuth.de, *Tzanko Donchev*

Impulsive systems are differential equations or inclusions with jump conditions which force a piecewise defined solution to jump, if it hits one of the switching surfaces. To prove convergence order 1 for the set-valued Euler discretization, the beating phenomena must be avoided. An adapted Filippov-Gronwall lemma is the basis of this analysis.

Several examples with numerical calculations including a set-valued version of the bouncing ball problem illustrate the results. Extensions to higher order Runge-Kutta methods with an adequate approximation of the jump times are discussed.

2 - Collision avoidance using reachable sets

Matthias Gerds, Department of Mathematics, University of Wuerzburg, Am Hubland, 97074, Wuerzburg, Germany, gerds@mathematik.uni-wuerzburg.de

This talk discusses an application from the automotive industry and addresses the problem of detecting whether a collision with an obstacle will occur or not. An approach towards this problem is to use reachable set information for non-linear control systems. For, if the reachable set of a car in a certain situation is known (at least approximately), then it is easy to decide whether a collision will occur or can be avoided by appropriate controls. The reachable sets are computed by appropriately formulated optimal control problems, which are solved by a direct discretization method.

3 - Semiconcavity of the value function for a class of differential inclusions

Peter Wolenski, Mathematics, Louisiana State University, LSU, 70803, Baton Rouge, Louisiana, United States, wolenski@math.lsu.edu

We consider the Mayer problem in optimal control in which the dynamics are in the form of a differential inclusion. The associated value function is known to be semiconcave if the velocity set has a smooth enough parametrization, but this is a difficult property to ascertain for general multifunctions. We provide new intrinsic sufficient conditions on a multifunction and the endpoint data so that the value function is semiconcave.

4 - Operations on Sets and Approximation of Set-Valued Mappings

Elza Farkhi, School of Math. Sciences, Tel-Aviv University, Haim Levanon Str., 69978, Tel Aviv, elza@post.tau.ac.il

The approximation of set-valued maps appears in numerical control and optimization. Approximation operators on such maps are constructed in two ways: 1. Indirectly, by single-valued representations of sets. Then operators on sets are reduced to their representing functions. We discuss examples of representations of convex or 1D sets and the corresponding set-valued approximations. 2. Directly, by operations on sets. Here, the metric sum and average of sets are applied to numerical set-valued integration and approximation of special trajectories of differential inclusions.

■ MB-40

Monday, 10:40-12h00
6.2.52

Network design 1

Stream: Network Optimization

Invited session

Chair: *Luis Gouveia*, DEIO, University of Lisbon, Campo Grande, Bloco C6, 1749-016, Lisbon, Portugal, legouveia@fc.ul.pt

1 - The Generalized Regenerator Location Problem

Ivana Ljubic, Department of Statistics and Decision Support Systems, University of Vienna, Bruennerstr. 72, 1210, Vienna, Austria, ivana.ljubic@univie.ac.at, *Si Chen*, *S. Raghavan*

In the generalized regenerator location problem (GRLP), we are given a set S of potential regenerator locations and a set T of terminal nodes that want to communicate with each other. A signal can only travel a maximum distance before its quality deteriorates. Therefore, regenerators need to be installed at nodes from S to enable communication between nodes from T at minimum cost. We model the problem as the (node-weighted) directed Steiner forest problem (NWDSF). We provide several MIP formulations for both, NWDSF and GRLP, and compare them theoretically and computationally.

2 - Benders decomposition for the hop-constrained survivable network design problem

Quentin Botton, Louvain School of Management - CORE, Université catholique de Louvain, place des doyens, 1, 1348, Louvain-la-Neuve, Belgium, quentin.botton@uclouvain.be, *Bernard Fortz*, *Luis Gouveia*, *Michael Poss*

Given a graph with nonnegative edge weights and a set of pairs of nodes Q , we study the problem of constructing a minimum weight set of edges so that the induced subgraph contains at least K edge-disjoint paths containing at most L edges between each pair in Q . We present the first formulation for the problem valid for any K and L . We use a Benders decomposition method to handle the big number of variables and constraints. We present a thorough computational study of various cutting plane and branch-and-cut algorithms on a large set of instances including the real based instances from SNDlib.

3 - Combining Column Generation and Local Search Heuristics for the Load Balancing Optimization of Telecommunication Networks

Dorabella Santos, Instituto de Telecomunicações - Pólo de Aveiro, Campus de Santiago, Aveiro, 3810-193, Aveiro, dorabella@av.it.pt, *Amaro de Sousa, Filipe Alvelos*

We address the problem of routing a set of traffic flows over a capacitated telecommunications network (we assume single path routing). The aim is to optimize the network load balancing using the min-max optimization of link loads. We propose the combination of column generation with local search based heuristics where the columns given by column generation define the search space for the local search. Using the lower bounds of column generation, we show through computational results that our proposal is very efficient in providing good quality feasible solutions in short computing times.

4 - A Branch-And-Cut Algorithm for the Partitioning-Hub Location-Routing Problem

Daniele Catanzaro, Computer Science, Université Libre de Bruxelles, Boulevard du Triomphe CP210/01, 1050, Brussels, Belgium, dacatanz@ulb.ac.be, *Martine Labbé, Aykut Ozsoy*

We introduce the Partitioning-Hub-Location-Routing Problem (PHLRP), a hub location problem involving graph partitioning and routing features. The PHLRP consists of partitioning a given network into sub-networks, locating at least one hub in each sub-network and routing the traffic within the network at minimum cost. This problem finds applications in deployment of an Internet Routing Protocol called Intermediate System - Intermediate System (ISIS), and strategic planning of LTL ground freight distribution systems. We describe an Integer Programming (IP) formulation for solving the PHLRP and explore possible valid inequalities to strengthen it. Computational experiments prove the effectiveness of the model and the valid inequalities which allow exact analysis for the PHLRP instances containing up to 20 vertices.

■ MB-41

Monday, 10:40-12h00

3.1.06

Behavioral Models in Revenue Management

Stream: Revenue Management

Invited session

Chair: *Tatsiana Levina*, School of Business, Queen's University, 143 Union str, K7L 3N6, Kingston, Ontario, Canada, tlevin@business.queensu.ca

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

1 - Strategic Bidders Club: Implications for Consumer Learning

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 develop a model of strategic consumer learning of bidding strategies in a market for opaque products, obtain the optimal strategies for the consumers, and study their properties. The effects of consumer cooperation on learning are examined and compared under two different scenarios: exchange of information only and exchange of information with coordinated bidding.

2 - Optimal Keyword Bidding to Allocate Expenditures Across Keywords: A Stochastic Optimization Analysis

Ozgur Ozluk, College of Business, San Francisco State University, 1600 Holloway Avenue, 94132, San Francisco, CA, United States, ozgur@sfsu.edu, *Susan Cholette, Mahmut Parlar*

Today, keyword advertising on the web pages of search engines is a predominant venue for advertising online. Advertisers bid for keywords, where bid price determines ad placement, which in turn affects the response function, defined as the click-through rate. Advertisers typically have a fixed daily budget that should not be exceeded, so an advertiser must allocate the budget as productively as possible by selecting which keywords to use and then deciding how much to allocate for each keyword. We construct and examine a stochastic model for this selection and allocation process.

3 - Empirical Investigation of Strategic Buyer and Seller Behavior in the Wait-or-Buy Game

Anton Ovchinnikov, Darden School of Business, University of Virginia, 100 Darden Blvd, 22903, Charlottesville, VA, United States, Ovchinnikova@darden.virginia.edu

We discuss a laboratory experiment — the wait-or-buy game - in which some subjects (business school students) are playing strategic buyers and others are playing revenue managers (sellers.) We describe the systematic biases in the behaviors of both buyers and sellers, as well as suggest how firms might adjust their revenue management strategies in order to capitalize on the buyers' biases and protect themselves against sellers' biases. We also discuss the implication of this empirical analysis on creating more accurate models of strategic consumer behavior.

4 - Selling to Heterogeneous Customers with Uncertain Valuations under Returns Policies

Qian Liu, IELM, HKUST, Hong Kong, qianliu@ust.hk, *Wenqiang Xiao*

We consider a firm that sells a product with finite capacity to a random market size. Each customer's valuation of the product includes an intrinsic value privately known by him before purchase and the ex ante uncertain product fitness revealed to him after purchase. In contrast to the established screening result with unlimited capacity, we show that offering a menu of return contracts simultaneously is not optimal with finite capacity. The firm is better off by offering a menu of return contracts sequentially, i.e., offering one at a time.

■ MB-42

Monday, 10:40-12h00

3.1.07

Mathematical Programs with Complementarity Constraints

Stream: Variational Inequalities, Complementarity Problems and Bilevel Programming

Invited session

Chair: *Joaquim Judice*, Dept. Mathematics, University of Coimbra, Largo D. Dinis, 3000, Coimbra, Portugal, Joaquim.Judice@co.it.pt

1 - Strong Stability in MPCC

Vladimir Shikhman, Dept. Mathematics, RWTH Aachen University, Templergraben 55, 52056, Aachen, Germany, shikhman@mathc.rwth-aachen.de, *Hubertus Th. Jongen, Jan-J. Rückmann, Sonja Veelken*

We study mathematical programs with complementarity constraints (MPCC). Special focus will be on C-stationary points. Under LICQ we characterize strong stability of C-stationary points (in the sense of Kojima) by means of first and second order information of the defining functions. The strong stability of C-stationary points allows a possible degeneracy of bi-active Lagrange multipliers. We relate our results to the critical point theory for MPCC discussing the notions of a non-degenerate C-stationary point and its C-index.

2 - On the formulation and solution of a traffic Linear Program with Complementarity Constraint

Isabel Ribeiro, Engenharia Civil (SMF), FEUP, Rua Dr. Roberto Frias, s/n, 4200-465, Porto, Portugal, iribeiro@fe.up.pt, *Maria Lurdes Simões*

A queuing system resulting from a signalized intersection regulated by pre-timed control in urban traffic network is considered. In this talk, we show how Global Optimization and Complementarity can be used to find the optimal cycle length and green split allocation for an isolated signalized intersection. The model is formulated as a Linear Program with Complementarity Constraints (LPCC). A sequential complementarity algorithm for computing a global minimum for the LPCC is analysed. Computational experience is included to highlight the efficacy of this method for processing this problem.

3 - The Asymmetric Eigenvalue Complementarity Problem: Theory and Algorithms

Joaquim Judice, Department of Mathematics, University of Coimbra, Largo D. Dinis, 3000, Coimbra, Coimbra, Portugal, Joaquim.Judice@co.it.pt, *Silvério Rosa*

Given a real matrix A and a real (symmetric or asymmetric) Positive Definite matrix B , the Eigenvalue Complementarity Problem (EiCP) is an extension of the well-known Generalized Eigenvalue Problem $GEiP(A,B)$ where the variables of the problem are required to be nonnegative and have to satisfy a complementarity constraint. In this talk the most difficult case is analysed, where at least one of matrices A or B of the EiCP is asymmetric. It is shown that the EiCP reduces to a Finite-Dimensional Variational Inequality, to a Mathematical Programming Problem with Linear Complementarity Constraints and to a Global Optimization Problem. Based on these reductions, necessary and sufficient conditions for the existence of a solution to the EiCP are established. A projected gap-function method and an enumerative algorithm are introduced for finding a solution to the asymmetric EiCP. The computation of several complementary eigenvalues and of the maximum and minimum of these eigenvalues is also discussed. Computational experience is reported to illustrate the efficiency of the algorithms to deal with the asymmetric EiCP.

4 - Dynamics of equilibrium problems: a hybrid systems approach

Monica-Gabriela Cojocar, mathematics & statistics, University of Guelph, Guelph, Ontario, Canada, mcojocar@uoguelph.ca

We relate variational inequalities, noncooperative games and hybrid dynamical systems so as to describe the *_disequilibrium_* evolution of an equilibrium problem (e.g. a dynamic network equilibrium problem or a dynamic game). To describe it, we use a hybrid system with a switch & jump mechanism between continuous dynamic states given by a differential equation. The hybrid system also provides a way to analyze stability issues of hybrid solutions w.r.t. the problem's equilibrium states. We apply the ideas to modelling population groups' strategies playing a noncooperative vaccinating game.

■ MB-43

Monday, 10:40-12h00

8.2.02

Algorithmic Decision Theory 2

Stream: Algorithmic Decision Theory

Invited session

Chair: *Alexis Tsoukiàs*, CNRS - LAMSADE, Université Paris Dauphine, 75775, Paris Cedex 16, France, tsoukias@lamsade.dauphine.fr

1 - Constructing indexes: poverty measurement

Alexis Tsoukiàs, CNRS - LAMSADE, Université Paris Dauphine, 75775, Paris Cedex 16, France, tsoukias@lamsade.dauphine.fr, *Vivien Kana*

In this paper we present a general approach on how to construct indicators aimed at being used in conceiving, implementing and evaluation public policies. The basic idea consists in using unsupervised and supervised classification procedures in such a way that the policy maker can construct an indicator useful for the specific policy to pursue. The case of "poverty measurement" is then discussed.

2 - The quality of life in Milano: a rating analysis

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*

The association MeglioMilano has been conducting for the past 20 years an Observatory of the Quality of Life in Milano. MeglioMilano created a year-by-year historical dataset in order to compare the city with itself. This year, the authors proposed a classification of the years based on based on the Electre tri outranking rating method. For the elicitation of the parameters (thresholds and criteria weights), 19 experts have been interviewed. The core of the method is to determine if there are enough reasons in favor and no vetoes as regards a statement like "year X is placed in class Y".

3 - The value of interconnecting water sources: a real option approach

Chiara D'Alpaos, DIMEG, University of Padova, via Venezia 1, 35131, Padova, Italy, chiara.dalpaos@unipd.it

Technological innovations lead to the construction of water utilities characterized by a high operational flexibility and high irreversible sunk costs. The interconnection and integration between supply sources, in particular, enable the system to handle crisis in the provision of the service caused, for example, by pollution emergencies or peaks in day demand curves. This operational flexibility have an economic value since it gives the provider the option to strategically decide the optimal switching rule between two different water sources and maximize its profits accordingly.

4 - Comparison of alternative approaches for calculation of human development indices

Veronika Skocdopolova, Dept. of Econometrics, University of Economics Prague, Winston Churchill sq. 4, 130 67, Prague 3, Czech Republic, veronika.skocdopolova@vse.cz, *Josef Jablonsky*

The Human Development Report (HDR) is an independent report which is published every year by the United Nations Development Programme (UNDP). Since the first Report was published in 1990, four composite indices for human development have been created. Computations of these indices are multi-criteria decision problems. In this paper we compare the standard computational approaches with other quantitative methods based on multi-criteria decision making. All methods are applied on the newest data set published in 2009.

■ MB-44

Monday, 10:40-12h00

8.2.03

Portfolio Decision Analysis II

Stream: Portfolio Decision Analysis

Invited session

Chair: *Nikolaos Argyris*, Management, Operational Research Group, London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, United Kingdom, n.argyris@lse.ac.uk

Chair: *Alec Morton*, Management/ Operational Research, London School of Economics, Houghton St, London, wc2a2ae, London, England, United Kingdom, a.morton@lse.ac.uk

1 - CUT and CUTE: a new multicriteria approach for non-additive concavifiable preferences

Nikolaos Argyris, Management, Operational Research Group, London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, United Kingdom, n.argyris@lse.ac.uk, *José Rui Figueira*, *Alec Morton*

We propose a new preference aggregation-disaggregation approach for concavifiable preferences, Concave UTILITY (CUT). CUT defines a space of possible value functions consistent with a DM's expressed preferences. There is an analogy between CUT and the well-known UTA procedure: CUT is more general as it does not require that preferences are additive. CUT can be used in an interactive setting; we call this usage CUTE (CUT Elicitation) and we show how CUT might be used in pre-ordering a finite set of discrete alternatives, linear programming and combinatorial optimization.

2 - Using interactive heatmaps and parallel coordinate plots to support multi-criteria portfolio selections

Christian Stummer, Department of Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, christian.stummer@univie.ac.at, *Elmar Kiesling*, *Johannes Gettinger*, *Rudolf Vetschera*

We compare interactive heatmaps and parallel coordinate plots as decision aids for multi-criteria portfolio selection by means of an experiment conducted with students at the University of Vienna. In this experiment, each participant used one of the two methods for exploring a solution space of Pareto efficient class schedules. We describe the experimental setting, summarize results with respect to subjective user evaluations and objective measures, and report findings on the impact of decision making styles on users' attitudes towards the two methods.

3 - Using Linear and Non-Linear Programming Methods for recommendation in multicriteria sorting problems

Philippe Nemery, Department of Mathematics, University of Portsmouth, Portsmouth, United Kingdom, pnemery@gmail.com, *Alessio Ishizaka*, *Dylan Jones*

Several multicriteria decision aid procedures have been proposed to assign a set of actions to predefined classes or groups. In this work, we are interested in the following problem. Given the initial performances of an action, the aim is to analyse how that performances of an action should be enhanced efficiently (i.e., with the minimum cost) in order to be assigned into a better category. On the other hand, we may also propose an efficient saving in performances without changing the assignment result.

4 - Portfolio project management using ahp: a case study

Amanda Silva, Produção, ITA, Brazil,
amanditasimoes@gmail.com, *Mischel Carmen N. Belderrain*,
Ademilton Santos, *Eduado Inoue*, *Milton Chagas Júnior*

This work applies a Multi-criteria Decision Making method, the Analytic Hierarchic Process — AHP, for the portfolio project management. The case study was applied to foreign trade company in São Paulo, Brazil. The criteria considered are Maturity of the Project Area, Investment / Return and Product Quality. Application in a real case has shown that AHP is only useful for a pre-evaluation of the projects, since the final screening is dependent on subjective factors.

■ MB-45

Monday, 10:40-12h00
8.2.12

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 - A Sequential Decision Problem with Partial Maintenance on Partially Observable Markov Process

Toru Nakai, Faculty of Education, Chiba University, Yayoi 1-33, Inage-Ku, 263-8522, Chiba, Japan, t-nakai@faculty.chiba-u.jp

We develop an optimal maintenance policy for some products. During their life cycle, conditions which causes some troubles changes. The decision-maker does not observe this condition directly, but information is obtained through a magnitude of a trouble. These conditions change according to a Markov process. As for information, a random variable exists for a magnitude of a trouble, and improve information by employing the Bayesian learning procedure. The decision-maker decides a level of repair or maintain a faulty component with cost which is different depending on the level. This problem is formulated as a sequential decision problem on a partially observable Markov process. The dynamic programming formulation implies a recursive equation about the optimal value, and observe monotonic properties for this value.

2 - Solving the Top-percentile Traffic Routing Problem by Approximate Dynamic Programming

Xinan Yang, School of Mathematics, University of Edinburgh, 43/3 Prestonfield Avenue, EH16 5EQ, Edinburgh, Midlothian, United Kingdom, s0677435@sms.ed.ac.uk, *Andreas Grothey*

This study investigates the optimal routing strategy under multi-homing in case where network providers charge ISPs according to top-percentile pricing. It is a multi-stage stochastic problem in which decisions should be made before knowing the traffic to be shipped. Solution approaches based on SIP or DP suffer from the curse of dimensionality which restricts their applicability. To overcome this we use Approximate Dynamic Programming (ADP) which exploit the structure of the problem to construct approximations of the value function in DP. Thus the curse of dimensionality is largely avoided.

3 - Single-Leg Airline Revenue Management with Overbooking and Cancellations

Nursen Aydin, Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, nursenaydin@su.sabanciuniv.edu, *S. Ilker Birbil*, *J.b.g. Frenk*, *Nilay Noyan*

Airline revenue management (ARM) is about identifying the seat allocation policies. In this study we propose new models for static and dynamic single-leg ARM problems with overbooking and cancellations. In the static case, we introduce computationally tractable models that give upper and lower bounds for the expected optimal revenue. In the dynamic case, we propose a new dynamic programming model based on two streams of events; booking requests and cancellations. We also conduct a set of simulation experiments to illustrate the performances of the proposed models.

4 - Linear Time Exact Algorithm for Capacitor Placement on Radial Distribution Feeders

Christiano Lyra, School of Elec. and Comp. Engineering (FEEC), University of Campinas (UNICAMP), Av. Albert Einstein 400, Cidade Universitária, 13083-852, Campinas, São Paulo, Brazil, christiano@pq.cnpq.br, *José Frederico Vizcaino*, *Fábio Usberti*

The optimal capacitor allocation problem for radial power distribution feeders searches the best compromise between cost of capacitors and their benefits to decrease reactive flows on the network. Heuristic approaches dominate the scene in addressing this problem. A previous paper proposed the use of dynamic programming (DP) to find optimal solutions; however, with simplifying assumptions that restricted its application to simple examples. Here, the DP approach is extended to consider the main requirements of the problem and applied to real scale networks. It is a linear time exact algorithm.

■ MB-46

Monday, 10:40-12h00
8.2.14

OR Challenges Related to the Recent and Future Disasters II

Stream: OR for Madeira (and related challenges)

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Coupling of Dynamic Network Flows and a Cellular Automaton for Evacuation Modeling

Markus Thiemann, Mathematics, TU Kaiserslautern, Paul-Ehrlich-Strasse 14, Room 438, 67663, Kaiserslautern, Germany, thiemann@mathematik.uni-kl.de, *Stefan Ruzika*, *Horst W. Hamacher*

We combine dynamic network flows and cellular automata (CA) by a coupling technique to obtain realistic predictions for pedestrian evacuation times. Output of each model is fed into the other, thus establishing a control cycle. As a result, the gap of evacuation times of both models is narrowed: the network flow model produces more realistic evacuation times by including data of microscopic pedestrian behavior. The CA benefits from route optimization resulting in lower evacuation times. These results were obtained within the project REPKA: Regional Evacuation, Planning, Control, Adaption.

2 - How to very quickly solve a staffing and dispatching problem for fire and rescue services

Tobias Andersson Granberg, Department of Science and Technology, Linköping University, Division of Communications and Transport Systems, SE-60174, Norrköping, Sweden, tobias.andersson@liu.se

A staffing and dispatching problem for fire and rescue services is identified as a subproblem to a location model where fire and rescue service units and personnel are to be optimally positioned. A simple, very fast heuristic is used to solve this problem. The solution quality of the heuristic is important, and in this study heuristic solutions are compared to the optimal solutions, produced by solving the corresponding model. The results show that the heuristic mostly find the optimal solution, and that the exact solution method is too time consuming to be practical.

3 - Logistics for Decision Support in Case of Natural Disasters in Developing Countries

Christian Tesch, Technische Universität Dortmund, Leonhard-Euler-Str. 2, 44388, Dortmund, NRW, Germany, tesch@vsl.mb.tu-dortmund.de

In this approach different scheduling heuristics are applied to logistic operations in disaster relief. The main objective is to improve the efficiency of handling relief goods in terminals. Based on limited resources for cargo handling in disaster areas, various weights and sizes of relief goods, improper truck arrival times and different departure times we apply and evaluate multiple strategies to schedule trucks in the unloading process. A real-time decision algorithm applicable in practical situations has been developed to handle the problem of uncertain and changing information.

4 - Multi-class Open Queueing Network with Non-preemptive Priority Discipline

Seongmoon Kim, School of Business, Yonsei University, 134 Shinchon-dong Seodaemun-gu, 120-749, Seoul, Korea, Republic Of, kimsam@yonsei.ac.kr

Emergency care centers show the characteristics of the open queueing network since the patients visit the processes in different orders. In addition, the patients are classified based on the levels of urgency to receive service with priority at some processes. We present a mathematical model for multi-class open queueing network with non-preemptive priority discipline. We present a case study based on actual data which have been collected at an emergency care center in a hospital.

■ MB-48

Monday, 10:40-12h00
8.2.04

III-posed Variational Problems II

Stream: III-posed Variational Problems - Theory, Methods and Applications

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Improving a hybrid preconditioner for solving large-scale normal equations 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, Marta Velazco

The normal equations systems are solved by the preconditioned conjugate gradient method in two stages. During the early interior point iterations the controlled incomplete Cholesky preconditioner is used. As an optimal solution is approached, the linear systems become highly ill-conditioned and the specialized splitting preconditioner is adopted. A new splitting preconditioner version approach that works with a singular submatrix is presented. Numerical experiments show that the new approach improves previous performance results for both robustness and time on some large-scale problems.

2 - On Some Properties and Numerical Methods for Problems of Topology Optimization

Wolfgang Aichtziger, Department of Mathematics, University of Erlangen-Nuremberg, Chair of Applied Mathematics 2, Martensstrasse 3, 91058, Erlangen, Germany, aichtziger@am.uni-erlangen.de

Topology optimization is a meaningful tool in design optimization of mechanical structures. A challenge is the correct formulation and treatment of local constraints. For example, stress turns out to be discontinuous as a function of the design variables. This is avoided by formulations in design and state variables. The price is violation of constraint qualifications and failure of standard optimization methods. We present some new results on problem properties, optimality conditions, and numerical techniques (Some results together with T. Hoheisel, Ch. Kanzow, and Ch. Schuerhoff).

Monday, 12:20-13:40

■ MC-01

Monday, 12:20-13:40
Aula Magna

Keynote Talk 3

Stream: Keynote Speakers

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

1 - Operations Research for Green Logistics

Rommert Dekker, Erasmus University Rotterdam, Econometric Institute, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, rdekker@few.eur.nl

After years of talking, green logistics or environmental friendly supply chain management seems to have taken off in many companies. In fact, industry seems to embark on hundreds of new initiatives, although it may be more popular in certain countries than in others. That is on one hand surprising, because at first sight becoming green may cost industry money and we would expect more initiatives from governments. The attention for green logistics in the OR community, however seems to lag behind in this respect. In this overview we will first indicate the importance of green aspects to logistics and supply chain management and the drivers behind it. Next we will give an overview of various aspects of green logistics. We start with extending the traditional cost objective in quantitative logistic studies with environmental criteria, like emissions, in the form of CO₂, NO_x and PM. In a following step we discuss the physical supply chain drivers such as transportation, facilities and products and highlight the fundamental green choices considered in this respect. Thereafter we focus on the soft drivers, by considering logistic concepts, decision support systems, sourcing and pricing in the supply chain. In doing so, we will highlight the contributions of OR so far to green logistics. In fact OR has contributed already a lot to green logistics by reducing costs in supply chains, although it most cases the environmental aspects were not addressed explicitly. Next we focus on those problems where a high contribution of Operations Research can be expected. These problems deal with congestions, with coordination in transports and the use of price mechanisms to improve efficiency and they occur in a great variety of cases. Hence there are many opportunities for Operations Research, both methodologically, problem oriented as well as supporting discipline in the many logistic studies.

■ MC-02

Monday, 12:20-13:40
3.2.14

Applications of Combinatorial Optimization

Stream: Combinatorial Optimization

Invited session

Chair: *Nelson Maculan Filho*, COPPE / PESC, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil, maculan@cos.ufrj.br

Chair: *Carlile Lavor*, Applied Mathematics, UNICAMP, IMECC-UNICAMP, 13083-859, Campinas, SP, Brazil, clavor@ime.unicamp.br

1 - Discretization of the Molecular Distance Geometry Problem by defining artificial orderings on the molecule

Antonio Mucherino, INRIA, Lille Nord Europe, France, antonio.mucherino@inria.fr, Carlile Lavor, Leo Liberti, Nelson Maculan Filho, Tiberius Bonates, Gabriel Paillard

The Molecular Distance Geometry Problem (MDGP) can be defined as the problem of finding all the atomic positions of a molecule by exploiting the given distances between some of its atoms. The MDGP is NP-hard in general, although some polynomially solvable subclasses are known, e.g. when all the distances are given. We discuss artificial orderings on atoms of the molecule that restrict the search for molecular conformations (satisfying the given distances) on a finite discrete space. The importance of these orderings is related to the formulation of the MDGP as a combinatorial optimization problem.

2 - Heuristic Method for the Multi-choice Multidimensional Knapsack Problem

Raid Mansi, Departamento de Produção e Sistemas, Universidade do Minho, Portugal, raidmm@yahoo.fr, *Cláudio Alves*, *J. M. Valério de Carvalho*, *Said Hanafi*

The Multi-choice Multidimensional Knapsack (MMKP) Problem is a variant of the knapsack problems. The proposed heuristic, which is an iterative process, is based on the resolution of a MMKP relaxation to provide an upper bound and generate a reduced problem. The resolution of this reduced problem improves a lower bound. Pseudo-cuts are added to the problem to eliminate search spaces already explored. The resolution of the MMKP relaxation is done using columns generation techniques. This Heuristic improves the value of 18 instances on the 33 referred in recent work.

3 - The maximum k-balanced subgraph of a signed graph

Rosa Maria Figueiredo, Departamento de Matemática, Universidade de Aveiro, Campus de Santiago, 3800, Aveiro, Aveiro, Portugal, rosa.figueiredo@ua.pt, *Daniele Catanzaro*, *Martine Labbé*

Let $G=(V,E)$ be an undirected graph and let s be a function that assigns a sign to each edge in E : G together with s is called a signed graph. Consider a parameter k . A signed graph is k -balanced if V can be partitioned into k sets in such a way that positive edges are found only within the sets and negative edges go between sets. The maximum k -balanced subgraph problem is the problem of finding a subgraph of G that is k -balanced and maximum according to the number of vertices. We present a description of the polytope associated with this problem and propose an exact algorithm for its solution.

4 - The coherence problem - polynomially solvable cases

Gilberto Calvillo, Unidad Cuernavaca, UNAM, Av. Universidad S/N, Col. Chamilpa, 62210, Cuernavaca, Morelos, Mexico, gilberto@matcuer.unam.mx, *David Romero*

Let G be a simple undirected graph whose edges are colored black or blue. Assume further that a real positive number (weight) is assigned to each edge of G .

The coherence problem, relevant in Paul Thagard's studies related to cognition processes and decision-making theory, consists in finding a bipartition (L,R) of the vertices of G , so as to maximize $A+B+C$, where A is the sum of weights of black edges with both endpoints in L , B is the sum of weights of blue edges having one endpoint in L and the other in R , and C is the sum of weights of black edges with both endpoints in R .

The coherence problem is NP-hard because it generalizes the well-known max-cut problem. Hence, several heuristics like neural networks and simulated annealing have since been proposed for its solution.

In this talk a polynomial time algorithm will be presented to exactly solve special cases of the coherence problem and some of its extensions.

■ MC-03

Monday, 12:20-13:40

3.2.15

Metaheuristics for the VRPTW

Stream: Metaheuristics

Invited session

Chair: *Caroline Prodhon*, University of Technology of Troyes, 12 rue Marie Curie, 10000, Troyes, France, caroline.prodhon@utt.fr

Chair: *Philippe Lacomme*, Université de Clermont-Ferrand, 63177, Clermont Ferrand, France, placomme@sp.isima.fr

1 - Heuristic methods for the Vehicle Routing Problem with Time Windows and Split Deliveries

Reghiou Mohamed, Logistics and Computer Science, Ecole Nationale des Sciences Appliquées de Tétouan, Mhannech II, B.P : 2121, 93000, Tétouan, Morocco, m.reghiou@uae.ma, *Christian Prins*, *Abdellah El Fallahi*

This work summarizes our investigation into various heuristic methods to solve the vehicle routing problem with time windows and split deliveries (SDVRPTW). The SDVRPTW is similar to the well studied Vehicle Routing Problem with Time Windows (VRPTW), except that a customer can be serviced by more than one vehicle. The paper proposes constructive heuristics and a two-stage metaheuristic based on the combination of several components of different metaheuristics. Comparisons with exact methods and a tabu search algorithm prove the efficiency of the proposed approaches.

2 - Granular Variable Neighborhood Search for the Team Orienteering Problem with Time Windows

Jan Melechovsky, LOSI, UTT, 12, rue Marie Curie, 10000, Troyes, France, jan.melechovsky@utt.fr, *Labadi Nacima*, *Renata Mansini*, *Roberto Wolfler-Calvo*

This note deals with the Team Orienteering Problem with Time Windows (TOPTW). The objective is to build m tours visiting a subset of vertices in order to maximize the total collected profit. Each tour must respect a given time limit. We present a metaheuristic solving the TOPTW. The method is based on the idea of exploring reduced granular rather than complete neighbourhood in order to gain the efficiency while preserving the quality of obtained solutions.

3 - Variable neighborhood search for the time-dependent vehicle routing problems with time windows

Stefanie Kritzingner, Department of Business Administration, University of Vienna, Bruennerstr. 72, 1210 Vienna, 1210, Vienna, Vienna, Austria, stefanie.kritzingner@univie.ac.at, *Karl Doerner*, *Richard Hartl*, *Fabien Tricoire*

We solve a time-dependent vehicle routing problem with time windows (TD-VRPTW) with variable neighborhood search. In the TD-VRPTW the time and the cost of traversing an arc are deterministic, but both depend on the time at which the traversing takes place. Besides the popular impacts in VRPs the time-dependency gains more and more importance. It makes VRPs much harder because there is no simple way to compute the duration of a route, which has an impact on solution feasibility and quality.

4 - Vehicle Routing Problem with Time Windows using SOMA

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

Self Organizing Migration Algorithm (SOMA) (Zelinka, 1999) belongs to the class of Evolutionary Algorithms. It is based on geometric principle and even though no individuals are created using parents crossover, the position of the individuals in the search space are changed during the evolution. SOMA is also able to solve the routing problems from the NP-class efficiently. This algorithm was used for solving the Vehicle Routing Problem with Time Windows mainly for the practical purposes to specify the service of a node (the collection and distribution of used products might be limited by e.g. opening hours, on site collection is realized only on collection days etc.).

■ MC-04

Monday, 12:20-13:40

3.2.13

Parallel machine scheduling with metaheuristics

Stream: Metaheuristics

Invited session

Chair: *André Rossi*, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr

1 - A literature review for the simulated annealing method with the implementation on the parallel machines since 2000

Pelin Alcan, The Department of Industrial Engineering, Yildiz Technical University, Mechanical Faculty,, Yildiz, 34349, Istanbul, Turkey, pelinalcan@gmail.com, *Huseyin Basligil*

Performing a detailed literature research has revealed that there are numerous heuristic methods applied to parallel machine problems. It is seen that, among these heuristics, simulated annealing yields the best solution in the shortest time, which is also the case with the other probabilistic approaches. Creating this work we have benefited from the databases of many journals. Research results show that there is a little work which is the simulated annealing method with the implementation of the parallel machine has been noticed.

2 - Scheduling independent jobs on identical parallel machines: An effective approach

Francesca Vocaturo, Dipartimento di Economia e Statistica, Università della Calabria, Via Pietro Bucci - Cubo 0C, 87036, Arcavacata di Rende (CS), Italy, vocaturo@unical.it, *Giuseppe Paletta*

We consider the nonpreemptive scheduling of independent jobs on identical parallel machines with minimum makespan objective. We propose an effective approach, consisting of a construction phase and an improvement phase. The constructive algorithm generates and combines partial solutions of the problem. We provide a bound on the performance ratio of this algorithm, by distinguishing between "prerun" and "postrun" value. Innovative local search procedures, based on the concept of partial solutions too, are used in the improvement phase. The effectiveness of our approach is evaluated through computational tests on benchmark instances.

3 - Speeding up a Rollout Algorithm for Complex Parallel Machine Scheduling

Marco Pranzo, Dipartimento di Ingegneria dell'Informazione, Università di Siena, Siena, Italy, pranzo@dii.unisi.it, *Michele Ciavotta*, *Carlo Meloni*

Rollout algorithms are easy to implement but they often require high computation time. We present some variants of the basic rollout scheme aimed at limiting the computational effort while preserving the overall solution quality. Namely, we propose dynamic heuristics pruning, candidates reduction mechanisms and the hybridization with a local search procedures. A tight lower bound is used to certify the quality of the generated solutions. A campaign of computational experiments, carried out also on instances from a real manufacturing plant, shows the effectiveness of this approach.

■ MC-05

Monday, 12:20-13:40

3.2.16

Multi-objective metaheuristics

Stream: Metaheuristics

Invited session

Chair: *Walter Habenicht*, Business Administration, University of Hohenheim, Lst. fuer IBL(510A), 70593, Stuttgart, Germany, walter.habenicht@uni-hohenheim.de

Chair: *Lionel Amodeo*, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie BP2060, 10000, Troyes, France, lionel.amodeo@utt.fr

1 - Pareto-Search in Discrete Vector Optimization Problems.

Walter Habenicht, Business Administration, University of Hohenheim, Lst. fuer IBL(510A), 70593, Stuttgart, Germany, walter.habenicht@uni-hohenheim.de

In this paper we deal with discrete vector optimization problems with large sets of efficient solutions. We assume that the efficient set has been identified (for example by some metaheuristic approach) and the non dominated set has been stored in a special data structure called quad tree. In order to organize efficiently a searching process in outcome space, namely in the non dominated set, we discuss different neighborhood definitions. These neighborhoods differ in the computational complexity of identifying the neighbors and in their ability to avoid suboptimal solutions. In all neighborhoods the process of identifying the neighbors is supported by the underlying data structure.

2 - Multiobjective optimization using the Lorenz dominance for a buffers sizing problem

Hicham Chehade, Charles Delaunay Institute, University of Technology of Troyes, 12 Rue Marie Curie, 10000, Troyes, France, chehadeh@utt.fr, *Lionel Amodeo*, *Farouk Yalaoui*

In this work, a multiobjective buffers sizing is studied. Two objectives are considered: the maximization of the throughput rate and the minimization of the buffers total size. A new resolution approach based on the Lorenz dominance relationship is introduced. The method is called L-archive which is based on a genetic algorithm with a niching strategy and uses the Lorenz dominance to identify the set of non dominated solutions. The L-archive algorithm is compared to the SPEA2 algorithm of Zitzler and the computational experiments show the advantages of our method.

3 - Comparison of multiobjective cooperative and classical evolutionary algorithms for global supply chain optimization.

Maksud Ibrahimov, Computer Science, The University of Adelaide, Plaza Building, The University of Adelaide, SA 5000, Adelaide, South Australia, Australia, maksud.ibrahimov@adelaide.edu.au, *Neal Wagner*, *Sven Schellenberg*, *Arvind Mohais*, *Zbigniew Michalewicz*

This paper discusses global optimization of supply chain (SC) operations. Often organizations lack communication between SC silos with optimization restricted at the silo level which does not always lead to the global optimum. A two-silo SC was built based on the combination of vehicle routing and scheduling problems. Three approaches were used: a classical evolutionary approach and two approaches based on cooperative co-evolution one with multi-objective optimization and one without. A real-world problem is presented involving an Australian sheet steel business.

■ MC-06

Monday, 12:20-13:40

8.2.30

DEA Methodology III

Stream: DEA and Performance Measurement

Invited session

Chair: *Wade Cook*, Schulich School of Business, York University, Management Science, Room S337M, 4700 Keele Street, M3J 1P3, Toronto, Ontario, Canada, wcook@schulich.yorku.ca

1 - Multiple Variable Proportionality in Data Envelopment Analysis

Wade Cook, Schulich School of Business, York University, Management Science, Room S337M, 4700 Keele Street, M3J 1P3, Toronto, Ontario, Canada, wcook@schulich.yorku.ca, *Joe Zhu*

Data envelopment analysis (DEA) provides an optimization methodology for deriving an efficiency score for each member of a set of peer decision making units. Under the original DEA model of Charnes, Cooper and Rhodes (1978) it was assumed that there are constant returns to scale (CRS). This idea was later extended by Banker, Charnes and Cooper (1984) to the more general case that allowed for variable returns to scale (VRS). In both of these structures, it is assumed that the returns to scale (RTS) classification, consistent with the classical definition, applies to the entire (input, output) bundle. In many settings it can be the case that the output bundles can be separated into distinct components wherein an RTS-type behavior may be different for one component than for another. We refer to such situations as involving multiple variable proportionality (MVP). Examples of MVP occur when there are different product groupings in a manufacturing facility, different wards in hospitals, and so on. Identification of such differential behavior can provide management with important insights regarding the most productive scale size (MPSS) in each of those components. In the current paper we introduce DEA-based tools that address those situations where MVP exists.

2 - Technical Efficiency based on Cost Gradient Measure

Miki Tsutsui, Socio-economic Research Center, Central Research Institute of Electric Power Industry, 2-11-1 Iwadokita, Komae-shi, 2018511, Tokyo, Japan, miki@criepi.denken.or.jp, *Kaoru Tone*, *Yuichiro Yoshida*

We propose a new model named cost gradient measure (CGM), which enables us to measure more price-conscious technical efficiency. In the CGM model, projection to the efficiency frontier is defined by the cost gradient direction of each decision making unit, which is the normal to the cost plane and the steepest descent direction of total input cost. This will be reasonable for company managers. Furthermore, we can derive CCR from CGM formula, which clearly implies CCR is under strong restriction of proportionality. Even if cost data is not available, CGM can be solved under several assumptions.

3 - Centralised DEA model for target setting when articulation of partial ideal targets are considered

Gabriel Villa, Department of Industrial Management, University of Seville, Camino de los Descubrimientos, s/n, Seville, Spain, gvilla@esi.us.es, *Sebastián Lozano*, *David Canca*

DEA models calculate the level of inputs/outputs to render inefficient units efficient. This article tries to identify these operating points in a case in which the organisations are able to articulate a set of ideal input/output targets that the DMU would wish to achieve. A central entity (CE) is the responsible of the allocation of some inputs of DMUs and could estimate and enforce to meet the amount of inputs and outputs expected for DMUs. We propose a set of DEA models that assigns the level of inputs and outputs to each DMU to be efficient, according to the ideal levels established by CE.

4 - On the choice of weights profiles in cross-efficiency evaluations

Nuria Ramón, Centro de Investigación Operativa, Universidad Miguel Hernández, Avda. Universidad, 03200, Elche, Spain, nramon@umh.es, *Inmaculada Sirvent*, *Jose L. Ruiz*

The literature has claimed that the differences between the weights profiles that different DMUs use in their assessments (self-evaluations) may be a concern. This is particularly relevant in cross-efficiency evaluations, since the cross-efficiency score of a given DMU is usually calculated as an average of its ratings obtained with the weights profiles provided by all the DMUs. We focus in this paper on the choice of these weights trying to avoid large differences between the profiles that the different DMUs provide. We also pay attention to problems such as the zero weights and to the possible strategies that can be used in the choice of the weights profiles to be considered.

■ MC-07

Monday, 12:20-13:40
8.2.47

Recent Advances in the Use of Mathematical Programming

Stream: Mathematical Programming [c]
Contributed session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Kaisa Miettinen*, Dept. of Mathematical Information Technology, University of Jyväskylä, P.O. Box 35 (Agora), FI-40014, University of Jyväskylä, Finland, kaisa.miettinen@jyu.fi

Chair: *Jussi Hakanen*, Dept. of Mathematical Information Technology, University of Jyväskylä, P.O. Box 35 (Agora), FI-40014, University of Jyväskylä, Finland, jussi.hakanen@jyu.fi

1 - The last buy decision in situations with an alternative item

Simme Douwe Flapper, Technische Universiteit Eindhoven, Netherlands, s.d.p.flapper@tue.nl

Many different last buy/final buy/last series situations can be found in practice, some triggered by suppliers, some triggered by customers. First, we present a classification of the different last buy/final buy/last series situations found in practice. Next we focus on the many situations where an alternative item is/ or will become available. A mathematical model to support the last buy decision in the latter situations is presented, and the results obtained for a case study are discussed. Finally, an overview of areas for further research is given.

2 - Corporate Investment Choice and Exchange Option between Production Functions

Jean-luc Prigent, ThEMA, University of Cergy-Pontoise, 33, Bd du Port, 95011, CERGY-PONTOISE, France, jean-luc.prigent@u-cergy.fr, *Olfa Bouasker*

We examine the strategy in resource allocation of a firm which must choose between several production functions using the real option approach. We look for the option value of the managerial flexibility between production functions. First, we determine the values of exchange options when the underlying asset is no more a geometric Brownian motion but equal to the sum of the net present value and of the corresponding growth / delay options. Second, we give a general model to evaluate Profit and Loss. We provide a valuation formula and show how risk aversion modifies the optimal choice.

■ MC-08

Monday, 12:20-13:40
6.1.36

Airside Airport Operations

Stream: Project Management and Scheduling
Invited session

Chair: *Jason Atkin*, School of Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, Notts, jaa@cs.nott.ac.uk

Chair: *Chris Potts*, School of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, C.N.Potts@soton.ac.uk

1 - Realistic runway scheduling problems

Jason Atkin, School of Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, Notts, jaa@cs.nott.ac.uk, *Edmund Burke*

Since the runway(s) can often for the bottleneck for the arrival and departure systems at airports, achieving high quality arrival and departure sequences is extremely important. We will discuss the similarities and important differences between these problems, showing why a solution method for one will not necessarily be useful for the other despite the similarity of the models. We will then extend this illustration to discuss why the real problems actually involve more than pure sequencing and present some more realistic models and results for London Heathrow.

2 - Models and Algorithms for Scheduling Aircraft Landings

Chris Potts, School of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, C.N.Potts@soton.ac.uk, *Julia Bennell*, *Mohammad Mesgarpour*

There is a great interest in optimizing the usage of airport runways due to an anticipated increase in numbers of flights during the next decade. Although a significant amount of previous research on runway scheduling has been carried out, very little of it has been implemented. This paper studies the scheduling of aircraft landing on a single runway. A generic mixed integer linear programming model is presented. Also, we propose some fast heuristics that are suitable for use by air traffic controllers. Finally, initial computational results and future work directions are discussed.

3 - Comparison of airport ground movement algorithms

Stefan Ravizza, School of Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, smr@cs.nott.ac.uk, *Jason Atkin*, *Edmund Burke*

The airport ground movement optimisation problem links other important airport airside operations together. With the expected increase in air traffic, ground movement operations will become increasingly important. It is essential to understand the characteristics of ground movement optimisation problems and solution approaches, since airport layouts differ significantly. We will compare exact and heuristic approaches for a number of supplied benchmark scenarios and critically analyse the differences between them and the advantages and disadvantages of each.

4 - A comparison of constructive algorithms for baggage sorting station allocation

Amadeo Ascó, ASAP, School of Computer Science and IT, University of Nottingham, C87, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, Nottinghamshire, United Kingdom, aaz@cs.nott.ac.uk, *Jason Atkin*, *Edmund Burke*

The correct allocation of limited airport resources can greatly affect the quality of service provided by airlines and airports to their customers. Efficient baggage handling is already important, and likely to become more so with the expected increases in civil air traffic. We will define the (previously neglected) baggage sorting station allocation problem and provide a model. We will then describe a number of constructive algorithms for solving this innately multi-objective problem and compare them against each other and previous work, illustrating the trade-offs between the objectives.

■ MC-09

Monday, 12:20-13:40

6.2.53

Complementarity Problems, Variational Inequalities and Equilibrium

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

Chair: *Florian Potra*, Mathematics & Statistics, University of Maryland, MD 21250, Baltimore, United States, potra@umbc.edu

1 - Weighted Complementarity Problems: Theory and Applications.

Florian Potra, Mathematics & Statistics, University of Maryland, MD 21250, Baltimore, United States, potra@umbc.edu

We introduce the notion of a weighted linear complementarity problem which generalizes the classical notion of a linear complementarity problem. We show that such problems arise in a natural way in market equilibrium and other contexts. We present some general theoretical results concerning the properties of the solution set of such problems, and present a class of interior point methods for their numerical solution. We give general conditions that insure the polynomial complexity and superlinear convergence of the interior point methods.

2 - Consistent Conjectures in Mixed Oligopoly

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*

A model of mixed oligopoly with conjectured variations equilibrium (CVE) is considered. The agents' conjectures concern the price variations depending upon their production increase or decrease. We establish existence and uniqueness results for the CVE (called an exterior equilibrium) for any set of feasible conjectures. To introduce the notion of an interior (or consistent) equilibrium, we develop a consistency criterion for the conjectures and prove the existence theorem for such an equilibrium. For the extension of our results to the case of non-differentiable demand functions, we also investigate the behavior of the consistent conjectures in dependence upon a parameter.

3 - Properties of Schur complements in Euclidean Jordan algebras

Roman Sznajder, Mathematics, Bowie State University, 14000 Jericho Park Road, 20715-9465, Bowie, Maryland, United States, rsznajder@bowiestate.edu

We study the concept of Schur complement in the setting of Euclidean Jordan algebras and describe Schur determinantal and Haynsworth inertia formulas. In addition, we prove an analogue of the Crabtree-Haynsworth quotient formula and show that any Schur complement of a strictly diagonally dominant element is strictly diagonally dominant. We also introduce the concept of Schur product of a real symmetric matrix and an element of Euclidean Jordan algebra when its Peirce decomposition with respect to a Jordan frame is given. An Oppenheim type inequality is proved in this setting.

4 - Iterative methods for nonlinear complementarity problems on isotone projection cones

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

We present a recursion related to a nonlinear complementarity problem defined by a closed convex cone in a Hilbert space and a continuous mapping defined on the cone. If the recursion is convergent, then its limit is a solution of the nonlinear complementarity problem. In the case of isotone projection cones sufficient conditions are given for the mapping so that the recursion to be convergent.

■ MC-10

Monday, 12:20-13:40

6.2.56

Graphs and Applications

Stream: Graphs and Networks

Invited session

Chair: *Bernard Ries*, Warwick Business School, University of Warwick, CV4 7AL, Coventry, Switzerland, Bernard.Ries@wbs.ac.uk

1 - Fractionally co-strongly perfect claw-free graphs with an application to wireless networking

Yori Zwols, Department of Industrial Engineering and Operations Research, Columbia University, Rm. 313, School of Engineering and Applied Sciences, 500 West 120th Street, 10027, New York, NY, United States, yz2198@columbia.edu

Strongly perfect graphs have been studied by several authors (e.g. Berge, Duchet, Ravindra, Wang). This talk deals with a fractional relaxation of strong perfection. Motivated by a wireless networking problem, we consider claw-free graphs that are fractionally strongly perfect in the complement. We obtain a forbidden induced subgraph characterization and an approximate structure theorem, and we display graph-theoretic properties of such graphs. This is joint work with Maria Chudnovsky and Bernard Ries.

2 - Profit Maximizing Pricing on graphs.

Rajiv Raman, DIMAP and Department of Computer Science, University of Warwick, Department of Computer Science, University of Warwick, CV4 7AL, Coventry, West Midlands, United Kingdom, R.Raman@warwick.ac.uk

We are given a graph, whose edges we wish to price. We are given a set of buyers, each with a budget and a specific path the buyer is interested in buying. The buyer will buy the path if she the sum of the prices of the edges in the path is at most her budget. Our objective is to set prices to the edges in order to maximize the profit we obtain by selling the paths to the buyers who can afford them. I will present complexity and approximation algorithms for this problem. This is joint work with K. Elbassioni, S. Ray and R. Sitters.

3 - Coloring vertices of triangle-free graphs

Bernard Ries, Warwick Business School, University of Warwick, CV4 7AL, Coventry, Switzerland, Bernard.Ries@wbs.ac.uk

The vertex coloring problem is known to be NP-complete in the class of triangle-free graphs. Moreover, it remains NP-complete even if we additionally exclude a graph F which is not a forest. We study the computational complexity of the problem in (triangle; F)-free graphs with F being a forest. From known results it follows that for any forest F on 5 vertices the vertex coloring problem is polynomial-time solvable in the class of (triangle; F)-free graphs. We show that the problem is also polynomial-time solvable in many classes of (triangle; F)-free graphs with F being a forest on 6 vertices.

4 - Computing identifying codes in chosen graph classes and dynamic scenarios

Adrian Kosowski, Dept. of Algorithms and System Modeling, Gdansk University of Technology, ul. Narutowicza 11/12, 80-233, Gdansk, Poland, adrian@kaims.pl

An identifying code in a graph is a subset of vertices whose intersection with the open neighborhood of each vertex is a distinct, non-empty set. Identifying codes are applied, among others, in fault-detection in networks and for locating fires in facilities.

In this talk we present some new structural and computational results for the problem of determining minimal identifying codes in some graph classes inspired by real-world network topologies. We also consider algorithms for locally updating identifying codes in dynamic settings, in which nodes are allowed to join or leave the network.

■ MC-11

Monday, 12:20-13:40

8.2.38

Energy Market Modeling

Stream: Emerging Applications of OR

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 - Analysis of a Possible Natural Gas Cartel

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, *Knut Rosendahl*

In this presentation we present an analysis of the global gas market under several possible cartels involving the Gas Exporting Countries Forum (GECF). We make use of the World Gas Model, a large-scale complementarity model for determining Nash-Cournot based market equilibria.

2 - Using Real Options to Evaluate Optimal Funding Strategies for Carbon Capture and Storage (CCS) Projects in the European Union

Jeremy Eckhause, Civil and Environmental Engineering, University of Maryland/LMI, 2000 Corporate Ridge, 22102, McLean, Virginia, United States, jeckhause@lmi.org, *Johannes Herold*

A barrier to large scale implementation of CCS is the lack of demonstration projects that validate the technology. A few projects in the EU are under development to use CCS on a large scale. Taking a funding agency's perspective, we employ a real options framework to select an optimal project portfolio. We solve stochastic dynamic programs to obtain funding strategies in order to maximize success by a target year. The model demonstrates the reduction of risk in the multi-stage competition, while considering knowledge spillover. State space, computational complexity and runtimes are analyzed.

3 - A Model for Oligopolistic Natural Gas Markets

Ibrahim Abada, Electricite de France/Univ. Paris, Université Paris Ouest, Nanterre - La Défense, 200, Avenue de la République, 92001, Nanterre, France, ibrahim.abada@edf.fr, *Steven Gabriel*, *Olivier Massol*, *Vincent Briat*

In our model, the interaction between certain market players is posed as a generalized Nash-Cournot competition. We take into consideration the long-term contracts aspects. The producers sell their gas to a set of independent traders who sell it then to end-users. Storage and transportation aspects are taken care of by global operators. We use a system dynamics approach to model possible fuels substitution between the consumption of coal, oil and natural gas. We describe some of the theoretical aspects as well as preliminary numerical results for the European natural gas market.

4 - Cartelisation in the Natural Gas Market: the Stability Issue

Olivier Massol, Center for Economics and Management, IFP - IFP School, 228-232 Avenue Napoléon Bonaparte, 92852, Rueil-Malmaison, France, olivier.massol@ifp.fr, *Stéphane Chung-Ming*

The creation of the Gas Exporting Countries Forum (GECF) has motivated numerous discussions. In that context, Egging et al. (2009) have recently proposed a numerical model to measure the market power that could potentially be exerted by a coalition of gas exporters. As the GECF is often described as "an informal association" with an unstable membership, an investigation focussed on the cartel stability might be needed. This is precisely the goal of our contribution that illustrates how a numerical model (a simple mixed complementarity problem) can provide some policy-relevant conclusions.

■ MC-12

Monday, 12:20-13:40

8.2.39

AHP 03

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Anabela Pereira Tereso*, Production and Systems Department, University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal, anabelat@dps.uminho.pt

1 - Multicriteria Decision Aid: Evaluation and Comparison of the Main Tools

Anabela Pereira Tereso, Production and Systems Department, University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal, anabelat@dps.uminho.pt, *Cristina Seixedo*

Good decision making is increasingly more important to organizations. This work presents a review of the literature in multicriteria decision aid with a reference to the main techniques available in the area. We also present a research on the software tools available in this field. These software tools were then characterized and classified and their main characteristics summarized in the present work. This work is part of a project that has as final goal to implement a software tool using AHP to help on the selection of the right multicriteria decision aid software.

2 - Environmental Risk Assessment for Roadway Transportation of LNG

Emel Topuz, Environmental Engineering, ITU, ITU Ayazaga Yerleskesi Insaat Fakultesi, Cevre Muhendisligi Bolumu Maslak, 34469, ISTANBUL, Turkey, topuze@itu.edu.tr, *Ilhan Talinli*, *Atakan Oztekin*

The objective of this study is to apply an environmental risk assessment approach for roadway transportation of Liquid Natural Gas (LNG) by using fuzzy AHP. Environmental and transportation factors are scored and compared with fuzzy numbers by experts and fuzzy inference methodology is applied. The outputs of this study helped to understand the source of risk and its magnitude which can be used to develop risk management for transportation of LNG. Moreover, quantified environmental risk magnitude is significant to use for further decision analyses in which environmental factors included.

3 - Designing a Prioritization Model for Investment Plans under Uncertainty Using Interval Comparison Matrices

Seyed Hesameddin Anvar, Industrial Engineering, Yazd University, Yazd, Yazd, Iran, Islamic Republic Of, hesam.anvar@gmail.com, *Masoud Narenji*, *Mohammad Fathian*

In hierarchical MCDM methods, one of the main steps is to weigh criteria and compute each alternative weight according to the defined criteria. One of the most common weighting criteria methods is to apply the pairwise comparison matrices. In this paper we model uncertainty in investment plans prioritization by using interval comparison matrices as inputs for Lexicographic Goal Programming (LGP) and Two-stage Logarithmic Goal Programming (TLGP) methods. Finally a numerical example for real location problem is solved for each method and compared with Analytic Hierarchy Process (AHP) approach.

4 - A Two Phased Multi Criteria Approach for Aviation Accident Analysis

Ahmet Kandakoglu, Department of Industrial Engineering, Istanbul Technical University, Macka, 34367, Istanbul, Turkey, kandakoglu@itu.edu.tr, *Erol Yucel*, *Y. Ilker Topcu*

This study proposes a two phased approach based on the 5M (Man, Machine, Medium, Mission and Management) model and the Analytic Hierarchy Process (AHP) method for quantitatively analyzing the aviation accidents. While the 5M model is used to identify all the causal factors in an accident, the AHP method is applied to quantify these factors using the subjective judgments of experts. This approach provides both an analytical framework to assess which factor influences the accident most and valuable insights for the preventive actions to reduce the accident risk in the safety management process.

■ MC-13

Monday, 12:20-13:40

2.2.21

Managing disruptions in facility location models

Stream: Location Analysis

Invited session

Chair: *Maria Paola Scaparra*, Kent Business School, University of Kent, The University, CT2 7PE, Canterbury, United Kingdom, M.P.Scaparra@kent.ac.uk

1 - Node Fails, Facility Fails: Facility Location Problem for Emergency Evacuation

Rongbing Huang, School of Administrative Studies, York University, M3J 1P3, Toronto, Ontario, Canada, rhuang@yorku.ca, *Mozart Menezes*, *Seokjin Kim*

In the p-median and p-center problems, people take advantage of the facility located at the same site. However, in the situation of some natural disasters like hurricane Katrina, or the recent earthquake in Haiti, the whole city may become functionless. Therefore, customers can't rely on the facility located at the same place. We compare this problem with the center problem and analyze the problem on some simple networks. An efficient algorithm is provided for the problem on the general network.

2 - Incorporating recovery time issues in facility protection planning

Chaya Losada, Business School, Kent University, CT2 7PE, canterbury, United Kingdom, cl243@kent.ac.uk, *Maria Paola Scaparra*

We consider a p-median system whose facilities are vulnerable to external disruptions. Disrupted facilities are not operative for a given length of time, the recovery time. We propose a protection model which identifies the optimal allocation of a protection budget among the system facilities so as to minimize the impact of potential disruptions over a planning horizon. We assume that protection reduces the facility recovery time. The proposed model is a mixed integer bi-level problem with integer variables in both levels. We solve it efficiently by decomposition methods.

3 - A Bilevel Fixed Charge Location-Protection Model for Facilities under Imminent Attack

Deniz Aksen, College of Administrative Sciences and Economics, Koç University, Rumelifeneri Yolu, Sariyer, 34450, Istanbul, Turkey, daksen@ku.edu.tr, *Necati Aras*, *Nuray Piyade*

In a public service network customers always travel to the nearest facility to get service. A system planner has to determine the locations of facilities each of which can be opened either in the protected or unprotected mode. The associated fixed costs differ from one candidate site to another. Protected facilities are immune against an attacker who is capable of destroying a certain number of unprotected facilities in the worst-case scenario. Partial protection or interdiction is not possible. We formulate this problem as a static Stackelberg game between the system planner and the attacker.

4 - An integer programming formulation for the non-uniform p-median problem with unreliable facilities

Maria Paola Scaparra, Kent Business School, University of Kent, The University, CT2 7PE, Canterbury, United Kingdom, M.P.Scaparra@kent.ac.uk, *Jesse O'Hanley*, *Sergio García Quiles*

We consider the problem of locating p unreliable facilities on a network so as to minimize the expected sum of the weighted travel distances between facilities and customers. Facilities can have different probabilities of failure and customers have prior information on the operational status of the facilities. We present a novel mixed integer programming formulation for this problem and report numerical experiments on some benchmark data sets.

■ MC-14

Monday, 12:20-13:40

2.2.15

Price and Capacity Planning in Supply Chains

Stream: Supply Chain Planning

Invited session

Chair: *Esma Gel*, Industrial Engineering, Arizona State University, P.O. Box 5906, 85287-5906, Tempe, AZ, United States, esma.gel@asu.edu

1 - Dynamic price and lead time quotation for make-to-order systems with contract customers and spot purchasers

Esma Gel, Industrial Engineering, Arizona State University, P.O. Box 5906, 85287-5906, Tempe, AZ, United States, esma.gel@asu.edu, *Ahmet Hafizoglu*, *Pinar Keskinocak*

We consider dynamic price and lead time quotation for a make-to-order company with demand from contract customers as well as spot purchasers. Contract customers are offered a uniform price and lead time, and upgraded service that prioritizes their orders. Spot purchasers are subject to dynamically quoted price and lead times, which are accepted or rejected by the spot purchasers with known probability. We discuss the potential of dynamic quotation for such environments, various properties of optimal control policies, and the optimal mix of contract customers and spot purchasers.

2 - An Approach to Robust Capacity Allocation in Supply Chains

Thomas Makuschewitz, IPS - Intelligent Production and Logistics Systems, BIBA - Bremer Institut für Produktion und Logistik GmbH at the University of Bremen, Hochschulring 20, 28359, Bremen, Bremen, Germany, mak@biba.uni-bremen.de, *Bernd Scholz-Reiter*, *Fabian Wirth*, *Michael Schönlein*

A perturbation can change the dynamic behavior of a supply chain. As a consequence planned capacity levels might no longer be sufficient to handle the work load. In this talk we present an approach to robust capacity allocation that ensures robustness of a supply chain with respect to perturbations of customer demand. As a measure for the robustness we use the stability radius that reflects the size of the smallest perturbation that destabilizes the supply chain. Based on results concerning this measure we set up an optimization problem for the capacity allocation at each production facility.

3 - A comparative study of near-optimal and flexible strategic remanufacturing capacity planning policies in CLSCs

Efstratios Athanasiou, Mechanical Engineering, Aristotle University of Thessaloniki, Laskarotou 11, 54646, Thessaloniki, Greece, efsatha@auth.gr, *Patroklos Georgiadis*

We study strategic remanufacturing capacity planning policies in a two-product CLSC. The system's response (transient flows, actual remanufacturing capacity level, profit) is studied throughout the two-product life cycle, under alternative scenarios regarding the market preference and taking explicitly into account the end-of-use product returns according to a residence time distribution. We adopt a dynamic planning tool based on System Dynamics methodology. The comparative study of near-optimal and flexible policies provides useful insights regarding remanufacturing capacity decisions.

4 - Supply Chain Management: planning decisions and economical performance criteria

Ana Cristina Santos Amaro, Instituto Sup. Contabilidade e Administração de Coimbra, ISCAC, Instituto Politécnico de Coimbra, Quinta Agrícola, Bencanta, 3040 Coimbra, Portugal, 3040, Coimbra, cristinaamaro@sapo.pt, *Ana Paula Barbósa-Póvoa*

In the global economy efficient supply chains, SCs, are required to guarantee profitability within uncertain markets. In this paper, a centralized managing strategy is proposed to model SC planning decisions based on different economical criteria evaluation, while analysing partnership scenarios within the global chain as well as different product portfolios demand and prices. A Mixed Integer Linear Programming approach (MILP) is developed to model SC planning decision scenarios. The applicability of the proposed approach is illustrated by a real case-study taken from the pharmaceutical sector.

■ MC-15

Monday, 12:20-13:40

2.2.12

Green Vehicle Routing Problems

Stream: Vehicle Routing

Invited session

Chair: *Tolga Bektas*, University of Southampton, School of Management, Highfield, SO17 1BJ, Southampton, -, United Kingdom, T.Bektas@soton.ac.uk

1 - Analysis of Travel Times and CO2 Emissions in Time-Dependent Vehicle Routing

Ola Jabali, Eindhoven University of Technology, 5600 MB, Eindhoven, Netherlands, O.Jabali@tue.nl, *Tom Van Woensel*, *Ton de Kok*

We consider the time-dependent VRP from two standpoints; one seeks to optimize exclusively on travel time; the other does so on total CO2 emissions. We also present a cost-based model that optimizes on a weighted average of travel time, emission and fuel costs. As the amount of CO2 emissions is correlated with vehicle speed, the emissions-based optimization is done by limiting vehicle speed. The emission per kilometer as a function of speed attains its minimum at speed v^* . We show that limiting vehicle speed to v^* might be sub-optimal. Solutions are obtained via a tabu search procedure.

2 - Fuel Emission Optimization in Vehicle Routing Problems with Time-Varying Speeds

Jiani Qian, Dept. Management Science, Lancaster University, b204 house 3, graduate college, lancaster university, la2 0pf, Lancaster, United Kingdom, j.qian@lancaster.ac.uk, *Richard Eglese*

The objective is to produce routes and schedules for a fleet of vehicles that minimize the fuel emissions in a road network where speeds depend on time. A new heuristic approach selects potential routes and then determines the speeds on each road for every vehicle that has been assigned a list of customers. This approach is compared to a time-increment based dynamic programming method in searching for the least polluting route between two customer nodes. To solve the full VRP, the new heuristic algorithm is embedded into a tabu search algorithm.

3 - An Analytical Approach to Medical Waste Management in Istanbul

Tülin Aktin, Industrial Engineering Department, Istanbul Kültür University, Ataköy Campus, E-5 Karayolu Uzeri, Bakırköy, 34156, Istanbul, Turkey, t.aktin@iku.edu.tr, *Ilayda Karabulut*, *Suzan Yavuztürk*

In this study, the vehicle routing problem encountered in Istanbul during the collection of medical wastes from hospitals with bed capacities over 20 is analyzed. Due to the geographical location of the city, the problem is examined in two parts: European side (PE) and Asian side (PA). Two MILP models (PE and PA) are developed to find the routing of vehicles that collect medical wastes from hospitals, as well as, to determine the location/allocation of new disposal sites on both sides of the Bosphorus. The study is implemented using real data obtained from Istanbul Metropolitan Municipality.

4 - The Pollution-Routing Problem

Tolga Bektas, University of Southampton, School of Management, Highfield, SO17 1BJ, Southampton, -, United Kingdom, T.Bektas@soton.ac.uk, *Gilbert Laporte*

This talk will present the Pollution-Routing Problem (PRP), an extension of the classical Vehicle Routing Problem (VRP) with a broader objective function that accounts for the amount of greenhouse gas emissions, fuel, travel times and their costs. Mathematical models will be described for the PRP with or without time windows. Results of computational experiments performed on realistic instances will be presented to shed light on the tradeoffs between various parameters such as vehicle load, speed and total cost, and to offer insight into economies of 'environmental-friendly' vehicle routing.

■ MC-16

Monday, 12:20-13:40

2.2.14

Rescheduling in railway operations

Stream: Public Transport

Invited session

Chair: *Gabrio Curzio Caimi*, Netzdesign und Fahrplan, BLS Netz AG, Genfergasse 11, 3001, Bern, Bern, Switzerland, gabrio.caimi@bls.ch

Chair: *Marco Laumanns*, IBM Research Zurich, 8803, Rueschlikon, Switzerland, mml@zurich.ibm.com

1 - Comparing Multi-Criteria Decision Making Methods for a Railway Dispatching Problem

Anne Binder, Dresden University of Technology, 01069, Dresden, Germany, Anne.Binder@mailbox.tu-dresden.de, *Thomas Albrecht*, *Christian Gassel*

In the literature on railway rescheduling, the optimization function consists of maximum 3 components: train delays, passenger discomfort and energy consumption. This multi-criteria problem is solved by reducing it to one cost function consisting of the weighted sum of the individual criteria. Here, the use of other methods for multi-criteria decision making is examined for a straightforward dispatching problem on a junction. It is proposed to use conflict probability as 4th criterion. By analyzing the Pareto front the sensitivity of the solution towards the weighting factors is shown.

2 - The effectiveness of rescheduling strategies: evidences from two case studies in Italy

Giorgio Medeossi, Department of Civil and Environmental Engineering, University of Trieste, Piazzale Europa 1, 34127, Trieste, Italy, giorgio.medeossi@phd.units.it, *Giovanni Longo*

The accuracy and performance of real time rescheduling algorithms is rapidly increasing. Before implementing them in control centres, it is important to quantify their benefits and understand their requirements. In this study, the effects of different rescheduling strategies in the nodes of Florence and Venice are reproduced by means of stochastic micro-simulation, pointing out the relationship between infrastructure topology, timetable structure and the objective functions. Despite the apparently similar topology, rescheduling strategies perform significantly different.

3 - Dispatching support system for a main station

Martin Fuchsberger, D-Math, Institute for Operations Research, ETH Zurich, Raemistrasse 101, 8092, Zurich, Zurich, Switzerland, fumartin@ifor.math.ethz.ch, *Marco Laumanns*

A dispatching support system for the station area of Berne, Switzerland is presented. The model assigns to each train a path based on a variety of alternative track routes, station platforms, speed profiles and arrival or departure times. While respecting safety regulations based on detailed blocking time theory, the optimal assignment is minimizing a weighted combination of delay propagation and number of broken connections. The model is iteratively adapted to the current state situation and solved in a rolling time horizon framework to cope with the continuously changing online situation.

4 - Coping with extremely variable train delay on a complex railway junction: lesson learned from Beograd case study

Giovanni Longo, DICA, University of Trieste, Via Valerio, 6/1, 34127, Trieste, Italy, longo@dica.units.it, *Giorgio Medeossi*, *Zorica Milanovic*

In large and complex railway nodes, different train categories and services share the same infrastructure. Moreover, they usually have different stochastic behaviour, and different reliability targets. However, from the infrastructure Manager perspective, a global reliability should be maintained, also through an adequate timetabling strategy. In this paper, starting from the analysis of the real behaviour of different train services in the Belgrade junction, a number of possible timetable structures are compared through stochastic micro-simulation in terms of reliability.

■ MC-17

Monday, 12:20-13:40

1.3.14

Online Planning in Vehicle Routing and Scheduling

Stream: Transportation Planning

Invited 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

Chair: *Francesco Ferrucci*, WINFOR (Business Computing and Operations Research), University of Wuppertal, Gausstrasse 20, 42119, Wuppertal, NRW, Germany, fferrucci@winfor.de

1 - A Dynamic Vehicle Routing Problem with Multiple Trips

Michel Gendreau, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca, *Nabila Azi*, *Jean-Yves Potvin*

We consider a routing problem in which vehicles performing multiple short-duration trips serve customer requests that arrive dynamically according to a known stochastic process. In this problem, requests may be turned down as they arrive, but the associated revenues are lost. The objective is to maximize the profits (revenues from served requests - transportation costs). Our solution method relies on a sample of demand scenarios, which is used to evaluate opportunity costs related to future requests. Computational results on randomly-generated test instances will be reported and analyzed.

2 - Schedule Nervousness Reduction in Online Vehicle Routing

Joern Schoenberger, Operations Research and Supply Chain Management, RWTH Aachen, Templergraben 64, 52056, Aachen, Germany, schoenberger@or.rwth-aachen.de, *Stefan Voss*, *Herbert Kopfer*

A vehicle schedule determines the arrival times of vehicles at customer sites. As soon as additional customer-specified requests become known a scheduler changes visiting sequences of vehicles and/or shifts requests among the available vehicles having to prevent significant variations of once announced arrival times at customer sites. We propose a penalty-based modeling approach for online vehicle routing problems that addresses explicitly the keeping of previously decided arrival times. Within computational simulation experiments, we demonstrate the general applicability of our approach.

3 - Solving the Dynamic Ambulance Relocation Problem using Approximate Dynamic Programming

Verena Schmid, Faculty of Business, Economics and Statistics, University of Vienna, Bruenner Strasse 72, 1210, Vienna, Austria, verena.schmid@univie.ac.at

For emergency service providers it is crucial to locate ambulances such that patients can be reached fast enough in case of emergency. The problem can be formulated using a dynamic program. We solve the dynamic ambulance relocation problem using approximate dynamic programming methods. Ambulance redeployment decisions will be made real-time. Our computational experiments show that the policy obtained outperforms greedy strategies used traditionally by ambulance service providers.

4 - An analysis of the impact of dynamic vehicle routing in service delivery systems

Vitória Pureza, Engenharia de Produção, Universidade Federal de São Carlos, Via Washington Luiz, km 235, 13565-905, Sao Carlos, Sao Paulo, Brazil, vpureza@dep.ufscar.br, *Daniel Lazarin*

In this work, we analyze the impacts resulting from the incorporation of dynamic vehicle routing and scheduling in service delivery systems for which meeting the delivery due dates is a priority issue. Specifically, we propose a constructive/deconstructive heuristic for the Dynamic Vehicle Routing Problem in order to obtain routes in real time. Sets of instances randomly generated from the data supplied by a drink company in Brazil are used to assess the relative performance of the heuristic to other methods.

■ MC-18

Monday, 12:20-13:40

1.3.15

Stochastic Modeling and Simulation II

Stream: Stochastic Modeling and Simulation

Invited session

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - Approximation Algorithms for the General Multi Assignment Problem

Ron Adany, Computer Science, Bar-Ilan University, 52900, Ramat-Gan, Israel, adanyr@cs.biu.ac.il, *Sarit Kraus*, *Fernando Ordóñez*

We consider the problem of assigning personalized advertisements to viewers in order to maximize revenue. Each viewer has a limited capacity and each ad has a given length and a revenue that is obtained if it is assigned to a given number R of different viewers. We focus on the Ads Packing problem assuming a subset of ads which can be packed is given. We present two bi-criteria approximations algorithms: Extra-Packing a (1,2)-approximation algorithm and Deep-Search-Replacer, an $(R+1,1)$ -approximation algorithm. Both algorithms were obtained by rounding the relaxed LP solution of the problem.

2 - A randomized algorithm for estimation number of clusters

Zeev (Vladimir) Volkovich, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il, *Oleg Granichin*, *Dmitry Shalymov*, *Renata Avros*

We address to the well known machine learning problem concerning estimation of clusters amount in a given dataset. Our approach offered in the framework of the common "elbow" methodology such that the true number of clusters is recognized as the discontinuity point of the differential risk function. A randomized optimization algorithm is applied to allocate this position. Appropriate theoretical study and numerical experiments provided demonstrate high ability of the proposed method together with its relatively low complexity cost in the case of big suggested number of clusters.

3 - On the number of coincidence of two homogeneous random walks with positive paces.

V. N. Surikov, Institution of Russian Academy of Sciences Dorodnicyn Computing Centre of RAS, 12345, Moscow, Russian Federation, svna@zao-zt.ru, *I. A. Kravchenko*

Objects identification tasks arise in many practical problems connected to the genetic objects' recognition and complex information systems' monitoring. There are some original results that can be used to separation hypotheses' about membership of two independent samples to the same object in the case of noised observation, or to stochastic close different states of the same object. The most commonly results are on the renewal theory's fundamental postulates based, and can be used to the large-scale technical systems' operational simulation.

4 - Synergic process of speech signal energy transmission

Vladimir Zhuravlev, Zaporozhzhya Technical University, 22 Nagornaya Street, office 301, 04107, Kiev, ws_50@mail.zp.ua, *Dorovskykh Anatoliy*

To explain contradictions of imperfect adequacy of speech and hearing process theories the math model of speech signal (SS) energy generation and receiving is posed. The model is based on synergic analysis of SS informational components in communication channel energy transfer speed and communication channel energy substance carriers — air molecules average quadratic speed ratio. Theoretical, estimating and experimental researches, which indirect prove the SS synergic properties, were carried out. The report is available at <http://kudin.net/ri/index.php/20100204-scientific-library.html>

■ MC-19

Monday, 12:20-13:40

1.3.20

Mathematical Finance

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Diogo Pinheiro*, CEMAPRE - ISEG, Technical University of Lisbon, Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, dpinheiro@iseg.utl.pt

1 - Optimal Life Insurance Purchase, Consumption and Investment Decisions with Multiple Risky Securities

Isabel Duarte, Universidade do Minho, Rua Monte do Barral, 37, Real, 4700-280, Braga, Portugal, isabelduarte@math.uminho.pt, *Diogo Pinheiro*, *Alberto A. Pinto*, *Stanley Pliska*

We analyse the problem faced by a wage earner looking for optimal consumption, investment, and insurance purchase strategies in order to maximize expected utility of consumption, of the size of the estate in the event of premature death, and of the size of the estate at the time of retirement for an underlying financial market composed by one risk-free security and an arbitrary finite number of risky securities whose diffusive term is given by a multi-dimensional Brownian motion. We use dynamic programming methods to obtain explicit solutions for the case of CRRA utility functions.

2 - Risk and beliefs updating mechanisms for contingent claims valuation in incomplete markets

Diogo Pinheiro, CEMAPRE - ISEG, Technical University of Lisbon, Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, dpinheiro@iseg.utl.pt, *Alberto A. Pinto*, *Athanassios Yannacopoulos*, *Stylianios Xanthopoulos*

We review two scenarios for the determination of asset prices in an incomplete market. One scenario is based on the update of the attitude towards risk of the agents involved on the trading of such assets, whereas the other scenario is based on the update of their beliefs about the future states of the world. Furthermore, we describe dynamic mechanisms that model the convergence of the buyer's and the seller's prices of a contingent claim in an incomplete market to a unique price and discuss the stability and robustness of these mechanisms with respect to random perturbations.

3 - Behavioural scenarios for contingent claims valuation in multiperiod incomplete markets

Nuno Azevedo, Mathematics, Cemapre, Rua do Quelhas n.º 6, 1200-781, Lisboa, Portugal, nazevedo@gmail.com, *Diogo Pinheiro*, *Alberto A. Pinto*, *Athanassios Yannacopoulos*, *Stylianios Xanthopoulos*

We describe behavioural scenarios for the determination of asset prices in incomplete multi-period financial markets. All these scenarios assume that the participating agents have some initial beliefs about the distribution of the future states of the world which the agents may be willing to update in order to reach an agreement about the price of a given asset. This final price is determined by optimizing some relevant quantity which can be seen as a measure of satisfaction or regret of the agents involved in the trade of such an asset.

4 - Real Options and Signaling in Strategic Investment Games

Takahiro Watanabe, Business Administration, Tokyo Metropolitan University, Minamioosawa 1-1, Hachioji_city, 1920397, Tokyo, Japan, contact_nabe08@nabenavi.net

An investment game with an incumbent and an entrant is examined. The profit flows involve two uncertain factors: (1) the basic level of demand of the market observed only by the incumbent and (2) the fluctuation of the demand described by a geometric Brownian motion which is common to both firms. In our model, the incumbent enters into the market earlier than the entrant, so the timing of the incumbent's investment may reveal the information of the demand level. I characterize this signaling effect and investigate the real option values of both firms.

■ MC-20

Monday, 12:20-13:40

1.3.33A

Cutting and Packing 3

Stream: Cutting and Packing

Invited session

Chair: *Ramon Alvarez-Valdes*, Statistics and Operations Research, University of Valencia, Faculty of Mathematics, Doctor Moliner 50, 46100, Burjassot, Spain, ramon.alvarez@uv.es

1 - The container loading problem with practical considerations

Maria Teresa Alonso, University of Valencia, 46100, Burjassot, mai.alonso@gmail.com, *Francisco Parreno*, *Ramon Alvarez-Valdes*, *Jose Tamarit*

We have developed a hybrid algorithm for the three-dimensional container loading problem taken into account practical considerations. Embedded in a GRASP structure we have designed a constructive algorithm inspired on Ngoi's box placement and a VND procedure for the improvement phase using increasingly aggressive moves.

2 - Coordination of the Vehicle Routing with Time Windows and the Container Loading

Olinto Araújo, CTISM, Universidade Federal de Santa Maria, Brazil, olinto@densis.fee.unicamp.br, *Vinicius Armentano*

We address the integrated problem of the vehicle routing with time windows and container loading, involving practical constraints that are often found in freight transportation. A tabu search algorithm is proposed for the vehicle routing problem, and the loading problem is solved by a multi-start random constructive heuristic with a load arrangement based on generalized cuboids that fit in given empty spaces. Computational tests on instances from the literature are reported.

3 - A model for the Container Stowage Problem

Ana Moura, Economics, Management and Industrial Engineering, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal, ana.moura@ua.pt, *Paulo Triunfante Martins*, *António Andrade-Campos*, *Victor Lobo*

This work presents a model for a fleet of containerships. Three different challenges will be addressed: how to select the fleet navigation routes; how to distribute the cargo by the available vessels; how to stow cargo on the vessels. The cargo at each port must be delivered within a time limit by containerships, each of them with different characteristics. The main subject is the ship's stowage plan because it has a great influence on port handling and vessels stability. In this work, a model for the problem resulted by the integration of CSP and VRP is presented and solved.

4 - Cutting And Packing Algorithms Research Framework

Denis Nazarov, Ufa State Technical University of Aviation, Russian Federation, denis.nsc@gmail.com

Cutting And Packing Algorithms Research Framework (<http://caparf.googlecode.com/>) is an open-source cross-platform framework under GPLv3 license. It provides convenient "testing scenario" model, various reports generators and easy way for developing your own algorithms. Caparf consists of problems definition (for each type of problems), algorithms for solving particular type of problems or even a number of types (including lower/upper bounds, exact methods) and test instances (raw data and generators).

■ MC-21

Monday, 12:20-13:40

6.2.47

Optimization Modeling I

Stream: Software for OR/MS

Invited session

Chair: *Robert Fourer*, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, 60208-3119, Evanston, IL, United States, 4er@iems.northwestern.edu

1 - Attacking Hard Mixed-Integer Optimization Problems through the AMPL Modeling Language

Robert Fourer, Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, 60208-3119, Evanston, IL, United States, 4er@iems.northwestern.edu, David M. Gay

There are many tricks for formulating complex optimization models by use of integer variables, but what's to be done when even the most advanced solvers can't produce results in reasonable time? A series of examples show how substantial improvements in performance can be achieved through carefully focused troubleshooting and experimentation facilitated by the power and flexibility of the AMPL modeling language and its solver interfaces.

2 - A Structure-Conveying Modelling Language for Mathematical and Stochastic Programming

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, Jacek Gondzio, Marco Colombo, Kristian Woodsend, Jonathan Hogg

We present a structure-conveying algebraic modelling language for mathematical programming. The proposed language extends AMPL with object-oriented features that allows the user to construct models from submodels. Unlike traditional modelling languages, the new approach does not scramble the block structure of the problem, and thus enables the passing of this structure to the solver. Solvers that exploit block linear algebra can therefore directly take advantage of the problems structure. The language contains features to conveniently model stochastic programming problems.

3 - Stochastic Optimization: Recent Enhancements in Algebraic Modeling Systems

Lutz Westermann, GAMS Software GmbH, Eupener Str. 135-137, 50933, Koeln, Germany, lutz@gams.com, Michael Bussieck

With all the uncertainty in data there is considerable demand for stochastic optimization in operational, tactical and strategical planning. Nevertheless, there exist a fairly small number of commercial applications building on stochastic optimization techniques. After a decade without much progress on the software side, modeling system providers have recently entered the second round of making it easier to go from a deterministic model to a stochastic version of such a model. We will review the different concepts emphasizing on recent enhancements in the GAMS system.

4 - Rapid application development with OptimJ, a practitioner's experience report

David Gravot, rostudel, 57, rue d'alleray, 75015, Paris, France, France, dgravot@rostudel.com, Patrick Viry

We report practical experience with the OptimJ modeling language on a number of customer projects led by Rostudel Operations Research. Rostudel has extensive experience with tools such as OPL, COMET, GAMS, AMPL, MPL, AIMMS. Recurrent problems when developing applications are the poor integration of optimization and data modeling, preprocessing and integration with software applications. OptimJ overcomes these difficulties by building directly upon the Java language. We focus on practical examples of complex and sparse data collections that frequently occur in optimization applications.

■ MC-22

Monday, 12:20-13:40

3.1.10

OR in Education I

Stream: Teaching OR/MS

Invited session

Chair: *Huiling Zhao*, Kent Business School, University of kent, 19 holter Mill, CT2 8SP, Canterbury, Kent, United Kingdom, hz34@kent.ac.uk

1 - Structured Process for systematic review of literature and the establishment of the References in Multi-Criteria Decision Aid

William Vianna, Production Engineering, Federal University at Santa Catarina (UFSC) - BRAZIL, Rua Cônego Bernardo, 100.

ap. 202, Trindade, 88036570, Florianópolis, Santa Catarina, Brazil, wpwilliam@hotmail.com, *Edilson Giffhorn, Leonardo Ensslin*

The objective of this paper is explore the use of a Structured Process for systematic review of literature and the establishment of the References in Multi-Criteria Decision Aid applications. This is carried in two research projects that deal with "Meta-evaluation of Educational Systems" and "Performance Indicators". The results are the selection of authors, journals and publications of impact that allow the validation of References, and consequently, the development of analysis and data interpretation.

2 - The Environmental Impact of Free school choice in Kent (UK)

Huiling Zhao, Kent Business School, University of kent, 19 holter Mill, CT2 8SP, Canterbury, Kent, United Kingdom, hz34@kent.ac.uk, *Kim Parker, Cecilio Mar Molinero*

In Kent (UK) there is a selective school system: academic results at the age of eleven determine the type of secondary school that children can attend and this may influence their life outcomes. Some parents are prepared to drive their children long distances from home to a "good" school causing congestion, pollution, and social cost. We allocate children to schools based on distance. By comparing model results with the actual, we assess environmental impact. The results confirm the well established view that social background is a major determinant in the dynamics of free school choice.

3 - Social Responsibility Management System: The case study of ESTG-IPG

Ana Rosa, Guarda Polytechnic Institute, 6300-559, Guarda, acristina@ipg.pt, *Rute Abreu, Constantino Rei*

Higher education is a strategic imperative, because neither CSR nor quality management system will subordinate to the other. The paper is centred in the new role of corporate social responsibility practices to achieve transparency, accountability and sustainability. The empirical evidence is based on a case study of the Escola Superior de Tecnologia e Gestão and it develops an exploratory analysis. The results show the application Portuguese Standard NP 4469-1:2008 showing the new public management practices.

■ MC-23

Monday, 12:20-13:40

6.2.49

MOO: Algorithms for Multi-Objective Combinatorial Optimization III

Stream: Multi-Objective Optimization

Invited session

Chair: *Luis Paquete*, Department of Informatics Engineering, University of Coimbra, Polo II, 3030-290, Coimbra, Portugal, paquete@dei.uc.pt

1 - Comparing two territory partitions in districting problems: Indices and practical issues

Fernando Pereira, Matemática, Universidade da Beira Interior, Covilha, Portugal, fpereira@noe.ubi.pt, *José Rui Figueira, Vincent Mousseau, Bernard Roy*

Planning is an activity of critical importance, with direct relevance for urban planners. The ramifications of such decisions generally have significant effect on peoples' lives. The current paper deals with the comparison between territorial maps. The theoretical problem involves the comparison of two partitions in a connected, undirected, and planar graph. In considering this problem, we introduce three new indices to compare territory partitions: compatibility, inclusion, and distance, all of which have importance for real-world planning situations.

2 - A Parallel Evolutionary Algorithm with Multiple Reference Points for Multi-objective Combinatorial Optimization

Arnaud Liefooghe, LIFL - CNRS - INRIA, Université Lille 1, Lille, France, arnaud.liefooghe@lifl.fr, *José Rui Figueira, El-Ghazali Talbi, Andrzej Wierzbicki*

When approximating the efficient set, multiple reference points can be uniformly distributed within a region that covers the Pareto frontier. Here, a preference-based evolutionary algorithm, based on an achievement scalarizing function, is defined for each reference point, so that all the algorithms can easily be launched in a parallel and distributed environment. Computational experiments are performed on a bi-objective flow-shop scheduling problem. Our results show that the parallelization of evolutionary multi-objective optimization algorithms based on reference point methods gives very promising and statistically significantly better results than comparable non-parallel approaches.

3 - The Tree-Dimensional Bin-Packing with 90° rotations

Marisa Figueiredo, Department of Informatics, CISUC, University of Coimbra, Departamento de Engenharia Informática da FCTUC, Pólo II, Pinhal de Marrocos, 3030-290, Coimbra, Portugal, msbfigueiredo@gmail.com, *Ana Almeida*

An interesting multi-criteria variant for the 3-Dimensional Bin Packing problem (3BPP) consists of determining the minimum number of three-dimensional rectangular bins that are required for orthogonally allocating a given set of three-dimensional rectangular items without overlap and minimizing the occupied space: the 3BPP-min problem. We propose a new approach for the 3BPP-min problem where 90 degrees rotations are allowed in order to obtain more compact packing. Computational results show the effectiveness of the new approximation algorithm.

4 - Multicriteria movement synchronization scheduling problems and algorithms

Zbigniew Tarapata, Faculty of Cybernetics, Military University of Technology, Kaliskiego Str.2, 00-908, Warsaw, Poland, zbigniew.tarapata@wat.edu.pl

The paper deals with multicriteria optimization model of movement scheduling for many objects to synchronize their movement. The model consists of two parts: disjoint path planning model for K objects; movement synchronization model in some intermediate nodes. We use two criteria for disjoint path planning: sum and maximum of achieving times of destination nodes by all objects. For synchronous movement two categories of criteria are defined: time of movement and "distance" of K moved objects from movement pattern. Some algorithm for solving the problem and its properties is considered.

MC-24

Monday, 12:20-13:40

6.2.50

Bioinformatics III

Stream: Computational Biology, Bioinformatics and Medicine

Invited session

Chair: *Jacek Blazewicz*, Instytut Informatyki, Politechnika Poznańska, ul.Piotrowo 2, 60-965, Poznan, Poland, jblazewicz@cs.put.poznan.pl

Chair: *Marta Szachniuk*, Institute of Bioorganic Chemistry, PAS, Noskowskiego 12/14, 61-704, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl

1 - A Novel Framework to Elucidate Core Classes in a Dataset

Daniele Soria, IMA, School of Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, dqs@cs.nott.ac.uk, *Jonathan Garibaldi*

A new framework to extract representative groups from a dataset will be presented. It specifies the application of different clustering methods, then statistical and visualisation techniques are used to characterise the results, and core classes are defined by consensus clustering. Classes may be verified using supervised classification to obtain rules which may be useful for new data. The framework is validated over a set of biological markers for breast cancer patients. The resultant classes are well separated and characterised by low, medium and high levels of markers. Clinically, the groups distinguish patients with poor overall survival from those with low grade and better survival.

2 - Infrastructure behind the EPIPE framework

Peter Sackett, Center for Biological Sequence Analysis, Technical University of Denmark, Kemitorvet, Building 208, DK-2800, Kongens Lyngby, Denmark, pws@cbs.dtu.dk

The talk will describe the EPIPE framework, which is designed to detect functional differences between similar protein sequences, e.g. isoforms derived from alternative splicing, sequences indicating locus variation, or protein families from one or more organisms. EPIPE draws on large databases and many, computationally intensive, protein feature prediction tools. In the post-genomic era with the 1000\$ genome around the corner, EPIPE can be used to meet the challenge of revealing functional variation, but the computational effort involved in handling large scale submissions is considerable.

3 - Graph theoretic approaches to clustering

Roberta De Asmundis, Dept. of Mathematics and Applications, University of Napoli FEDERICO II, Compl. MSA, Via Cintia, 80126, Napoli, Italy, robertadeas@hotmail.com, *Paola Festa*, *Mario Guarracino*

Spectral clustering has been recently proposed as a clustering algorithm simple to implement and that can be solved efficiently by standard linear algebra software. When data are given in form of a similarity graph, the clustering can be restated as the problem of finding a partition of the graph such that edges between different groups have a very low weight and the edges within a group have high weight. In a graph this can be related to a minimum cut problem which is NP hard. In this work we explore the possibility to decrease the computational complexity of a de facto standard algorithm for graph partitioning providing evidence of its performance on real world problems.

4 - Predicting the evolution of Biomedical Ontologies

Catia Pesquita, Department of Informatics, Universidade de Lisboa, Edifício C6 Piso 3, Campo Grande, 1749 - 016, Lisboa, Lisboa, Portugal, cpesquita@xldb.di.fc.ul.pt, *Francisco Couto*

Ontologies represent one of the most relevant breakthroughs in bioinformatics, providing a semantic model that supports tasks such as text and data mining, database interoperability, annotation, and automated reasoning. However, the task of maintaining biomedical ontologies up to date is daunting due to the dynamical nature of biomedical knowledge. Here, we present preliminary results on the prediction of the evolution of the Gene Ontology, one of the most prominent biomedical ontologies, comparing different sets of features across several versions.

MC-25

Monday, 12:20-13:40

6.2.48

Risk Management in Operations

Stream: Financial Mathematics and OR

Invited session

Chair: *Stefan Spinler*, Production Management, Beisheim School of Management, WHU, Burgplatz 2, 56179, Vallendar, Germany, sspinler@whu.edu

1 - A mixed-integer linear programming model for sovereign debt issuance

Malek Abdel Jawad, Mathematical Sciences, Brunel University, John Crank Building, Kingston Lane, UB8 3PH, Uxbridge, Middlesex, United Kingdom, mapgmma@brunel.ac.uk, *Paresh Date*, *Alessandra Canepa*

Governments borrow funds to finance the excess of cash payments or interest payments over receipts, usually by issuing fixed income debt. The goal of this work is to determine the composition of the portfolio issued by the government, to minimize the cost of servicing debt while controlling risk and maintaining market liquidity. We show that this debt issuance problem can be modelled as a stochastic optimization problem with a receding horizon. The stochastic nature of interest rates is modelled using Kalman filter. We demonstrate the utility of our approach by back-testing on UK debt issuance.

2 - Pricing of Full Service Repair Contracts

Sebastian Huber, Chair of Logistics Mgmt., WHU Otto Beisheim School of Management, Burgplatz 2, 56179, Vallendar, Germany, sebastian.huber@whu.edu, *Stefan Spinler*

Investment products (e.g. industrial trucks) are often sold with a fixed fee repair contract. The service provider has to set a price offer to heterogeneous customers optimizing his portfolio profit for contracted and on-call service. We combine price willingness based on risk aversion under mean-variance utility with a cost model based on stochastic failures and repair cost. Moral hazard is constrained by a guaranteed service time with a penalty based on a queue. We find the optimal price depending on customer cost expectation and incentivizing the provider to inform customers truthfully.

3 - Game-theoretic analysis of forward market under uncertainty

Alexander Vasin, Operations Research, Moscow State University, Leninskie Gory, MGU, VMK faculty, 119991, Moscow, Russian Federation, vasin@cs.msu.su, Agata Sharikova

This paper considers an oligopoly with fixed marginal cost. The outcome at both the forward and the spot market is a Cournot outcome dependent on demand and supply at the market. We assume that the outcome at the spot market is random and determine optimal behavior of consumers depending on reservation prices and risk-aversion parameters. Producers aim to maximize their profits via choosing subgame perfect equilibrium (SPE) of the two-stage game as their strategies. We show that there exists an SPE in correlated mixed strategies. The random variable determines one of two possibilities for spot market: either "bear market", or "bull market". We compare this SPE with Nash equilibria of one-stage markets

4 - Retailer Product Portfolio Selection & Pricing Problem

Soumojit Kumar, Operations management, Indian Institute of Management, Calcutta, Annexe-204, Indian Institute of Management Calcutta, Diamond Harbour Road, Joka, Kolkata-700104, 700104, Kolkata, West bengal, India, soumojitk08@iimcal.ac.in, Uttam Sarkar

Retailers with limited storage capacity have to decide to stock the right mix of product variants to optimize their dual objective of maximizing profit as well as retain market share. The optimal portfolio solution is determined and the pricing of each variant is also a decision variable. The retailer has a certain amount of market share and can vary the prices of the variants between a maximum retail price and a lower bound. Excess inventory is sold at a salvage value usually less than the cost of the variant making a loss. Heuristics are developed to reach the optimal point.

■ MC-26

Monday, 12:20-13:40

3.1.11

Machine Learning to help people with disabilities

Stream: Machine Learning and Its Applications

Invited session

Chair: Emilio Parrado-Hernandez, Signal Processing and Communications, Universidad Carlos III de Madrid, Avenida de la Universidad 31, 28911, LEGANES, emipar@gmail.com

Chair: Jaisiel Madrid-Sanchez, Technosite, 28037, Madrid, jmadrid@technosite.es

1 - Automatic data processing for web accessibility personalization

Olatz Arbelaitz, Computer Architecture and Technology, University of the Basque Country, Manuel Lardizabal 1, 20018, Donostia, Euskal Herria, Spain, olatz.arbelaitz@ehu.es, Julio Abascal, Javier Muguerza, Iñigo Perona

People with physical, sensory or cognitive restrictions have difficulties to take advantage of the facilities offered by the web. The barriers can be surmounted using systems that are able to adapt the interfaces to the users' characteristics. Most actual user models are designed based on the preconceived characteristics of users with disabilities. The use of machine learning techniques to build user models will allow to take into account their real capabilities since those techniques will extract knowledge from the information obtained from web navigation logs belonging to the users.

2 - Identification of gait alterations with a wearable inertial system

Andreu Catala, CETPD, Universitat Politècnica de Catalunya, Rambla de l'Exposició 59-69, 08800, Vilanova i la Geltru, Spain, andreu.catala@upc.edu, Albert Samà, Diego Pardo

Gait perturbations due to chronic diseases like Parkinson or as a consequence of the age as in elderly people are an important cause of disability. Recognizing and monitoring of gait alterations is crucial in order to accomplish better diagnosis, better rehabilitation design and also fall prevention. We apply PCA to an organized set of time series provided by the wearable inertial sensor used during the patient daily life activities. It allows us to discriminate the internal dynamics of the system and correlate them with the actual spatio-temporal properties obtained during gait

3 - Improving accessibility with machine learning

Manuel Ortega, Research, Technosite, C/ Albasanz 16, planta 3, 28037, Madrid, Spain, mortega@technosite.es

People with disabilities and elderly people face great barriers when trying to access digital information. Interfaces and contents are usually not designed to fit their needs. This could be overcome through automatic generation of interfaces. This solution can be addressed as an optimization problem. Machine Learning can also provide tools that adapt contents to users with special needs and is useful for user modelling and context-varying system adaptations.

■ MC-27

Monday, 12:20-13:40

8.2.06

Financial Optimization 3

Stream: Financial Optimization

Invited session

Chair: Laura Di Giacomo, Statistica Probabilità Statistiche Applicate, Università La Sapienza, p.le Aldo Moro 5, 00185, Roma, Italy, lauradg@caspur.it

Chair: André Salles, Industrial Engineering, 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

1 - Markowitz principles for multi-period portfolio selection problems with bankruptcy condition

Thamayanthi Chellathurai, Treasury and Risk Management, Canadian Imperial Bank of Commerce, Capital and Credit Risk Analytics, CIBC, 21 Melinda Street, CCE- 9th Floor, M5L 1A2, Toronto, Ontario, Canada, thamay.c@gmail.com

The multi-period portfolio selection problem is formulated as a Markowitz mean-variance optimization problem in terms of time-varying means, covariances, higher order and inter-temporal moments of the asset prices. To preclude possible arbitrage opportunities at future trading dates, a bankruptcy condition is enforced approximately. The expected return of the portfolio is dependent not only on the means of the asset prices at discrete times, but also on the higher order and inter-temporal moments. Numerical results are presented for some test problems.

2 - Optimal Control of Exchange Traded Funds Instruments (ETF)

Laura Di Giacomo, Statistica Probabilità Statistiche Applicate, Università La Sapienza, p.le Aldo Moro 5, 00185, Roma, Italy, lauradg@caspur.it

An optimal control policy is fundamental for the management of ETF through formal mathematical programming system. The formulation of the algorithm will be presented and extensive implementation would be discussed.

3 - An Approximate DP Approach to Benchmark Practice-based Heuristics for Natural Gas Storage Valuation

Nicola Secomandi, Tepper School of Business, Carnegie Mellon University, 5000 Forbes Avenue, 15213, Pittsburgh, PA, United States, ns7@andrew.cmu.edu, Guoming Lai, Francois Margot

The valuation of the real option to store natural gas is a practically important problem. Traders value this option heuristically because its exact valuation is at odds with the high-dimensional price evolution models that they use. We develop a novel and tractable approximate dynamic programming method that coupled with Monte Carlo simulation computes lower and upper bounds on the value of storage. We use these bounds to benchmark heuristics used in practice.

4 - Liquidity Risk in the Brazilian Stock Market: An Empirical Evidence

Alvaro Costa, Federal University of Rio de Janeiro, 22440033, Rio de Janeiro, corletto@gmail.com, André Salles

The market liquidity refers to the capacity of buying or selling an asset quickly, without discounts and in a big quantity. A lot of research published in the literature of finance analyzes the market liquidity, the liquidity risk and their interrelations with the firms' cost of capital. Some of this research deals with the liquidity of the financial assets, in particular the liquidity risk of these assets. This work purpose to verify the firms' liquidity risk from the determination of time series of the liquidity, of financial asset selected, were used heteroscedasticity models of volatility. The sample used consists stocks negotiated in the Brazilian stock market.

■ MC-28

Monday, 12:20-13:40

8.2.10

Applications of stochastic programming to the energy sector - gas

Stream: Stochastic Programming 1

Invited session

Chair: *Marte Fodstad*, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, 7491, Trondheim, Norway, martefo@iot.ntnu.no

1 - Evaluating the impact of forecasting techniques on a stochastic optimization model for a gas sale retailer

Juan Ramon Trapero Arenas, Management Science, Lancaster University, LA1 4YX, Lancaster, United Kingdom, j.traperoarenas@lancaster.ac.uk, *Nikolaos Kourentzes*, *Francesca Maggioni*

Deregulation of natural gas market in recent years has increased the necessity of accurate forecasting and optimization tools. Forecasting gas consumption is crucial to establish optimal strategies for companies dealing with gas retail commercialisation. Temperature and gas consumption data collected from an Italian retailer are used to compare different forecasting approaches based on univariate and multivariate methods. The influence of the forecasting performance is assessed in terms of losses in the gas seller's budget.

2 - A stochastic portfolio optimization model for the natural gas supply chain

Marte Fodstad, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, 7491, Trondheim, Norway, martefo@iot.ntnu.no, *Kjetil Midthun*, *Frode Rømo*, *Asgeir Tomasgard*

We present a portfolio optimization model for tactical planning in the natural gas supply chain. The model takes the perspective of a large producer optimizing its portfolio of production rights, transportation rights, take-or-pay contracts and spot market opportunities. The objective is to maximize profits while contract obligations are satisfied. Spot prices and contract obligation and prices are stochastic parameters. We will describe the model, show examples of typical model effects and results on realistic data.

3 - Hydrogen Production Facility Network Design with Stochastic Wind Energy Supply and Nodal Pricing

Jorge Barnett Lawton, PhD Student, MIT-Zaragoza International Logistics Program, Zaragoza Logistics Center, Calle de Bari 55, Portal 5, PLAZA, 50197, Zaragoza, Spain, jbarnett@zlc.edu.es, *Mozart Menezes*, *Jarrod Goentzel*

We analyze the profit maximization problem for an integrated firm generating electricity from wind and producing hydrogen through electrolysis, operating on a single node of an electric transmission network under nodal pricing. We present the firm's optimal actions for any given market scenario, and formulate the firm's expected profit function. We then use these results to address the hydrogen production location/capacity problem.

4 - Solving stochastic equilibrium problems with stochastic gradient methods: analysis of collaborative service provision in telecommunication sector

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, *Denis Becker*

In this paper we develop algorithms for solution of stochastic multilevel equilibrium problems which belong to the family of stochastic gradient methods. Such problems arise in environments composed by multitude of actors engaged in complex relations of competition and collaboration. Numerical experiments confirm the efficiency of the proposed techniques. We apply this methodology to the analysis of markets for ICT products and services in the process of transformation from young markets with few actors to mature markets with large number of participants.

■ MC-29

Monday, 12:20-13:40

8.2.11

Algorithmic Applications of Boolean Functions

Stream: Boolean Programming

Invited session

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

1 - A Boolean theory of tonal signatures

Bruno Simeone, Dept. of Statistics, University of Rome La Sapienza, Piazzale Aldo Moro 5, 00185, Rome, Italy, bruno.simeone@uniroma1.it, *Isabella Lari*, *Gilbert Nouno*, *Malik Mezzadri*

We explore the musical concept of tonal signatures developed by the French jazz flute player and composer Malik Mezzadri. A tonal signature of a scale S is a minimal subset of notes within S that is not contained in any scale S' different from S . We present a set covering model to find a smallest signature. We show that the signatures of a scale are the prime implicants of a suitable monotone Boolean function represented by a CNF. On this ground, we introduce a more general notion of Boolean signature, depending on a Boolean operator. Short pieces will be played on this new harmonic concept.

2 - A Classification Problem and the Maximal Weight Archipelago Subgraph Problem

Bela Vizvari, Industrial Engineering, Eastern Mediterranean University, Gazimagusa, Mersin 10, Turkey, vizvaribela@gmail.com, *Bruno Simeone*

Motivation. The relation of two stocks can be expressed by the correlation of their prices. In an ideal clustering of stocks there are positively correlated ones in each cluster and different clusters are connected by negative correlations. The ideal clustering can be achieved only by neglecting some correlations. Archipelago Graph. A signed graph is an archipelago if all negative edges are connecting different components of the graph of the positive edges. Results. Some edges are to be deleted from a weighted signed graph being not an archipelago. Two questions are answered in connection with that problem: how high weights must be deleted and how to obtain an archipelago subgraph of maximal weight.

3 - A polynomial algorithm for dualizing monotone Boolean functions arising in geometry

Khaled Elbassioni, Department 1:Algorithms and Complexity, Max-Planck-Institut für Informatik, Campus E1 4, 66123, Saarbrücken, Saarland, elbassio@mpi-inf.mpg.de

We consider the problem of dualizing a monotone Boolean function whose CNF representation corresponds to a geometric hypergraph. We show that, when the hypergraph admits a balanced subdivision, a recursive decomposition can be used to obtain efficiently all minimal terms in the DNF representation of the function. We apply this framework to get efficient parallel algorithms for dualizing monotone Boolean functions whose CNF's are induced by a set of points and a set of geometric objects, such as half-spaces, hyper-rectangles and balls, in fixed dimension.

4 - Minimization of quadratic pseudo-Boolean functions

Ivo Rosenberg, Math.Stat, Université de Montréal, C.P. 6128 suc.centre ville, H3C3J7, Montréal, Qué., Canada, rosenb@dms.umontreal.ca, *Calvin Mbuntcha-Wuntcha*

The problem is to find the minimum value of an n -variable quadratic polynomial on the unit n -dimensional hypercube. For this NP-complete problem - which includes several classes of NP-complete problems - we propose a heuristic based on steepest descent curves through the interior of the hypercube. At a point where such a curve definitely leaves the hypercube we freeze certain coordinates of the polynomial to 0 or 1 and continue the steepest descent from the point on the reduced polynomial. Repeated application leads to a point of local minimum.

■ MC-30

Monday, 12:20-13:40

8.2.13

MCDA II: Health and Environment

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

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

Chair: *David Collier*, Golders Associates, OX33 1ER, Oxford, United Kingdom, David_Collier@golder.co.uk

1 - Strategic appraisal of environmental risks: a contrast between the UK's Stern Review on the Economics of Climate Change and its Committee on Radioactive Waste Management

Alec Morton, Management/ Operational Research, London School of Economics, Houghton St, London, wc2a2ae, London, England, United Kingdom, a.morton@lse.ac.uk, *Simon Dietz*

We compare two high-profile strategic policy reviews undertaken for the UK government: radioactive waste management and climate change. The Stern Review on the Economics of Climate Change was largely an exercise in expert modelling within a cost-benefit framework. The Committee on Radioactive Waste Management, on the other hand, followed a much more explicitly deliberative and participative process, using MCDA to bring together scientific evidence and stakeholder and public values. We ask why the two reviews were different, and whether the differences are justified.

2 - Lessons from Two Recent Major MCDA Projects

David Collier, Golders Associates, OX33 1ER, Oxford, United Kingdom, David_Collier@golder.co.uk, *Michael Egan*

The paper contrasts two projects involving substantial specialist teams. One was based on a conventional scored and weighted multi-attribute decision analysis. In the other, the MADA framework was used largely without quantification to structure the problem and understand the main decision drivers. We will discuss the lessons for the use of MCDA frameworks and stakeholder involvement and draw conclusions about the appropriate use of quantification, the structured integration of MCDA outputs with other strands of information and management insight, and the role of decision specialists.

3 - Facilitated health care priority setting at a time of economic crisis

Mara Airoidi, Management - OR group, London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, United Kingdom, m.airoidi@lse.ac.uk, *Nikolaos Argyris*, *Alec Morton*

At times of economic crisis it is particularly difficult for diverse stakeholders to agree on resource allocation. In this paper we present our experience to support the English National Health Service setting priorities and facing the challenge of disinvestments. The approach is decision analytic, participative and allows using clinical and epidemiological evidence systematically. Particular attention is given to the difficulty of obtaining a list of potential disinvestments from stakeholders on one hand, and the impracticality of evaluating all interventions currently provided on the other.

4 - On the design of custom packs: grouping of medical disposable items for surgical procedures

Brecht Cardoen, Vlerick Leuven Gent Management School & Faculty of Business and Economics, Katholieke Universiteit Leuven, Reep 1, B-9000, Gent, Belgium, brecht.cardoen@vlerick.be, *Mario Vanhoucke*

In order to limit the non-operative time in the operating theater, hospitals or surgeons often stimulate the use of custom packs in which medical disposable items are grouped. In this paper, we examine how many different types of custom packs have to be introduced for a given population of surgeries and surgeons, and how these packs should be configured. We develop a mixed integer linear programming approach that guides these decisions, taking into account, for example, the resulting number of touch points or the value of waste. We report on our experience in applying the solution methodology for the design of custom packs in an average-sized hospital in Belgium. We examine the solution quality that is obtained and discuss the major issues we encountered during the configuration process.

■ MC-31

Monday, 12:20-13:40

8.2.15

Societal Complexity and Stakeholders

Stream: Methodology of Societal Complexity

Invited session

Chair: *Marcos Estellita Lins*, Production Engineering, Federal University of Rio de Janeiro, Rua Belisário Távora 80 ap 506, Laranjeiras, 22245-070, Rio de Janeiro, Rio de Janeiro, Brazil, lins@pep.ufrj.br

1 - Multi-actor multi-criteria analysis (MAMCA) as a means to cope with societal complexity

Klaas De Brucker, Faculty of Economics and Management, Hogeschool-Universiteit Brussel (HUB), Stormstraat 2, BE-1000, Brussels, Belgium, klaas.debrucker@hubrussel.be, *Cathy Macharis*

In this contribution it will be shown that the dynamics of stakeholder management, in combination with the implementation of MCA, can be used to cope with problems of societal complexity. Special attention will be given to the design of the value structure that is instrumental for this purpose. Several alternative approaches will be contrasted, such as the traditional value structure versus the multi-actor value structure (used in MAMCA). Regarding the latter, different methods for exploring (or aggregating) stakeholder objectives will be discussed and illustrated using real-life case-studies.

2 - Systemic Intervention - Methodological Pluralism in Managing the Problem Situations

Slavica P. Petrovic, Faculty of Economics, University of Kragujevac, D. Pucara 3, 34 000, Kragujevac, Serbia, pslavica@kg.ac.rs

As a theoretical, methodological and applicable development within critical systems thinking, Systemic Intervention is based on the ideas of process philosophy and the theory of boundary critique. The resulting three-stage methodology is focused on: critique - reflection on, and choice between, boundaries; judgment - judgment about which theories and methods can be most appropriate; and action - the implementation of methods to create - at least local - improvement. In managing the problem situations, the Creative design of methods provides a strategy for selecting, designing and mixing methods during intervention.

3 - Dialogical self, Theory of Mind and Meta-cognition as a contribution

Marcos Estellita Lins, Production Engineering/ Operational Research, Federal University of Rio de Janeiro, Rua Belisário Távora 80 ap 506, Laranjeiras, 22245-070, Rio de Janeiro, Rio de Janeiro, Brazil, estellita@pep.ufrj.br

Validation is important to applying formal models to complex societal problems. since unwitting pre-decisions reflect issues that are left out of the research, and can be crucial to the validity of the research. This work proposes the use of concept or cognitive maps to express complexity and conflictive nature of the social problems. We have borrowed multiagency concepts from Dialogical Self theory and Theory of Mind in order to provide a phenomenological support to Problem Structuring Methods. Looking at the big picture helps promoting outside validity. Some applications are provided.

4 - Recent OR Advances on Societal Complexity, stream Methodology of Societal Complexity

Julien Cotret, Computer science, LIRMM, LIRMM UMR 5506 - CC 477 161 rue Ada 34095 Montpellier Cedex 5 France, montpellier, France, julien.cotret@laposte.net

Problems encountered within the e-democracy are closely related to the web 2.0 phenomenon. One objective of the e-democracy is the opinion construction and/or extraction on the web to support a political decision. One efficient way is to have citizens debate on subjects or texts. The first issue is the analysis of the produced content, the second one is to improve the participation. Being able to manage the flow of generated data, models and tools become a necessity. In this paper, we present the "Annotation" as a practical and effective model on which we will base our argument.

■ MC-32

Monday, 12:20-13:40

8.2.17

OR in Forestry II

Stream: OR in Agriculture and Forest Management

Invited session

Chair: *Isabel Martins*, Departamento de Matemática, Instituto Superior de Agronomia, Centro de Investigação Operacional, Tapada da Ajuda, 1349-017, Lisbon, Portugal, isabelinha@isa.utl.pt

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 - Assessing sustainable management in forest Mediterranean ecosystems in Southern Portugal.

Brigite Botequim, Department of Forestry, The Institute of Agronomy of Lisbon, Tapada da Ajuda, 1349-017, Lisbon, Portugal, bbotequim@isa.utl.pt, *Paulo Borges*, *Miguel Constantino*, *Jose Borges*

Addressing sustainability concerns in Mediterranean forest ecosystems management is a complex task. This paper focuses on techniques for oak scenario analysis. Both a linear and integer programming models and Decision Support System architecture aim at addressing the complexity of such forest management problems and promote its sustainability. The mathematical model includes objectives such as net present value, cork and timber flows and carbon stocks. Results are discussed for a large-scale application encompassing over 1 million ha of cork and holm oak forest ecosystems in Southern Portugal.

2 - Tree search for forest harvest scheduling problems subject to area and connectivity constraints

Teresa Neto, Matemática, Instituto Politécnico de Viseu, R. Coronel Fonseca, Lote 2, Carneira, 2005-010 Santarém, Santarém, Portugal, tneto@mat.estv.ipv.pt, *João Pedro Pedrosa*, *Miguel Constantino*, *Isabel Martins*

This work presents a tree search method for finding good feasible solutions, in reasonable times, for forest harvest scheduling problems subject to area constraints (on clearcuts and habitats) and connectivity constraints. For the connectivity constraints, an index is used. The method is a search process inspired in branch-and-bound, designed specifically for this problem. In each branch, a partial solution leads to two children nodes, corresponding to harvesting or not a given stand, in a given period. Pruning is based on constraint violations or unreachable objective values.

3 - Integer and multiobjective programming approaches for modelling target volume flows in harvest scheduling subject to maximum area restrictions

Maria da Conceicao Fonseca, Departamento de Estatística e Investigação Operacional, Universidade de Lisboa, Faculdade de Ciências and Centro de Investigação Operacional, Bloco C/6 Campo Grande, Cidade Universitária, 1749-016, Lisboa, Portugal, mdfonseca@fc.ul.pt, *Isabel Martins*, *Mujing Ye*, *Miguel Constantino*, *Jorge Cadima*

A typical requirement in harvest scheduling is a non-declining flow of timber harvested over the planning horizon. Therefore, two objectives should be considered: maximize the profit and at the same time obtain an even flow of timber harvested along the planning horizon. This goal can be achieved either by integer programming approaches using volume constraints to impose such a non-declining yield or by a multiobjective programming approach. All the approaches are compared from a computational point of view.

■ MC-33

Monday, 12:20-13:40

8.2.19

Electric Vehicles

Stream: Energy, Environment and Climate [c]

Contributed session

Chair: *Andrei Neboian*, Chair of Logistics Management, WHU, Burgplatz 2, 56179, Vallendar, Germany, andrei.neboian@whu.edu

1 - Fleet renewal with electric vehicles - a real options approach

Andrei Neboian, Chair of Logistics Management, WHU, Burgplatz 2, 56179, Vallendar, Germany, andrei.neboian@whu.edu, *Stefan Spinler*, *Paul Kleindorfer*

We evaluate commercial fleet renewal strategies with electric vehicles (EVs) using real options. We show that the fleet operator can hedge against uncertainties of the battery price and fuel price by having an option to replace certain amount of diesel vehicles with EVs every year. We use a discrete time lattice based option model, with two underlying stochastic processes, taking into account technology learning via experience curve. CO2 price will be modeled as a Geometric Brownian motion subject to regime switching. We derive optimal replacement strategies which maximize total project value.

2 - Risk analysis to Electric Vehicles Fast Charging Stations

Jorge Borges, MIT PORTUGAL SES / IN+, INSTITUTO SUPERIOR TECNICO (IST) - UNIVERSIDAD DE LISBOA (UTL), Lisbon, Portugal, jorge.g.borges@gmail.com, *Christos Ioakimidis*

To drive an electric vehicle (EV), it is necessary an infrastructure system that can provide charging when the vehicle is parked as well as ongoing charge (to refill the EV power in a fast process, like Fast charging stations). Fast Charging is intended to perform similar to a commercial gasoline service station, aiming to achieve a 50% charge in an EV battery in 10 to 15 minutes. But as gasoline stations must be refuelled, Fast charging stations must also be supplied by the electric grid and therefore are dependent by the electricity price. This work makes a risk analysis to a fast charging station. It was developed a business model that simulates the fast charging price from the driver's point of view.

3 - Assessing the Power Sector-Related Environmental and Cost Impacts of Plug-In Hybrid Electric Vehicles in Germany

Reinhard Madlener, Faculty of Business and Economics / E.ON Energy Research Center, RWTH Aachen University, Mathieustrasse 6, 52074, Aachen, Germany, rmadlener@eonerc.rwth-aachen.de, *Christoph Mazur*

In the coming years the diffusion of PHEV among private households will increase. PHEV offer individual transport services less dependent on fossil fuels, so that variable costs for those households and emissions will decrease. Still, increased demand for electricity created by PHEV will significantly influence the total daily grid load (and thus capacity requirements and power generation cost). Due to the country-specific energy mixes and charging strategies, the impact on total emissions (from vehicles and power plants) will vary as well. Our study focuses on the situation in Germany.

■ MC-34

Monday, 12:20-13:40

8.2.23

Production and Inventory decisions with recycling

Stream: Lot-sizing and Scheduling, Economic Order Quantity

Invited session

Chair: *Simone Zanoni*, Dipartimento di Ingegneria Meccanica, Università di Brescia, via Branze 38, 25123, Brescia, Italy, Italy, zanoni@ing.unibs.it

1 - The value of flexibility of different sourcing strategies for spare parts after end-of-production

Rainer Kleber, Faculty of Economics and Management, Otto-von-Guericke University Magdeburg, POB 4120, 39016, Magdeburg, Germany, rainer.kleber@ovgu.de, *Karl Inderfurth*

The provision of spare parts for after sales service requires high flexibility. Options available provide different levels of flexibility: placing a final order at the end-of-production is not flexible at all, extra procurement is often charged with high unit cost and minimum lot size requirements, and remanufacturing is limited by the availability of used components. In a numerical study we combine the above options to strategies and investigate to which extent quantity, time and stock related flexibility properties of the different sourcing options contribute to a strategy's profitability.

2 - Multi-product economic lot scheduling problem with remanufacturing (ELSPR) and yield loss

Simone Zanoni, Dipartimento di Ingegneria Meccanica, Università di Brescia, via Branze 38, 25123, Brescia, Italy, Italy, zanoni@ing.unibs.it, *Laura Mazzoldi*, *Ivan Ferretti*

We study a variant of the multi-product economic lot scheduling problem with remanufacturing (ELSPR). The system includes three limited capacity resources: after a disassembly and testing activities, product components are disposed or involved in remanufacturing operations (considering a probabilistic success of recovery), while new products are manufactured on a separate line. A simple heuristic is also applied to provide near-optimal solutions to the related economic lot scheduling problem: numerical study shows applicability of the heuristic and the savings that can be obtained.

3 - Environmental collaboration in Closed-loop Supply Chain with dynamic returns

Pietro De Giovanni, Management Science, ESSEC BS, av. B. Hirsch, Cergy Pontoise, 95800, Cergy, France, France, pietro.degiovanni@essec.fr

In a closed-loop supply chain, the players coordinate their strategies to building up the goodwill and exploit it for marketing and operational purposes. The goodwill dynamic enhances the return rate whose behavior is investigated under infinite time horizon. We compare the players' strategies and outcomes under wholesale price and reverse revenue sharing contracts, showing that coordination in environmental management is successful only when returns residual value is sufficiently large while the inefficiency due to a two-parameter contract is not too damaging.

4 - Assessing the impact on optimal production capacities in a closed-loop logistics system of the assumption that returns are stochastically independent of sales

Ernest Benedito, Universitat Politècnica de Catalunya, Spain, ernest.benedito@upc.edu, *Albert Corominas*, *Albert Corominas*

We study a production system with reverse logistics such that new and recovered products are indistinguishable, manufacturing and storage capacities are limited and where product returns depend on previous sales. With these assumptions, the optimal manufacturing and storage capacities are hard to calculate, mainly because of the relation between sales and returns. In order to improve the tractability of the problem, we do the calculations assuming that sales and returns are stochastically independent, and then we analyse how this hypothesis influences the outcome of a given policy.

■ MC-35

Monday, 12:20-13:40

6.2.46

Soft OR and Problem Structuring Methods II

Stream: Soft OR and Problem Structuring Methods

Invited session

Chair: *Fran Ackermann*, University of Strathclyde, United Kingdom, fran@mansi.strath.ac.uk

1 - 'Getting messy' with problems: teaching students problem structuring methods

Fran Ackermann, Management Science, Strathclyde University, 40 George Street, G1 1QE, Glasgow, United Kingdom, fran.ackermann@strath.ac.uk

For many teaching PSMs within the constraints of a degree program can be a challenge. For example, effort is needed in managing expectations — particularly as the system doesn't give 'a clear right answer'. And then there is the requirement of working 'live' with groups - a daunting task to many! Finally adding the extra consideration of distance learning just exacerbates the situation. However PSMs clearly provide benefit to many and are a valuable part of an OR's armoury. This paper reflects on a selection of these challenges, and provides some insights into their management.

2 - On Verification of Cognitive-Map-Based Models of Ill-structured Situations

Svetlana Kovriga, Institute of Control Sciences of Russian Academy of Sciences, 65, Profsovnaya st., 117997, Moscow, Russian Federation, mackinder@mail.ru, *Nina Abramova*

The inevitable participation of experts in structuring and solving problems in ill-structured situations by means of cognitive maps causes human-induced risks. In order to reduce these risks the verification method that applies a number of criteria of the cognitive-map-based models validity is proposed. This method is illustrated by a number of examples including detection of risks of causal influences false transitivity. The risks of this kind are typical for cognitive mapping. This result refutes the stereotypical conception of universality of causal influences transitivity principle.

3 - Improving Surgical Center Management of a University Hospital through combined Soft and Hard O.R. approaches

Leonardo Pessoa, CASNAV - Centro de Análises de Sistemas Navais, Praça Barão do Ladário s/nº - Ilha das Cobras, Centro, 20091-000, Rio de Janeiro, Rio de Janeiro, Brazil, lampessoa@gmail.com, *Marcos Estellita Lins*, *Angela Silva*, *Roberto Fiszman*, *Milena Diniz*

This paper focuses on the Surgical Center of "HUCFF", which is a benchmark among Brazilian teaching hospitals. However, low surgical production is a major concern for managers. The aim of this work is to point out ways to increase performed surgeries, yielding benefits for patients, students and also researchers. Soft and Hard O.R. tools are used, striving for better assessment. Direct experimentation could decrease system performance, exposing patients to negative effects. Thus, simulation has special affinity in this case. Use of cognitive maps include health-staff points of view, supporting simulation experiments. Results concern both quantitative and qualitative recommendations.

4 - Selection of executive aircraft using tools to support decision: Cognitive Maps and Decision Tree

Eliseu Zednik, COMAER, ITA, CTA, 12.246-021, São José dos Campos, São Paulo, Brazil, zednikff@ita.br, *Mischel Carmen N. Belderrain*

This work is the use of Cognitive Maps and its transition to a model Multicriteria Decision Support or problems of the type of decision trees. This study focuses on the importance of problem structuring applied to problems of type selection Portfolios. Through this kind of tool is obtained PVF Viewpoints fundamental clarify on which product best meets the requirements of the desirable maker. Thus, the decision-making process will have a greater chance of success especially in scenarios typically complex, with greater potential for mental representation of perceived reality.

■ MC-36

Monday, 12:20-13:40

3.1.05

Genetic Fuzzy Systems; Fuzzy Goal Programming 2

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence

Invited session

Chair: *Fernando Gomide*, DCA—FEEC—UNICAMP, 13083-970, 13083-970 Campinas — SP, Brazil, gomide@dca.fee.unicamp.br

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 - Adaptive Meta-heuristics with Genetic Fuzzy Systems

Vitor Marques, DCA, FEEC, Unicamp, 13083-970, Campinas, SP, Brazil, vmarques@gmail.com, *Fernando Gomide*

The paper introduces a genetic fuzzy system (GFS) to control meta-heuristics. The system adaptively chooses parameters values and runs simultaneously with the meta-heuristics. The GFS learns a fuzzy rule-base for parameter selection. A rule selection procedure reduces system complexity. Learning trades-off exploration and exploitation during search. A case study with vehicle routing with time windows illustrates the approach using genetic algorithm and tabu search. Experimental results show that the GFS improves solution quality and reduces users effort considerably.

2 - A Web Based DSS for Improved Innovation Management

Kemal Kilic, Faculty of Engineering and Natural Sciences, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, kkilic@sabanciuniv.edu

The webbased DSS relies on a questionnaire and generates two reports. The first report benchmarks the company with others in terms of various innovation determinants (InnoDets). The second report provides focused policy suggestions. Hence, only those determinants that the company has room for further improvement, which significantly improve the innovativeness, should be identified. In order to determine the significance of the InnoDets a fuzzy system modeling based feature weighting algorithm which utilizes genetic algorithms is proposed. This is a rare study that ranks and rates various InnoDets.

3 - Fuzzy Goal Programming for Portfolio Selection

Verónica Cañal, Applied Economics, University of Oviedo, Avda. del Cristo s/n, 33006, Oviedo, Spain, Spain, vcanal@uniovi.es, *Bilbao-Terol Amelia*, *Mar Arenas-Parra*, *Maria Victoria Rodriguez-Uria*

In this paper, we are working with the problem of portfolio selection, taking into account not only their returns and risk but also their ethical profile. The financial criteria considered are the expected return and the return performance relative to a pre-specified benchmark. It is supposed that these criteria are not exactly known and also that the investor's preferences about ethical features of the portfolio are known in an imprecise way. As fuzzy logic provides an useful framework to deal with this kind of uncertainty, criteria are incorporated into Fuzzy Goal Programming model.

4 - Heuristic Procedures in Goal Programming: An Application to Fuzzy Portfolio Selection Problems

Lourdes Canos, Organizacion de Empresas, Universidad Politecnica de Valencia, Crtra. Nazaret-Oliva s/n, 46730, Grao de Gandia (Valencia), Spain, loucada@omp.upv.es, *Maria J. Canos*, *Vicente Liern*

In the fuzzy portfolio selection problem, it is quite usual to start by solving a crisp problem whose optimal solution is subsequently improved. In our approach, the optimal return and risk provided by the crisp problem are considered as the investor's minimum aspiration levels in a fuzzy goal programming problem; then, we obtain advantageous portfolios. We present a heuristic procedure based on genetic algorithms that allows us to work with large instances of the problem. We present some numerical results by using data from the IBEX35 index and the Spanish Stock Exchange Interconnection System.

■ MC-37

Monday, 12:20-13:40

3.1.09

OR Applications for Public Policy Assessment in Developing Countries

Stream: OR for Development and Developing Countries

Invited session

Chair: *Claudia Rave*, Energy Institute, National University of Colombia, AA 1027, cr 80 No 65 - 223, BL M2 of 112, 57, Medellín, Colombia, claudia.rave@gmail.com

1 - Modeling approach for externality analysis of urban development in Medellin metropolitan area

Claudia Rave, Energy Institute, National University of Colombia, AA 1027, cr 80 No 65 - 223, BL M2 of 112, 57, Medellín, Colombia, claudia.rave@gmail.com, *Patricia Jaramillo*, *Marcela Perez*, *Elizabeth Zapata*

A prospective modeling approach was developed to generate origin-destination matrices connected to changes in urban service infrastructure elements on the cities. The system integrates an expert system model to estimates attraction travel weights for each element (facilities, industries, malls) or region (urbanization and densification), and re-estimates the distribution entropy model. The application is useful to define pattern changes due to new urban developments and its different impacts on the city related to externalities over environment, final energy use and traffic congestion

2 - Reverse logistics and environmental management in the oil supply chain management: A case study 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, *Iliana Gutiérrez*, *Jorge Maquera*, *Santos Valerio Príncipe Anticona*

This work identifies the main environmental impact of the oil chain. It is proposed that production cycles can be implemented by Reverse Logistics techniques, providing a recycling way into the market products used by the production processes. Therefore, a benefit it is obtained in several areas such as: citizenship society, saving economic natural resources of energy, employment generation, etc. A case study was implemented in four cities of Peru and it was found that legal boundaries, environmental management, logistics, storage and transportation of solid waste is not good enough.

3 - Evaluation of the computer system and risks of information technology for Peruvian entities

Mercedes Bustos, Lima, Volcan Cia. Minera SAA, AV.Gregorio Escobedo 710, Lima, Lima, Peru, mbustos@volcan.com.pe

This study was conducted for two entities (private sector of an international rank and government of Peru) to evaluate their systems and risks of IT to improve informatics services. We used COBIT model for auditing management and control of information systems Maturity Model, measures of development degree of the processes of the organization (CMU, USA), and COSO methodology for assessment and risk analysis. We conclude that the the entities should implement the recommendations structured in a plan to improve performance in IT.

4 - Modeling platform development for scenario analysis and decision making, LAD-t

Claudia Rave, Energy Institute, National University of Colombia, AA 1027, cr 80 No 65 - 223, BL M2 of 112, 57, Medellín, Colombia, claudia.rave@gmail.com, *Juan Esteban Restrepo*, *Fabian Giraldo*, *Elizabeth Zapata*, *Patricia Jaramillo*

A prospective platform has been developed to allow scenario planning and prospective indicators estimation and analysis. The platform is a metamodeling software development, for math models interaction through a model coordinator and a central database. An application was implemented for cities occupation patterns modeling, configured by optimization and simulation models (GAMS, Vensim) and an interface integrated with GIS. The platform is versatile for models improvement, adding and updating and has been a powerful tool to support decision making and cooperative work

■ MC-38

Monday, 12:20-13:40

6.2.44

Recent Advances in the Economics Supported by OR I

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

Chair: *Stefan Pickl*, Department for Computer Science, Universität der Bundeswehr München, heisenbergstr. 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 - Flexible Capacity Strategy in an Asymmetric Oligopoly Market with Competition and Demand Uncertainty

Yang Liu, Department of Logistics and Maritime Studies, HongKong Polytechnic University, Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hung Hom, Hong Kong, 852, Hong Kong, Hong Kong, lgt.yangliu@polyu.edu.hk, *Chi To Ng*

We construct an asymmetric oligopoly competition model with flexible and inflexible firms under demand uncertainty. All firms carry out a decision-making operation process spanning stages of capacity, production and pricing. Flexible firms can postpone production decisions until observing the actual demand, whereas inflexible firms cannot. We characterize the unique competition equilibrium and verify the unique costing threshold to determine the optimal strategy. Further, increasing production cost benefits flexible firms under certain conditions, but is always harmful to inflexible firms.

2 - Forecasting by Econometric Models to Supporting Management

Tunde Dobrodolac, Faculty of Economics, Segedinski put 9-11, 24000, Subotica, Serbia, tinde@ef.uns.ac.rs

In contemporary environment characterized by dynamic structure of factors and the non-predictability of the relations existing among them, one of the central problem is to selected strategic goals. Forecasting and prediction as precedents of the process of planning include the investigation of future events. Application of econometric models can be successfully used to predict the future development of economic processes, supporting so strategic decision-making.

3 - Transnational Interregional I-O Table Analysis for Policy Making

Mei-Chen Lo, National United University, Taiwan, meichen_lo@nuu.edu.tw, *Ozaki Toshimasa*, *Gwo-Hshiong Zteng*

The I-O tables-received were used to consider different scenarios of the regional development. We analyzed FDI strategies via a scenario of increasing consumption up to normative standards for policy making. The authors have calculated the scenario of IT product price increase in the region up to the free-market level. All the simulations were made to estimate multiplicative effects caused by upscaling industries in the regional economy. The basic picture and framework of the Transnational Interregional I-O Table between China and Taiwan as example is introduced.

4 - Entry deterrence under scope economies

Margarida Catalão-Lopes, DEG, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, mcatalao@ist.utl.pt, *Cesaltina Pires*

In this paper we develop a model where the incumbent may expand to a second market so as to signal the existence of scope economies and deter potential entry. We show that the incumbent only expands to another market when scope economies are large enough. Thus expansion is indeed a signal of larger economies of scope and for certain parameter values it leads to entry deterrence. We characterize the unique Perfect Bayesian Equilibrium (PBE) for the various parameter values and show that the PBE may involve accommodation, entry deterrence or a mixed strategy equilibrium.

■ MC-39

Monday, 12:20-13:40
6.2.45

Recent Advances in Optimal Control Theory

Stream: Optimal Control

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: *Lyudmila Kuzmina*, Kazan Aviation Institute, Kazan State Technical University of A.N.Tupolev's name, Adamuck, 4-6, 420015, Kazan-15, Russian Federation, Lyudmila.Kuzmina@ksu.ru

1 - Higher Order Simple Adaptive Control

Isaac Yaesh, Control, IMI/ASD, P.O.B. 1044/77, 47100, Ramat Hasharon, Israel, iyaesh@imi-israel.com, *Uri Shaked*

A dynamic version of the Simple Adaptive Control (SAC) method is considered. The new method, referred to as Higher Order SAC (HOSAC), is derived by applying an augmentation method allowing the transformation of the dynamic output-feedback control problem to one of static control which is then solved using SAC. Sufficient conditions in terms of linear matrix inequalities are derived relating the closed-loop stability to the Almost Passivity of the plant. These may be applied to plants with polytopic uncertainties. Two examples illustrate the new controller's superior performance.

2 - A variational calculus based method for optimal control problems

Ana García-Bouso, Statistics and Operations Research, Universidad Rey Juan Carlos de Madrid, C/Tulipán s/n, 28933, Móstoles, Madrid, Spain, ana.bouso@urjc.es, *Alberto Olivares*, *Ernesto Staffetti*

Classical indirect optimal control approaches are based on the Euler-Lagrange necessary condition in its differential form. An indirect numerical scheme derived from an integral version of the Euler-Lagrange equation is used, the underlying idea being to reformulate the optimal control problem into an unconstrained variational one. Stationary points of this variational calculus equivalent problem are computed by means of a numerical method obtained approximating its true solution by virtue of a family of cubic B-spline basis functions. This leads to a non-linear equations system.

3 - Optimal Control under Probability Constraint

Guy Cohen, CERMICS, Ecole des Ponts-Paristech, Cité Descartes, Champs sur Marne, 6-8, avenue Blaise Pascal, 77455, Marne la Vallée, France, guy.cohen@mail.enpc.fr, *Pierre Carpentier*, *Jean-Philippe Chancelier*

The problem is to drive a spatial vehicle to a target at the final time while minimizing e.g. the fuel consumption. This is a classical optimal control problem. However temporary stochastic failures of the engine may prevent reaching the target after the engine usage is recovered. Therefore, a stochastic optimal control problem is formulated under the constraint of ensuring a minimal probability of hitting the target. This problem is solved by dualizing the probability constraint and using an Arrow-Hurwicz stochastic algorithm.

4 - A.M.Lyapunov theory methodology and modelling problems

Lyudmila Kuzmina, Kazan Aviation Institute, Kazan State Technical University of A.N.Tupolev's name, Adamuck, 4-6, 420015, Kazan-15, Russian Federation, Lyudmila.Kuzmina@ksu.ru

The work is developing approximate methods for nonlinear analysis of large-scale systems dynamics. A.M.Lyapunov methodology, N.G.Chetayev stability postulate combined with asymptotic approach allow to establish the effective method in modelling problem of complex systems, for qualitative analysis, control, synthesis. Constructed approach, founded on stability/singularity postulates, with generalization of parametric stability, is creating efficient method in fundamental problems for dynamic systems with subsystems of different nature, for approximate theories substantiation, important for Knowledge theory.

■ MC-40

Monday, 12:20-13:40
6.2.52

Routing in telecommunication networks

Stream: Network Optimization

Invited session

Chair: *Amaro de Sousa*, Instituto de Telecomunicações, Universidade de Aveiro, Campus Universitário, 3810-193, AVEIRO, Portugal, asou@ua.pt

1 - COSE-MS: An algorithm for SRLG diverse routing

Teresa Gomes, Electrical and Computer Engineering, University of Coimbra / INESC Coimbra, Polo II da Univ, de Coimbra, Pinhal de Marrocos, 3030-290, COIMBRA, Portugal, teresa@deec.uc.pt, *Luís Fernandes*

A Share Risk Link Group (SRLG) is the set of arcs in the network that share a common physical resource subject to failure. The problem of finding a SRLG diverse path pair is NP-Complete. We will present a short revision algorithm COSE for (min-min) SRLG diverse routing. Then we will propose algorithm COSE-MS, for solving the min-sum problem. This is achieved by introducing Suurballe algorithm and the Modified Suurballe's Heuristic in COSE. Finally we will compare COSE-MS performance with an algorithm which enumerates SRLG diverse paths, by non decreasing cost of their total (additive) cost.

2 - Algorithms for Inverse-Multiplexed Routing with Minimal Capacity Requirements and Differential Delay Accumulation

João Santos, Networks and Systems, DWDM R&D, Nokia Siemens Networks Portugal S.A., Rua Irmaos Siemens, 1, Alfragide, 2720-093, Amadora, Portugal, joao.santos@nsn.com, João Pedro, Paulo Monteiro, João Pires

The combination of virtual concatenation with multipath routing in the optical transport network enables substantial capacity savings in comparison with single-path approaches. However, routing over paths with different propagation times introduces differential delay between the concatenated streams. Hence, the authors propose and evaluate an integer linear programming model and three other heuristic methodologies for solving the joint routing problem for virtually-concatenated traffic by simultaneously minimizing the maximum link load and the accumulated differential delay in the network.

3 - Infeasibility in Inverse Shortest Path Routing Problems

Mikael Call, Department of Mathematics, Linköping University, Linköpings universitet, 581 83, Linköping, Sweden, mikael.call@liu.se, Kaj Holmberg

Traffic engineering in IP networks often requires that all traffic is routed in accordance with a shortest path routing (SPR) protocol, e.g. OSPF or IS-IS. This implies that some routing patterns are not eligible. We analyze LP models of an associated inverse SPR subproblem. This yields a description of infeasibility in terms of combinatorial structures formed by tentative routing patterns. Further examination of the inverse SPR problem and the LP models yields additional insights, e.g. the extremal structure, graph search (separation) algorithms and alternative problem formulations.

4 - Models for Optimal Survivable Routing with a Minimum Number of Hops: Comparing Disaggregated with Aggregated Models

Pedro Patrício, Mathematics, University of Beira Interior, Rua Fernando Henriques da Cruz, 9, 6200-093, Covilhã, Portugal, pedrofp@mat.ubi.pt, Luis Gouveia, Amaro de Sousa

In this work we address two traffic engineering problems. We determine how traffic commodities must be routed in order to maintain an optimal network performance, minimizing the average or the maximum number of routing hops in each commodity, while ensuring some desired survivability guarantees. We study disaggregated and aggregated Integer Linear Programming models for both problems, the theoretical relationships between the two classes of models as well as an empiric comparison of their effectiveness to solve the proposed traffic engineering problems.

■ MC-41

Monday, 12:20-13:40
3.1.06

Topics in Revenue Management

Stream: Revenue Management

Invited session

Chair: Nishant Mishra, Management Science and Operations, London Business School, Regents Park, NW1 4SA, London, United Kingdom, nmishra.phd2003@london.edu

1 - Allocation of Returned Products among Different Recovery Options through an Opportunity Cost based Dynamic Approach

Oznu Ozdemir, Rotterdam School of Management Decision and Information Sciences, Erasmus University, Erasmus University Rotterdam School of Management Burgemeester Oudlaan 50, Room T09-44, 3062PA, Rotterdam, Netherlands, OOzdemir@rsm.nl, Meltem Denizel, Mark Ferguson

In this paper we investigate the disposition decisions of a recovery firm. We consider a make-to-order recovery environment with two disposition options: refurbishing and harvesting. We formulate this problem as a multi-period LP model and suggest two approaches: (1) a static approach that uses the LP solution directly and (2) a dynamic one that employs a revenue management method of bid-price controls. We present a novel reformulation in the form of a transportation problem and develop a one-pass optimal solution procedure. Our numerical analysis shows the superiority of the dynamic approach.

2 - A model for competition in network revenue management

Nishant Mishra, Management Science and Operations, London Business School, Regents Park, NW1 4SA, London, United Kingdom, nmishra.phd2003@london.edu

We propose a model for oligopolistic capacity competition between several airlines offering multiple products over a network. Using a variational inequality approach, we show the existence and uniqueness of Nash Equilibrium under certain regularity conditions. We then present numerical results for some small and large network examples and derive insights on how competition can affect quantities and prices for various players. Finally, we also show how the model can be used to decide the value, with regards to making better revenue management decisions, of mergers between airlines.

3 - Managing the Inventories of Perishable goods with Controllable Shelf Lives

Qing Li, Dept. of ISMT, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, imqli@ust.hk

The shelf lives of perishable goods can be determined by purchasing and maintenance decisions. If the inventories are depleted under FIFO, then the retailer may order/maintain items of different life times to balance the cost against the risk of overage. Such strategy should never be used if consumer sensitivity to freshness is high. The retailer is less likely to order items with a longer life time under LIFO than under FIFO. Our numerical studies demonstrate merits of dynamic coordination. Consumer behavior adds a new dimension to the research in perishable inventory control.

4 - Explaining Stickiness in Prices of Non-Perishable Goods under Dynamic Pricing Policies

Gunnar Feldmann, Industrial and Systems Engineering, Texas A&M University, Zachry Engineering Center, 3131 TAMU, 77843, College Station, TX, United States, gfeldmann@tamu.edu, Abhijit Deshmukh

The use of dynamic pricing is expanding beyond its initial application for revenue management of perishable goods in service industries. Empirical research shows that the price trajectories under dynamic pricing are qualitatively different in perishable and non-perishable goods. Prices tend to be 'sticky' for non-perishable goods, leading to high-low pricing policies. In this paper we develop optimal price setting and price change models that consider menu costs and reference prices to explain why pricing policies for non-perishable goods converge to a high-low pattern.

■ MC-42

Monday, 12:20-13:40
3.1.07

Solution Algorithms for Bilevel Problems

Stream: Variational Inequalities, Complementarity Problems and Bilevel Programming

Invited session

Chair: Ayalew Getachew Mersha, Optimization and Optimal control group, Austrian Academy of Sciences, Johann Wilhelm Klein Strasse 9, 4040, Linz, Upper Austria, Austria, ayalew.mersha@oew.ac.at

1 - Bilevel Stochastic Optimization Approach to Natural Gas Cash-Out Problem

Vyacheslav Kalashnikov, Systems & Industrial Engineering (IIS), ITESM, Campus Monterrey, Ave. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, Nuevo Leon, Mexico, kalash@itesm.mx, Gerardo Perez, Nataliya Kalashnykova, Asgeir Tomsgard

A stochastic formulation of the natural gas cash-out problem is given in form of a bilevel multi-stage stochastic programming model with recourse. After reducing the original formulation to a bilevel problem, a stochastic scenario tree is defined, and time series forecasting is used to produce stochastic values for data of gas price and demand. A new solution algorithm based upon a reduction of the bi-level programming problem to a single-level one, is described. Numerical experiments were run to compare the stochastic solution with the perfect information and the expected value solutions.

2 - Global optimization of quadratic bilevel problems

Oleg Khamisov, Applied mathematics, Institute of Energy Systems, Lermontov str. 130, 664033, Irkutsk, Russian Federation, mis@isem.sei.irk.ru

We study quadratic bilevel programming problem in optimistic sense. The leader problem can be nonconvex quadratic but the follower problem must be convex quadratic. The approach based on quadratic convex and concave support functions and developed earlier for ordinary (i.e. one level) nonconvex quadratic problem with nonconvex quadratic constraints is used. The underlying procedure is of the branch and bound type. Bounding, branching rules and convergence conditions are given together with preliminary computational results.

3 - Computing the Pareto frontier of a bi-objective bilevel linear problem using a multiobjective mixed-integer programming algorithm

Maria João Alves, Faculty of Economics, University of Coimbra / INESC-Coimbra, Av. Dias da Silva, 165, 3004-512, Coimbra, Portugal, mjalves@fe.uc.pt, *Stephan Dempe*, *Joaquim Judice*

In this work we study the bilevel linear programming problem with multiple objective functions at the upper level and a single objective at the lower level. We examine some properties of the problem, in particular the bi-objective case, and propose a methodological approach based on its reformulation as a multi-objective mixed 0-1 linear programming problem. A multiobjective reference point algorithm is used, which enables to characterize the whole Pareto frontier in the bi-objective case. Illustrative numerical examples are presented to show the viability of the proposed methodology.

■ MC-43

Monday, 12:20-13:40
8.2.02

Algorithmic Decision Theory 3

Stream: Algorithmic Decision Theory [c]

Contributed session

Chair: *Federico Della Croce*, Automatica e Informatica, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italy, federico.dellacroce@polito.it

1 - Pareto-Search in Discrete Vector Optimization Problems.

Walter Habenicht, Management, University of Hohenheim, Lst. fuer Industriebetriebslehre(510A), D-70593, Stuttgart, Germany, habenich@uni-hohenheim.de

In this paper we deal with discrete vector optimization problems with large sets of efficient solutions. We assume that the efficient set has been identified and the non dominated set has been stored in a special data structure called quad tree. In order to organize efficiently a searching process in outcome space we discuss different neighborhood definitions. These neighborhoods differ in the computational complexity of identifying the neighbors and in their ability to avoid suboptimal solutions.

2 - An empirical study of the core concept for the Multidimensional Knapsack Problem

Andre Amaral, Instituto Superior Técnico, CEG-IST, Technical University of Lisbon, 1049-001, Lisbon, Portugal, andre.r.s.amaral@ist.utl.pt, *José Rui Figueira*

The core concept of the 0-1 knapsack problem is well known. An interesting research question is how to suitably extend this concept to the Multidimensional Knapsack Problem (MKP) because, for the MKP, it is not obvious how to characterize the efficiency measure of the items. In a paper by Puchinger et al. (available from the link: <http://www.ads.tuwien.ac.at/publications/bib/pdf/puchinger-06.pdf>) several tentative definitions of efficiency measures for the MKP are computationally tested. In our work, new definitions of efficiency measures are presented for the MKP, and we will discuss the results of our extensive computational tests using the new definitions.

3 - A strong branching approach for the multi-dimensional knapsack problem

Federico Della Croce, Automatica e Informatica, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italy, federico.dellacroce@polito.it, *Andrea Grosso*

We consider the 0/1 multi-dimensional knapsack problem and discuss the performances of a heuristic procedure particularly suitable for a parallel computing environment embedding variable fixing, core problem approach and a strong branching scheme based on the reduced costs of the corresponding LP relaxation solution value. The proposed approach is compared to the literature results on the well known OR-Library multi-dimensional knapsack problem benchmarks instances improving several best known lower bounds.

4 - Finding Nadir Points for Multi-criteria Integer Programming Problems

Banu Lokman, Industrial Engineering Department, METU, Middle East Technical University, Industrial Engineering Department, 06531, Ankara, Turkey, banutuna@ie.metu.edu.tr, *Murat Koksalan*

Finding the worst possible value for each criterion among the set of efficient solutions has important uses in multi-criteria problems. Such points are called nadir points. It is not straightforward to find the nadir points, especially for large problems with more than two criteria. We develop an exact algorithm to find the nadir values for multi-criteria integer programming problems. We also find bounds with performance guarantees. We demonstrate that our algorithms work well in our experiments on Multi-criteria Knapsack Problems.

■ MC-44

Monday, 12:20-13:40
8.2.03

Portfolio Decision Analysis III

Stream: Portfolio Decision Analysis

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 - Does the decision analysis match the portfolio?

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*

Decision quality says the most detailed analysis should occur where it adds the most value. This case study of a DA—using pharmaceutical company analyzes data obtained on a portfolio. Measurements of the characteristics of the portfolio and its partitions reveal patterns and relationships. These patterns suggest certain sub-portfolios would benefit more from greater analytic detail. Using the number of scenarios included as a measure of analytic detail, we considered whether the analytic detail correlated with the predicted benefit. Results support the hypothesis.

2 - Hierarchical portfolio decision analysis for developing corporate strategies

Kevin Bossley, Catalyze Ltd, SO21 2LL, Winchester, United Kingdom, kevinbossley@catalyze.co.uk

Strategy planning is a classic portfolio decision analysis problem with organisations trading off competing objectives with hundreds of projects and initiatives. We present a case study where a bottom-up hierarchical approach is used to develop a balanced strategy for a multinational corporation. MCDA decision conferences are held with individual businesses and the results of these are combined in a final workshop to agree the corporate strategy which balances short and long term objectives with full support of the businesses.

3 - Valuing business benefits more consistently

Santiago Castro, Research, Cogentus, Soane Point., 6-8 Market Place, RG1 2EG, Reading, Berkshire, United Kingdom, santiagocastro@yahoo.com

A popular prioritisation methodology is to score the benefits of each option and divide by the costs to generate a value for money (VFM) ratio. However a scope insensitivity (SI) bias often occurs: lower cost options have a higher VFM than more costly ones, and receive a higher ranking in the prioritised list. We investigate whether SI can be alleviated by applying transformations to the benefit values. We have applied transformations to two resource allocation models. The benefit scores are raised to several different exponents with the intention of achieving a wider spread of the scores.

■ MC-46

Monday, 12:20-13:40

8.2.14

OR on Environmental Networks and Management

Stream: OR for Madeira (and related challenges)

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 - Species specific connectivity in reserve-network design

Leonor S. Pinto, Matematica, ISEG/UTL - cemapre, Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, lspinto@iseg.utl.pt, *J. Orestes Cerdeira*, *Raul Brás*, *Mar Cabeza*, *Kevin Gaston*

Connectivity is a critical feature to ensure sustainability of species needs in reserve-network design. We define the following model to incorporate species-specific connectivity. For each species s , a representation target t_s and a graph G_s describing its dispersal pattern are given. Solutions are sets of sites that induce, for each species s , a connected component of G_s of at least t_s sites. We give an integer cutting algorithm to achieve minimum size solutions and lower bounds on their sizes. Heuristic methods are also presented, and computational experiments are reported.

2 - Gene-Environment Networks under Ellipsoidal Uncertainty

Erik Kropat, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de, *Gerhard-Wilhelm Weber*, *Selma Belen*

We consider gene-environment networks under ellipsoidal uncertainty and the corresponding set-theoretic regression. Functionally related groups of genes are identified by clustering techniques. The regulatory system of clusters is determined by affine-linear coupling rules and explicit representations of the uncertain multivariate states are obtained by ellipsoidal calculus. Various set-theoretic models are introduced for an estimation of the unknown parameters. We discuss the solvability by semidefinite programming and conclude with research challenges.

■ MC-47

Monday, 12:20-13:40

8.2.16

OR in Oil Sector II

Stream: OR in Oil Sector

Invited session

Chair: *Irina Dolgoplova*, Economics and Administrative Sciences, Middle East Technical University, Odu Kent, Konuk Evi 1, B Block, 108, Ankara, Turkey, 06420, Ankara, Turkey, irina.dolgoplova@gmail.com

1 - The Development of a Decision Support System for Management of Petroleum Hydrocarbon Contamination in Soil

Aisha Bello-Dambatta, School of Engineering, Computing and Mathematics, University of Exeter, Harrison Building, New Park Road, University of Exeter, EX4 4QF, Exeter, Devon, United Kingdom, ab353@exeter.ac.uk, *Akbar Javadi*

Land contamination is a big environmental and infrastructural problem, the most common of which is petroleum hydrocarbon contamination. This could be exposed to humans via different routes, potentially causing harm on human health. We present a Web-based knowledge based decision support system for the risk assessment and management based on the UK framework for evaluating these risks. The risk assessment component is developed as an expert system, and the decision-support component is developed multi criteria decision analysis, for the site specific appraisal of remedial options.

■ MC-48

Monday, 12:20-13:40

8.2.04

Green vehicle routing and scheduling

Stream: Optimization for Sustainable Development

Invited session

Chair: *Nora Touati Moun gla*, LIX, Ecole Polytechnique, École polytechnique., Laboratoire d'informatique (LIX), 91128, Palaiseau, Cedex, France, France, touati@lix.polytechnique.fr

1 - Strategic Planning for Disaster Recovery with Stochastic Last Mile Distribution

Pascal Van Hentenryck, Department of Computer Science, Brown University, Box 1910, 02912, Providence, RI, United States, pvh@cs.brown.edu, *Carleton Coffrin*

We consider the single commodity allocation problem (SCAP) for disaster recovery. SCAPs are complex stochastic optimization problems that combine resource allocation and warehouse routing. This work formalizes the specification of SCAPs and introduces a novel multi-stage hybrid-optimization algorithm that utilizes the strengths of mixed integer programming, constraint programming, and large neighborhood search. The algorithm is validated on hurricane disaster scenarios generated using state-of-the-art disaster simulation tools and is deployed to aid federal organizations in the United States.

2 - A Bi-objective Vehicle Routing and Scheduling Problem for Planning Hazardous Materials Distribution

Konstantinos Androutsopoulos, Management Science and Technology, Athens University of Economics and Business, Evelpidon 47A, 11362, Athens, -, Greece, kandro@aueb.gr, *Konstantinos Zografos*

This paper presents the formulation of the hazardous materials distribution problem as a bi-objective vehicle routing and scheduling problem on a network with time dependent travel time and risk attributes. The travel speed on any link of the underlying network is assumed piecewise linear function of the time and an efficient procedure is proposed for calculating the corresponding link travel time. A heuristic algorithm is proposed based on the weighted sum method, where the bi-objective problem is decomposed to a series of single-objective instances. Results regarding the performance of the solution algorithm on a set of test problems are also reported.

3 - About green vehicle routing and scheduling problem

Nora Touati Moun gla, LIX, Ecole Polytechnique, École polytechnique., Laboratoire d'informatique (LIX), 91128, Palaiseau, Cedex, France, France, touati@lix.polytechnique.fr, *Vincent Jost*

The vehicle routing and scheduling problem has been studied with much interest within the last four decades. We explore the existing literature dealing with the vehicle routing and scheduling problem with environmental issues in order to provide an overview of the characteristics of problems that have been investigated within this field and how these problems are treated using combinatorial optimization tools. We focus particularly to the transportation of hazardous materials problems, time dependent and dynamic vehicle routing and multi-modal routing problems.

4 - Modeling Sustainable Traffic Assignment Policies Using Bilevel Programming

Semih Yalcindag, Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, semihyal@su.sabanciuniv.edu, *S. Ilker Birbil*, *Orhan Feyzioglu*, *Orhan Ilker Kolak*, *Nilay Noyan*

We develop bilevel programming models with elastic demand to determine optimal sustainable transportation policies. The upper level problem represents the decisions of policy makers based on sustainability measures, while the lower level represents the route choice decisions of travelers. In particular, we determine the emission functions in terms of traffic flow to incorporate the gas emission amounts into the proposed models and consider several policies to reduce the gas emission; toll pricing, zone charging and capacity enhancement. We present numerical results on a test network.

Monday, 14:00-15:20

■ MD-01

Monday, 14:00-15:20

Aula Magna

Keynote Talk 4

Stream: Keynote Speakers

Invited session

Chair: *Stefan Nickel*, Institut fuer Operations Research, Universitaet Karlsruhe, Geb 11.40, 76128, Karlsruhe, Baden-Wuerttemberg, Germany, Stefan.Nickel@kit.edu

1 - Location problems on networks with routing

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

Various location problems on networks involve routing decisions related to sending flows between pairs of nodes, using the located facilities as final or intermediate nodes. In addition to the location of the facilities, these problems involve essential aspects of network design, as the arcs to be used must also be decided. This issue is one extra source of difficulty which, in practice, is reflected in formulations with a huge number of variables, highly inefficient even for relatively small size instances. In this talk we discuss some problems of this type, including some hub location models, and their relation to network design. Alternative formulations are presented and recent advances leading to successful solution methods are introduced.

■ MD-02

Monday, 14:00-15:20

3.2.14

Algorithms for planning and scheduling problems

Stream: Combinatorial Optimization

Invited session

Chair: *Eleni Hadjiconstantinou*, Business School, Imperial College London, South Kensington Campus, SW7 2AZ, London, United Kingdom, e.hconstantinou@imperial.ac.uk

1 - A Multi-load AGV dispatching problem in seaport container terminals

Evelina Klerides, Tanaka Business School, Imperial College London, South Kensington, SW7 2AZ, London, United Kingdom, e.klerides@imperial.ac.uk, *Eleni Hadjiconstantinou*

We consider the Automated Guided Vehicle (AGV) dispatching problem in seaport container terminals where vehicles are allowed to carry more than one container at a time. The main focus of the study is on dual-load AGVs which may carry either two 20-ft containers or one 40/45-ft container. We propose a mathematical formulation for the corresponding optimization problem which minimizes a defined dispatching "cost" under a rolling horizon approach. Preliminary computational experimentation is performed using different scenarios found in the literature.

2 - A Branch-and-Price Algorithm for The Bin Packing Problem with Conflicts

Joe Naoum-Sawaya, Management Sciences, University of Waterloo, 200 University Avenue W, N2L 3G1, Waterloo, Ontario, Canada, jnaoumsa@uwaterloo.ca, *Samir Elhedhli*

We provide a branch-and-price algorithm for the Bin Packing Problem with Conflicts, a variant of the classical bin packing problem that has major applications in scheduling and resource allocation. First, we use a branching rule that matches the conflicting constraints, preserving the structure of the subproblems after branching. Second, maximal clique valid inequalities are generated based on the conflicting constraints and are added to the subproblems. The algorithm is tested on a standard set of problems. Numerical results indicate its efficiency and stability.

3 - Project scheduling under multiple resource constraints - A case study in the Portuguese Navy

Humberto Duarte Afonso, DAGI-DEIO, Marinha de Guerra Portuguesa, Praça do Municipio (Edifício de Marinha), 1149-001, Lisboa, Portugal, hduafonso@hotmail.com, *Joao Telhada*

Project scheduling with resource constraints has been a field widely studied. However, constraints typically refer to some uniform pattern. Problems where the requirements on the resources vary along the execution of a task have to be tackled differently. Some linear programming approaches are used and compared with those obtained by adapting the problem. Computational results are presented, to evaluate the relative quality of the lower bounding techniques introduced. This work is based on a real-life project scheduling in the Portuguese Navy that is used in the maintenance of the fleet.

4 - Multi-run heuristic algorithm for conflict-free agv scheduling in container terminals

Fabio Furini, DEIS, Università di Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, Italy, fabio.furini@unibo.it, *Eleni Hadjiconstantinou*, *Evelina Klerides*

The Automated Guided Vehicle (AGV) Scheduling algorithm aims at constructing conflict-free schedules for AGVs, subject to operational constraints, so that the deviation from an ideal timetable is minimised. We adapt a well known Train Timetabling approach to the specific case of AGV Scheduling in ports. Special attention is given to the occupancy of the cranes in order to obtain feasible loading and unloading sequences. Computational results on benchmark test instances, taken from the literature, show the efficiency of the proposed approach.

■ MD-03

Monday, 14:00-15:20

3.2.15

Dynamic routing problems

Stream: Metaheuristics

Invited session

Chair: *Philippe Lacomme*, Laboratoire LIMOS, Université Blaise Pascal, BP 10125, 63173, Aubière Cedex, France, lacomme@sp.isima.fr

Chair: *Caroline Prodhon*, University of Technology of Troyes, 12 rue Marie Curie, 10000, Troyes, France, caroline.prodhon@utt.fr

1 - Parameter tuning for dynamic optimization. Application: The Dynamic Pickup and Delivery Problem with Time Windows

Jawad Omari, Programmes, KADDB, Amman, Amman, Jordan, jawad82@batelco.jo

A hybrid metaheuristic based on Variable Neighborhood Search, Tabu Search, and Guided Local Search is used to solve the Dynamic Pickup and Delivery Problem with Time Windows. The study focuses on how to change the search parameters in order to adapt to the dynamic nature of the problem; meaning, at the beginning of the working day, parameters are set to minimize the number of vehicles and the total distance traveled, later on towards the end of the working day, parameters are set to accommodate for the largest number of new requests. Li & Lim benchmark data sets will be used for comparison.

2 - Dynamic Vehicle Routing for Demand Responsive Transportation

Jorge Pinho de Sousa, Faculdade de Engenharia da Universidade do Porto / INESC Porto, Campus da FEUP, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, jsousa@inescporto.pt, *Rui Gomes*, *Teresa Galvão Dias*

Providing quality public transportation may be very expensive in low demand scenarios. Demand Responsive Transportation (DRT) systems address this problem by providing routes and frequencies that vary according to actual demand. DRTs extend the "classical" Vehicle Routing Problems in a number of ways, and involve multiple, conflicting objectives. To obtain an approximation of the Pareto solution set, we have designed metaheuristic approach that starts with a greedy, random construction of a feasible route. Preliminary computational results on randomly generated instances look quite promising.

3 - Solving the Vehicle Routing Problem with Stochastic Demands using the SimuRial Procedure

Javier Faulin, Department of Statistics and OR, Public University of Navarre, Los Magnolios Building, First floor, Campus Arrosadia, 31006, Pamplona, Navarra, Spain, javier.faulin@unavarra.es, *Angel A. Juan, Daniel Riera, Scott Grasmann, Ricardo Solar*

The VRP with Stochastic Demand is a NP-hard problem in which an expected feasible solution could become infeasible. Our approach SimuRial is focused on reducing the probability of occurrence of such undesirable situations using Reliability and Availability concepts in order to build solutions with a low probability of suffering a route failure. This is basically attained by constructing routes in which expected demand will be somewhat lower than the vehicle capacity. Thus, the idea is to keep a certain amount of vehicle capacity surplus while designing the routes, so that if final routes' demands exceed their expected values up to a certain limit, they can be satisfied without having a route failure.

■ MD-04

Monday, 14:00-15:20

3.2.13

Job Shop scheduling with metaheuristics

Stream: Metaheuristics

Invited session

Chair: *Ibrahim Osman*, Operations & Information Management, American University of Beirut, Business School, Bliss Street,, 11-0236, Beirut, Lebanon, Ibrahim.osman@aub.edu.lb

Chair: *Maurizio Faccio*, Department of Innovation in Mechanics and Management, University of Padova, Italy, maurizio.faccio@unipd.it

1 - Local search with a job-insertion based neighborhood for the job shop with setup times

Reinhard Bürgy, Dept of Informatics, University of Fribourg, Bd de Pérolles 90, 1700, Fribourg, Switzerland, reinhard.buergy@unifr.ch, *Heinz Gröflin*

We consider the job shop problem with sequence-dependent setup times. The objective is to schedule the operations in order to minimize the makespan. A feasible neighborhood, based on a job-insertion framework, is constructed where a critical operation is moved together with some other operations whose moves are "implied". The neighborhood is shown to be opt-connected and is implemented in a tabu search method. Numerical results are compared to recent benchmarks (Balas et al. 2008, Artigues and Feillet 2008) and show that the method is competitive.

2 - Scheduling in a Job Shop Production System with multiple parallel Machines and multiple Products in case of Unknown Process Cycle

Maurizio Faccio, Department of Innovation in Mechanics and Management(DIMEG-Padova), University of Padova, Via Venezia 1, Padova, Italy, maurizio.faccio@unipd.it, *Anna Azzi, Alessandro Persona, Fabio Sgarbossa*

A job shop production system processes after set up batches of products in some specific sequence. In the modern production the product's process cycle is not always known from the beginning. The paper faces scheduling in a flexible production system with unknown production cycle, multiple products-machines, with a multi-objective approach, to minimize the makespan and to improve the machines utilization. A metaheuristic optimization model is described and the obtained results from an industrial application compared with the classical scheduling priority rules and with Johnson's heuristics.

3 - A Hybrid Shifting Bottleneck-Tabu Search Heuristic for the Job Shop Total Weighted Tardiness Problem

Kerem Bulbul, Manufacturing Sys. & Industrial Eng., Sabanci University, Faculty of Engineering and Natural Sciences, Orhanli, Tuzla, 34956, Istanbul, Turkey, bulbul@sabanciuniv.edu

We study the job shop scheduling problem with the objective of minimizing the total weighted tardiness and propose a hybrid shifting bottleneck (SB) - tabu search (TS) algorithm. In terms of the SB, the proposed TS replaces the reoptimization step by optimizing the total weighted tardiness for partial schedules in which some machines are currently assumed to have infinite capacity. In the context of the TS, the SB features a long-term memory which helps to diversify the local search. We exploit this synergy and demonstrate the effectiveness of the algorithm on standard benchmark instances.

■ MD-05

Monday, 14:00-15:20

3.2.16

Statistics

Stream: Metaheuristics

Invited session

Chair: *Leonidas Pitsoulis*, Mathematical and Physical Sciences, Aristotle University of Thessaloniki, Engineering School, Department of Mathematical and Physical Sciences, 54124, Thessaloniki, pitsouli@gen.auth.gr

Chair: *Francisco Aparisi*, Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Camino de Vera s/n, 46022, Valencia, Valencia, Spain, faparisi@eio.upv.es

1 - A Fast Algorithm for Robust Regression

Leonidas Pitsoulis, Mathematical and Physical Sciences, Aristotle University of Thessaloniki, 51124, Thessaloniki, Greece, pitsouli@gen.auth.gr

The presence of groups of outliers makes linear regression a difficult problem. A new estimator for robust regression is introduced, called Penalised Trimmed Squares (PTS) estimator, which is defined by a Quadratic Mixed Integer programming (QMIP) problem. Due to the high computational complexity of the resulting QMIP problem, exact solutions for moderately large regression problems is infeasible. In this work we establish the theoretical properties of the PTS estimator and propose an approximate algorithm called Fast-PTS to compute the PTS estimator for large data sets efficiently.

2 - Optimization of a Set of Multiple Poisson Statistical Quality Control Charts

Francisco Aparisi, Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Camino de Vera s/n, 46022, Valencia, Valencia, Spain, faparisi@eio.upv.es, *Eugenio Epprecht*

Some industrial applications require controlling simultaneously several Poisson variables. Each of the variables is based on the sum of a common Poisson variable and an independent variable. Each chart has a probability of false alarm (in-control ARL) and a probability of detecting the shift in the variable (out-of-control ARL). An optimization is carried out using Genetic Algorithms and consists of obtaining the control limits for the multiple charts given an in-control ARL, minimizing the time to detect the shift in the process, minimizing the out-of-control ARL of the set of Poisson charts

3 - An Efficient Optimization Method for Revealing Local Optima of Projection Pursuit Indices

Larabi Marie-Sainte Souad, computer science, Toulouse1 Capitole University, 2 rue du doyen Gabriel Marty, Manufacture des Tabacs ME310, 31042, toulouse, France, larabi.souad@yahoo.fr, *Alain Berro, Anne Ruiz-Gazen*

In order to represent graphically multidimensional data in statistics, we can use projection pursuit methods which look for structures (groups or outliers), by optimizing a function called projection index (PI). To determine these possible structures, we must choose optimization method capable to find the global optimum of PI and the local optima susceptible to reveal these structures. We suggest using a metaheuristic called Tribes, a hybrid PSO method, which does not ask for parameters to settle and provoke premature convergence to local optima.

■ MD-06

Monday, 14:00-15:20

8.2.30

DEA Methodology IV

Stream: DEA and Performance Measurement

Invited session

Chair: *Armando Milioni*, Departamento de Organizacao, Instituto Tecnologico de Aeronautica, CTA ITA IEMB, 12228-900, Sao Jose dos Campos, Sao Paulo, Brazil, milioni@ita.br

1 - Weight restrictions in Data Envelopment Analysis using Multicriteria Tools

Lidia Angulo-Meza, Materials Science, Universidade Federal Fluminense, Av.Dos Trabalhadores 420 Vila Santa Cecilia, 27255125, Volta Redonda, Rio de Janeiro, Brazil, lidia@metal.eeimvr.uff.br, *João Carlos Soares de Mello, Lucas Oliveira*

This work illustrates the use of weights obtained with a multicriteria method for decision support as a tool for defining weights restrictions in Data Envelopment Analysis. We prove that the interval weights obtained for an additive multicriteria method is equivalent to the assurance region method for Data Envelopment Analysis weight restrictions. The technique is illustrated with an application in the real state business, respecting limits previously established for each criterion by the decision-maker.

2 - An interactive approach to produce common weights and estimation of value efficiency in data envelopment analysis

Majid Zohrehbandian, Mathematics, Islamic Azad University, karaj, Tehran, Iran, Islamic Republic Of, zohrehbandian@yahoo.com

Halme et al. present value efficiency for incorporating preference information in DEA. Here, we present a refinement to their works. We use an MOLP model which its objective functions are input/output variables. Then, by using Zionts-Wallenius method, we aid the DM in searching for the Most Preferred Solution (set on a supporting hyperplane which approximate indifference contour of a DM's value function) and generating common weights of objective functions. Finally, we calculate value efficiency scores by comparing the inefficient units to units having the same value as the MPS.

3 - Parametric Dea models with weight constraints

Armando Milioni, Departamento de Organizacao, Instituto Tecnologico de Aeronautica, CTA ITA IEMB, 12228-900, Sao Jose dos Campos, Sao Paulo, Brazil, milioni@ita.br, *Rodrigo Cesar Silva*

This paper presents the Adjusted Spherical Frontier Model (ASFM-lp) model, a parametric Data Envelopment Analysis (DEA) model for allocating new inputs to a group of Decision Making Units (DMU's). This model considers that a fair allocation of the input is one that maximizes the DEA-CCR efficiencies of the DMUs. The formulation that we provide is a generalization of the standard ASFM formulation and allows the introduction of weights restrictions, an important development in DEA, which was disregarded in the latter model. Numeric examples are presented to show the application of the method.

4 - Estimating Malmquist Productivity Index by Using Stochastic Programming Models

Mahnaz Mirbolooki, Mathematics, Science and Research Branch, Islamic Azad University, Tehran, Iran, Tehran, Iran, Islamic Republic Of, mirbolouki.mahnaz@gmail.com, *Gholam Reza Jahanshahloo, Farhad Hosseinzadeh Lotfi, Mohammad Hassan Behzadi*

DEA-based Malmquist productivity index measures the productivity change over time. This index can be decomposed into two components: measuring the technical efficiency change and measuring the frontier shift. We investigate the progress and regress of decision making units(DMUs) in the future and forecast the Malmquist index. For this purpose with the use of sampling from inputs and outputs of DMUs in past successive times, the distribution of each input and output of DMUs have been estimated and by introducing stochastic programming models, stochastic Malmquist index has been proposed.

■ MD-08

Monday, 14:00-15:20

6.1.36

Scheduling Problems - Approaches and Complexity

Stream: Project Management and Scheduling

Invited session

Chair: *Frank Werner*, Faculty of Mathematics, Otto-von-Guericke University, FMA,I, nstitute of Mathematical Optimization, PSF 4120, 39016, Magdeburg, Germany, frank.werner@mathematik.uni-magdeburg.de

1 - Single Machine Scheduling with a Non-renewable Financial Resource

Evgeny Gafarov, Institute of Control Sciences of the Russian Academy of Sciences, Profsoyuznaya 65, 117997, Moscow, Russian Federation, axel73@mail.ru, *Alexander Lazarev, Frank Werner*

We consider single machine scheduling problems with a non-renewable resource. This type of problems has not been intensively investigated in the literature so far. For several problems of this type with standard objective functions (namely the minimization of makespan, total tardiness, number of tardy jobs, total completion time and maximum lateness), we present some complexity results. Particular attention is given to the problem of minimizing total tardiness. In addition, for the so-called budget scheduling problem with minimizing the makespan, we present some properties of feasible schedules.

2 - Solving a scheduling problem at cross docking terminals

Ruslan Sadykov, INRIA Bordeaux - Sud-Ouest, 351 cours de la Libération, 33405, Talence, France, Ruslan.Sadykov@inria.fr

At cross docking terminals, products from incoming trucks are sorted according to their destinations and transferred to outgoing trucks using a small temporary storage. Recently, we proposed an algorithm of high but polynomial complexity for a trucks scheduling problem with the objective to minimize the storage usage during the product transfer. We will present results of numerical tests of this algorithm and a comparison with other approaches from the literature.

3 - Dual and reverse problems to minimize maximum penalty scheduling problems.

Alexander Lazarev, Institute of Control Sciences, Profsoyuznaya st. 65, 117997 Moscow, Russia, 117997, Moscow, Russian Federation, jobmath@mail.ru

We study the classical NP-hard non-preemptive single machine scheduling problem to minimize the maximum penalty with release dates. Penalty of each job is a monotone and non-decreasing function of its completion time. We propose polynomial algorithms for the dual and inverse problems where the minimum penalty is maximized. Both algorithms run in quadratic time. Note that the solution values of the inverse and dual problems are valid lower bounds for the original problem. Therefore, our algorithms can be used within the branch-and-bound scheme when solving the original NP-hard problem.

4 - Optimization and Performance Analysis of Parallel Dynamic Programming Algorithm for Knapsack Problem

Alexander Lazarev, Institute of Control Sciences, Profsoyuznaya st. 65, 117997 Moscow, Russia, 117997, Moscow, Russian Federation, jobmath@mail.ru, *Mikhail Posypkin*

We study a parallel dynamic programming algorithm for Knapsack problem based on block decomposition. Two cases are considered: processors can store intermediate results of previous computations and intermediate results should be communicated to each processor. The former corresponds to classical cluster architecture while the latter is tailored to grid computing. For both cases we state a scheduling problem of minimizing the total complete time. We suggest a fast algorithm to solve this problem and present results of simulation and real experiments confirming the algorithm's efficiency.

■ MD-09

Monday, 14:00-15:20

6.2.53

Nonlinear optimization for industrial applications

Stream: Mathematical Programming

Invited session

Chair: *Thomas Lehmann*, Optimization, Konrad-Zuse-Zentrum, Takustr. 7, 14195, Berlin, Berlin, Germany, lehmann@zib.de

1 - Nonlinear Mixed-Integer Programs Arising in Petroleum Industry

Thomas Lehmann, Optimization, Konrad-Zuse-Zentrum, Takustr. 7, 14195, Berlin, Berlin, Germany, lehmann@zib.de,
Klaus Schittkowski, *Oliver Exler*

In petroleum industry many mixed-integer nonlinear optimization problems arise. Since model functions are determined by expensive simulation runs, the efficiency in terms of the number of function calls is crucial.

We introduce a toolbox of SQP-type algorithms that successively solve mixed-integer quadratic programs. Linear outer approximations guarantee global optimality for convex programs.

Comparative numerical results for 55 test cases arising from applications in petroleum industry are presented. In addition 100 nonlinear and often non-convex academic problems are considered.

2 - Fast and Safe Container Cranes as Bilevel Optimal Control Problems

Matthias Knauer, Zentrum für Technomathematik, Universität Bremen, Bibliothekstraße 1, 28359, Bremen, Germany, knauer@math.uni-bremen.de, *Christof Büskens*

In order to use a new concept of crane systems in high rack warehouses, reference trajectories have to ensure that the swing of the crane is under control during the fast movement and disappears at the final point. These trajectories can be obtained solving optimal control problems. Further, on user demand, the crane has to be brought safely to a rest position from any state within a fixed time. While solving the optimal control problem for the trajectories, additional constraints have to be considered now, depending on the optimal solution of other optimal control problems.

3 - DAE Optimal Control Problems with Applications in Electrical Engineering

Martin Kunkel, Institut für Mathematik, Universität Würzburg, Lehrstuhl für Angewandte Mathematik II, Am Hubland, 97074, Würzburg, Germany, martin.kunkel@mathematik.uni-wuerzburg.de, *Matthias Gerds*

We consider transient partial differential algebraic equations (PDAEs) which arise in various applications, e.g. in simulation of integrated circuits containing semiconductors. Herein, the electrical network is modelled by DAEs and the semiconductors are modelled using the drift-diffusion equations. Proper finite-element space discretization yields a system of DAEs. We discuss optimal control problems subject to DAEs and present possible solution strategies such as function space nonsmooth Newton methods.

■ MD-10

Monday, 14:00-15:20

6.2.56

Graphs and Networks IV

Stream: Graphs and Networks

Invited session

Chair: *Cédric Bentz*, LRI, Univ. Paris-Sud, 91405, Orsay, France, cedric.bentz@lri.fr

1 - Minimizing the number of critical stages for the on-line steiner tree problem

Nicolas Thibault, ERMES - Paris 2, Paris, France, nicolasvincentpierre@gmail.com

We study the following on-line problem. Our goal is to connect one by one a new member to the current steiner tree, while satisfying a quality constraint: the weight of the tree must be at most c (a given constant) times the weight of an optimal steiner tree. Then, we want to minimize the number of "critical stages" (stages with heavy changes in the tree). We propose an on-line strategy leading to at most $i/(2(c - ((\ln 3)/2) - 2) - 1)$ critical stages. We also prove that there exists situations where any algorithm needs at least $(i/(2(4c+1)) - 1)$ critical stages to maintain the quality constraint.

2 - Minimum d-blockers and d-transversals for the maximum stable set problem

Christophe Picouleau, CNAM, Laboratoire Cedric, 292 rue saint Martin, 75003, Paris, France, chp@cnam.fr, *Dominique de Werra*, *Marie-Christine Costa*

Let $G=(V,E)$ be a simple undirected graph. A d -transversal is a subset of V which intersects any maximum stable set while a d -blocker is a subset of V whose removal decreases the size of a maximum stable set by at least d . A minimum d -transversal (resp. d -blocker) is a d -transversal (resp. d -blocker) with minimum cardinality. We study minimum d -transversals and d -blockers of stable sets in bipartite and in split graphs. Whereas both problems are polynomial in bipartite graphs, for split graphs the situation is different: the search for a minimum d -transversal is polynomial and it is NP-hard for a minimum d -blocker. Our results on bipartite graphs are strengthened to the minimum d -transversal and minimum d -blocker of minimum set covers problems.

3 - Dense graph partition for community detection

Julien Darlay, G-SCOP, 46, avenue Félix Viallet, 38031, Grenoble, France, julien.darlay@g-scop.inpg.fr, *Nadia Brauner*, *Julien Moncel*

The density of a subgraph is defined as the ratio between the number of edges and the number of vertices of this subgraph. Finding the subgraph of maximum density can be done using flow technics or linear programming. 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-Complete and we propose a polynomial time algorithm when the graph is a tree.

4 - Power Domination in Graphs

Paul Dorbec, LaBRI, Université de Bordeaux - CNRS, 351 cours de la Libération, 33400, Talence, France, paul.dorbec@u-bordeaux1.fr

Supervision of a power system may be performed by the adequate placement of phase measurement units. The minimum number of these units that need to be placed to entirely monitor a system corresponds to the power domination number of the corresponding graph (Haynes, Hedetniemi, Hedetniemi, Henning, 2002). In contrast with other domination parameters, the power domination holds some spreading rules made possible by the use of Ohm's and Kirchhoff's laws. This parameter thus has a life-game like behavior and requires original proof techniques to be studied. In this talk, we shall define precisely the parameter, review some known results and discuss some current works on the problem.

■ MD-11

Monday, 14:00-15:20

8.2.38

Stochastic Models in Manpower Planning

Stream: Emerging Applications of OR

Invited session

Chair: *Andreas Georgiou*, Department of Business Administration, University of Macedonia, 156 Egnatia Street, 54006, Thessaloniki, Greece, acg@uom.gr

1 - A Model Based Study on The Career Prospects of Individuals in An Indian University

Arindam Gupta, Statistics, University of Burdwan, Department of Statistics, The University of Burdwan, Golapbag, Burdwan, W.B., India, 700104, Burdwan, West Bengal, India, arindamdeep@yahoo.com, *Asis Kumar Chattopadhyay*

To study the movement of individuals over occupational categories it is natural to start by looking at the movement of people between different categories. Since such moves are unpredictable at the individual level it is necessary to find a model to describe the mechanism of movement in probabilistic terms. We have used a markov model to describe this in a half open and half closed system. A measure of career pattern based on above model has been developed and the simulated distribution of this measure has also been studied. A numerical study has been done on the University of Calcutta, India.

2 - Dealing with observable and latent heterogeneity in Markov manpower systems

Marie-Anne Guerry, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Brussels, Belgium, maguerry@vub.ac.be

In modeling manpower systems, it is of crucial importance to deal with heterogeneity. Most of the manpower models are taking into account heterogeneity due to observable sources, neglecting heterogeneity due to latent sources. In this paper a multinomial Markov-switching model is introduced to deal with heterogeneity due to latent sources for the internal flows of the personnel as well as for the wastage flows. A re-estimation algorithm is presented to estimate the parameters of the Markov-switching manpower model.

3 - The dynamic behavior of a mixed push-pull manpower model

Tim De Feyter, Centre for Corporate Sustainability, Hogeschool-Universiteit Brussel, Stormstraat 2, 1000, Brussels, Belgium, tim.defeyter@hubrussel.be, *Marie-Anne Guerry*

In the mixed push-pull model, the internal mobility of a manpower system is regulated by push as well as pull transitions. The model is a generalization of the Markov and the Renewal manpower model. In this paper we study the dynamic and asymptotic behavior of the mixed push-pull model under the assumptions of time-homogeneity and a known constant recruitment policy and investigate the mechanisms underlying the difference with the dynamic behavior of the traditional push and pull model. We show that under certain conditions, the system evolves towards a limiting personnel distribution.

4 - Investigating Aspirations, Priorities and Optimization Opportunities in Markov Manpower Planning Models

Andreas Georgiou, Department of Business Administration, University of Macedonia, 156 Egnatia Street, 54006, Thessaloniki, Greece, acg@uom.gr

Integrating various optimization aspects in hierarchical manpower planning models has been of interest since the early introduction of these structures. Decision makers' aspiration levels and priorities are often contradicted by rigid constraints that can not be easily circumvented. This work presents ideas which can be employed in manpower nonhomogeneous markov systems which evolve in time, in an effort to reach satisfactory structures. Optimization approaches based on a general goal programming framework are considered and possible other variations that can be employed in this direction are investigated

5 - Control aspects in an enhanced manpower planning model

Nikolas Tsantas, Department of Mathematics, University of Patras, Department of Mathematics, University of Patras, 26500, Patras, tsantas@upatras.gr, *Vasileios Dimitriou*

This work deals with the exercise of recruitment control to a time dependent, hierarchical system which incorporates training classes as well as two streams of recruitment; one coming from the outside environment and another from an auxiliary external system. The motivation for this model lies in the need to take into account not only the tendency of the employees to attend seminar courses so as to improve their career prospects, but also the organizations' intention to avoid situations associated with the unavailability of skilled individuals for hiring.

1 - Finding Effective Strategies for Improving Textile and Clothing Supply Chain in Pakistan using SWOT Analysis and AHP

Deedar Hussain, Production and Systems Department, University of Minho, Portugal and NED University, Pakistan, University of Minho, Campus de Gualtar, 4710-057, Braga, Minho, Portugal, deedar_gha@hotmail.com, *Manuel Figueiredo*, *Anabela Pereira Tereso*, *Fernando Ferreira*

The global shift of textile and clothing manufacturing to low cost environments has created a strong competition in Asia and Far East. Old and new players are developing the missing links in the chain. Although they are at different development stages, they share the advantage of being suitable sources for low-value and standard products. Similar is the context for Pakistan which supplies mainly standard products of low added value. This study gets inputs from our previous work, "SWOT Analysis of Pakistan Textile Supply Chain" and aims to develop competitive strategies using Saaty's AHP.

2 - Risk management in the process of foreign supplier selection: Case Study

Olga Fedotova, DEGEI, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Aveiro, Portugal, olgafedotova@ua.pt, *Luís Ferreira*

Managing risk in inbound supply chain operations has become increasingly important in today's competitive and globally environment. This research aims to reinforce inbound supply chain risk management by proposing a methodology, based on the analytic hierarchy process (AHP), for evaluating and ranking potential suppliers.

A realistic case study is presented in which a Portuguese industrial manufacturer evaluates and ranks its current foreign suppliers of stainless steel against two other potential foreign suppliers.

3 - Evaluating health-care waste disposal alternatives using analytical hierarchy process

Melis Almula Karadayi, Systems Eng., Yeditepe University, 34726, Istanbul, mkaradayi@yeditepe.edu.tr

Today, as in all other organizations, the amount of waste generated in the health-care institutions is rising due to their extent of service. Disposal of health-care waste management, including Turkey, is one of the most common problems of developing countries. This paper presents the application of analytical hierarchy process for evaluating health-care waste disposal alternatives for Istanbul, including "incineration", "steam sterilization", "microwave" and "landfill". Economic, environmental, technical and social criteria and their related sub-criteria are employed to evaluate health-care waste disposal alternatives.

4 - An AHP model to evaluate brand equity of sports clubs

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

Brand equity is defined as the sum of all values that is attributed to a brand, which makes it a crucial element while directly influencing the market value. If the mentioned brand belongs to a product, brand value can easily be attached to the qualifications of that product, but if it is a service, measurement of this value is more complex. Although there has been numerous studies on this topic, there is a gap in sports sector. In this study a comprehensive evaluation has been done, outputting the criteria. Then, a pairwise comparison is done in order to prioritize these criteria.

■ MD-12

Monday, 14:00-15:20

8.2.39

AHP 04

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Y. Ilker Topcu*, Industrial Engineering, Istanbul Technical University, Istanbul Teknik Universitesi, Isletme Fakultesi, Macka, 34367, Istanbul, Turkey, ilker.topcu@itu.edu.tr

■ MD-13

Monday, 14:00-15:20

2.2.21

Discrete Location I

Stream: Location Analysis

Invited session

Chair: *Antonio Manuel Rodríguez-Chía*, Estadística e Investigación Operativa, Universidad de Cádiz, Facultad de Ciencias. Pol. Río San Pedro., 11510, Puerto Real, Cádiz, Spain, antonio.rodriguezchia@uca.es

1 - Discrete location for bundled demand points

Alfredo Marín, Departamento de Estadística e Investigación Operativa, University of Murcia, Facultad de Matemáticas, Campus de Espinardo, 30100, Murcia, Spain, amarin@um.es

We consider a discrete location problem where the demand points are grouped and propose a formulation, an enforcement for it and an associated agrangian relaxation, and then we build feasible solutions to the problem from the optimal solutions to the relaxed subproblems. Valid inequalities for the formulation are also identified and added to the set of relaxed constraints. This method produces good feasible solutions and enables us to address large instances of the problem. Computational experiments have been performed with benchmark instances from the literature on related problems.

2 - Lower Bounds for a Capacitated Facility Location Problem with Penalties and Revenues

Maria João Lopes, Departamento de Métodos Quantitativos, Lisbon University Institute (ISCTE - IUL); CIO, Av. das Forças Armadas, 1649-026, Lisboa, Portugal, mjfl@iscte.pt

We consider a variant of the Capacitated Facility Location Problem in which the demand of each customer may not be entirely supplied. In this variant, the available supply is not enough to satisfy the total demand. A penalty is associated with each unit left out. On the other hand, each customer can be supplied by more than one facility. Nevertheless, satisfying the demand of a customer entirely by exactly one facility is aimed. If this condition is satisfied revenue is considered. We propose a formulation for this problem and valid inequalities to improve the lower bounds.

3 - Assessing the accuracy for estimation of Origin-Destination matrices in the railways system context

Eva Barrena, Applied Mathematics I, University of Sevilla, Avda. Reina Mercedes s/n, 41012, Sevilla, Spain, ebarrena@us.es, *M^a Teresa Cáceres*, *Francisco A. Ortega*, *Miguel Angel Pozo*

The estimation of a travel matrix Origin-Destination (O-D), updated with traffic counts from the transport network and from a previous O-D matrix, is a problem that is of interest for researchers, due to the challenge linked to the complexity involved, as well as for transport companies interested in knowing the behavior of their users via a more economical and efficient procedure than the ones based on surveys. The most representative estimation methods are based on entropy maximization, statistical inference models and optimization methods, whose effective resolution applies iterative algorithms, heuristics and metaheuristics.

The objectives of this paper consist in the evaluation of the prospects of this problem for a specific company such as RENFE-Cercanías Madrid, as well as the evaluation of possible methodologies to apply depending on their adequacy to the real context. This work has been partially supported by the the Andalusian Government project Ref. P09-TEP-5022 and by the Spanish research Project PT-2007-003-08CCPP (CEDEX).

4 - On a common structure of the discrete optimization with ordering

Antonio Manuel Rodríguez-Chia, Estadística e IO, Universidad de Cádiz, Facultad de Ciencias, Pol. Río San Pedro, 11510, Puerto Real (Cádiz), Cadiz, Spain, antonio.rodriguezchia@uca.es, *Elena Fernandez*, *Justo Puerto*

This paper studies discrete optimization problems with ordering requirements. These problems are formulated on general discrete sets in which there exists an implicit ordering on their elements together with a cost function that evaluates each element of a given subset depending on its ordering relative to the remaining elements in the set. It is proven that ordered sequences over the original set define an independence system. The simplest and its restriction to sets of a fixed cardinality are studied. Ordering problems on the intersection of two independence systems are addressed.

■ MD-14

Monday, 14:00-15:20

2.2.15

Pricing Issues

Stream: Supply Chain Planning [c]

Contributed session

Chair: *Carla A. S. Geraldés*, Department of Industrial Management, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 134, 5301-857, Bragança, Portugal, carlag@ipb.pt

1 - A New Multi-Objective Approach for Pricing and Distribution in a Supply Chain

D. Shishebori, Industrial Engineering, Iran University of Science and Technology, Narmak, 1684613114, Tehran, Tehran, Islamic Republic Of, shishebori@in.iut.ac.ir, *S.g.r. Jalali-Naini*, *M. Karimi-Nasab*

In this research a new multi-objective approach is proposed to determine distribution policy for a wholesaler of supplementary nutrition to a set of local distribution centers positioned around the wholesaler, geographically. Each local distribution center has its own stochastic demand over planning periods. Also the demand of each local distribution center in a planning period is considered as a normal distribution function. There is a time series relation between the mean of demand of each local distribution center in a period and previous periods. The model illustrates the conflict of two objectives for the main partners of the problem: manager of the wholesaler aims at maximizing the total profit of the wholesaler, and local distribution centers desire to maximize the minimum service level received from the wholesaler. The approach optimizes selling price, carrying cost, batch size and services level of multi items for each local distribution center in every planning period. Some of the theorems are proven about different characteristics of the proposed model and a new solution method is proposed for obtaining a set of global Pareto-optimal solutions of the problem. The solution method is proven to be able to find all global Pareto-optimal solutions of the problem in certain conditions. Finally the computational experiences of running the proposed approach in a real case study are analyzed.

2 - Determination of pre-order and after-order prices for a capacitated supply system

Bisheng Du, Department of Business Studies, Aarhus School of Business, Aarhus University, Fuglesangs Alle 4, DK-8210 Aarhus V, 8210, Aarhus V, Aarhus, Denmark, bisd@asb.dk, *Christian Larsen*

In order to transfer some of the risk of having developed inadequate capacity to his buyers a supplier may be willing to offer his buyers to make pre-orders, issued before the capacity decision, in exchange for reduced prices compared to the prices the buyers pay after having observed their demand. By use of a news-vendor model we develop the optimization problem for the single buyer case and investigate the optimal prices. In addition, we also investigate the case of demand probability updating given the advance demand information.

3 - Competitive Price-Matching Guarantees under Demand Uncertainty and Customer Heterogeneity: Effects of Product Availability and Its Verification

Arcan Nalca, School of Business, Queen's University, Canada, arcan.nalca@business.queensu.ca, *Tamer Boyaci*, *Saibal Ray*

Price-matching-guarantees (PMGs) are offers where firms promise to match any lower price offered by competitors. Firms nowadays reserve the right to verify the availability of the product at competitors' and decline to match the price unless it is available. Focusing on these elements, we investigate the effects of demand uncertainty and verification of availability in the context of PMGs and show that verifying availability is a significant profit-enhancing mechanism for innovative products.

4 - Integrated approaches to warehouse planning and operations

Carla A. S. Geraldés, 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*

In this talk we discuss a tactical model recently available in warehouse literature. The model integrates the replenishment decision in inventory management, the allocation of products to warehousing systems and the assignment of products to storage locations in warehousing management. Our aim is to show the models' potentialities and weaknesses when applied to a wide variety of problems and to identify challenging research opportunities for developing global warehouse decision support models that fill the gap between researchers and warehouse practitioners.

■ MD-15

Monday, 14:00-15:20

2.2.12

Exact Algorithms for Vehicle Routing

Stream: Vehicle Routing

Invited session

Chair: *Roberto Baldacci*, DEIS, University of Bologna, Via Venezia, 52, 47023, Cesena, Italy, r.baldacci@unibo.it

1 - The vehicle routing problem with time windows and edge set costs

Line Blander Reinhardt, DTU Management, The Technical University of Denmark, Produktionstorvet 424, 2800, 2800 Kgs. Lyngby, Denmark, lbre@man.dtu.dk, *David Pisinger*, *Mads Kehlet Jepsen*

In real life applications the vehicle routing problem takes many forms. The cost of access to a set of edges is investigated together with the well known time window restriction. The cost of accessing a set of edges is a single payment to allow all the vehicles to access all of the edges in the set payed for. A real life example of this is when a company makes a single payment so that all vehicles obtain unlimited access to a specified number of ferry routes in a given time period. A mathematical model, solution methods and test results are presented.

2 - Experiments with new cuts on the VRP

Eduardo Uchoa, Engenharia de Produção, Universidade Federal Fluminense, Rua Passo da Pátria 156, São Domingos, 22430-210, Niterói, Rio de Janeiro, Brazil, uchoa@producao.uff.br, *Diego Pecin*, *Artur Pessoa*, *Marcus Poggi de Aragão*

The most successful current exact algorithms for the VRP combine a set-partitioning formulation (where columns may be elementary routes or q-routes) with cuts. It is possible to cut: (i) in the SP variables, or (ii) in the variables of the original formulation. The SP cuts are potentially stronger, but have the side effect of making the pricing intractable on instances with many clients per route. We present recent developments on the second kind of cuts, over arc-capacity indexed variables. Computational experiments over classical VRP (and scheduling) instances show significant gap reductions

3 - Column Generation and Branch-and-Price for the m-PVRP

Sandra Ulrich Ngueveu, LOSI (Laboratory of Industrial Systems Optimization), University of Technology of Troyes, 12, rue Marie Curie, 10010, Troyes, France, ngueveus@utt.fr, *Christian Prins*, *Roberto Wolfler-Calvo*

The m-Peripatetic Vehicle Routing Problem models regular money transportation with peripatetic and capacity constraints ensuring that no sequence of clients is repeated during m periods and that the amount of money allowed per vehicle is limited. The total cost is to be minimized. We present new lower bounding procedures and a branch-and-price algorithm based on dual heuristics that compute dual feasible solutions for the set partitioning relaxation. Their efficiency lies upon the approximation of routes with q-routes, the dual ascent that estimates the best dual values and column generation.

4 - New Benchmark Results for the Capacitated Vehicle Routing Problem

Roberto Baldacci, DEIS, University of Bologna, Via Venezia, 52, 47023, Cesena, Italy, r.baldacci@unibo.it, *Aristide Mingozzi*, *Roberto Roberti*

The Capacitated Vehicle Routing Problem (CVRP) is the problem of designing optimal delivery routes for a fleet of vehicles in order to supply a set of customers with given demands at minimum cost. In this paper, we improve the exact method recently proposed by Baldacci, Christofides, and Mingozzi (2008) using Subset-Row (SR) inequalities and a new route relaxation, called *ng-route*. Computational results show that the proposed method outperforms the best methods presented in the literature.

■ MD-16

Monday, 14:00-15:20

2.2.14

Robust planning and rescheduling

Stream: Public Transport

Invited session

Chair: *Natalia Kliewer*, Information Systems, Freie Universitaet Berlin, Garystr. 21, 14195, Berlin, Germany, natalia.kliewer@fu-berlin.de

1 - GRASP algorithms for the Robust Railway Network design problem

Antonio J. Lozano, Department of Mathematics, University of Huelva, Dpto. de Matemáticas, Facultad de Ciencias Experimentales, 21071, Avda de las Fuerza Armadas s/n, 21007, Huelva, Spain, antonio.lozano@dmate.uhu.es, *Juan A. Mesa*, *Federico Perea*

Designing a railway network aiming at maximizing trip coverage assuming an alternative transportation mode (for instance a bus) competing with the railway system is a NP-hard problem. If we add a robustness component to the problem, which in our case consists of allowing links to fail, the problem becomes even more complex. In this talk we will introduce a class of GRASP algorithms to give a feasible near-optimal solution in a reasonable amount of time.

2 - Strategic Planning in the Airline Industry under uncertainty

Marc Naumann, Decision Support & Operations Research Lab, University of Paderborn, Warburger Str 100, 33098, Paderborn, NRW, Germany, naumann@dsor.de, *Leena Suhl*, *Achim Koberstein*

Today, fuel costs are a growing part in airlines' expenditures and their fluctuations become higher. We connect schedule development and fleet assignment and develop a new strategic planning model for airlines under fuel price uncertainty. We present a stochastic model that determines the optimal offered flights, passenger routes and aircraft types. To counteract fuel price uncertainty, financial hedging is considered. We show that the optimal offered flights and the aircraft types depend on the fuel price development. Finally, the integration of hedging improves profit at given risk levels.

3 - An Applicable Recovery Framework for Airline Operations

Lucian Ionescu, Information Systems, Freie Universität Berlin, Garystr. 21, 14195, Berlin, Berlin, Germany, Lucian.Ionescu@fu-berlin.de, *Viktor Dück*, *Natalia Kliewer*

The airline transportation frequently has to deal with occurring delays, which may lead to infeasible schedules during the day of operations. This forces the Operations Control Center to recover these schedules through mostly expensive actions. For the offline scheduling problem there exists a lot of indicators for robustness with possibly negative correlated impacts on each other. To objectively measure these impacts a realistic evaluation framework including real-time applicable recovery actions is needed. In this context, we present an online approach to cost-efficiently deal with disruptions by an extendable recovery framework with regard to the estimated impact for all following tasks.

4 - Approaches to increase delay-tolerance of vehicle and crew schedules in public bus transport

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

In public bus transport delays occur frequently during the transportation process. Delayed buses not only affect the vehicle schedule but also the associated crew schedule. Delayed drivers cause similar effects the other way round. Thus planned schedules can become infeasible and the operations control has to manage expensive recovery actions. We present offline approaches to increase delay-tolerance of both schedules. Focus is on using buffer time to cope with minor disruptions and to control delay propagation. The approaches are compared with regard to planned costs and delay-tolerance.

■ MD-17

Monday, 14:00-15:20

1.3.14

Breaks in Vehicle Routing and Scheduling

Stream: Transportation Planning

Invited session

Chair: *Christoph Manuel Meyer*, Department of Economics, Chair of Logistics, University of Bremen, Wilhelm-Herbst-Straße 5, 28359, Bremen, Germany, meyer@wiwi.uni-bremen.de

1 - Vehicle Routing under Consideration of the European Social Legislation

Christoph Manuel Meyer, Department of Economics, Chair of Logistics, University of Bremen, Wilhelm-Herbst-Straße 5, 28359, Bremen, Germany, meyer@wiwi.uni-bremen.de, *Herbert Kopfer*

In practice, planners have to consider legal restrictions on driving and working hours in transportation planning. In this presentation, the impact of the European social legislation on vehicle routing and scheduling is investigated. Special attention is given to the integration of the optional rules of the legislation which have often been neglected in vehicle routing methods so far. These optional rules allow for an increased solution space. We will show that their inclusion in models and solution approaches results in improved vehicle schedules both for centralized and distributed planning.

2 - Vehicle Routing with Breaks and Rests, a Practitioner's Point of View

Robert Scheffermann, Logistics Systems Engineering, Forschungszentrum Informatik, Haid-und-Neu-Straße 10-14, 76131, Karlsruhe, Germany, scheffer@fzi.de, *Andreas Cardeneo*, *Werner Heid*

Recently published methods to schedule breaks and rests in VRPs share the same basic mechanisms: branching, domination and slack-time. We argue that when scheduling rests in VRPs it is inevitable to consider multiple time-windows. We will present their impact on these mechanisms, showing that the number of branches grows dramatically and the effect of domination becomes very weak. We will also show that the naïve utilization of slack-time leads to volatile solutions. We present methods for branching based on multi-objective genetic programming and domination based on a S-metric selection.

3 - A pickup and delivery model considering EU driving time regulations

Alexandra Hartmann, Business School, University of Applied Sciences, Saarland, 66115, Saarbrücken, Germany, alexandra.hartmann@htw-saarland.de

Motivated by a real-life application in long-haul freight transportation, a new pickup and delivery model is proposed for routing and scheduling a group of requests assigned to a vehicle. In addition, rest period planning is integrated in the model by taking EU driving and working regulations into account. Multiple time windows are specified at the origin and destination of each request. The objective is to minimize the total route duration and the violation of time windows. Computational results for the new mixed-integer linear program based on real-life data are presented.

■ MD-18

Monday, 14:00-15:20

1.3.15

Queueing Systems

Stream: Stochastic Modeling and Simulation

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: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - The Effect of the Number of Servers in Quasi-Random-Input Queues

Moshe Eben-Chaime, Industrial Eng. & mgt., Ben Gurion University, P.O. Box 653, 84105, Be'er-Sheav, Israel, even@bgu.ac.il

The finite source population of quasi-random input (QRI) queues creates state dependent arrival rates. Thus, probabilities and performance measure admits no closed form expressions, a barrier to the development of analytical results. Yet, we present new such results. First, monotone effect of the number of servers on most performance measure is shown. QRI queuing models are applied to the design of human-machine systems. Establishing the convexity of the mean queue length in the number of servers implies diminishing marginal productivity of both the servers and the sources — the machines.

2 - Queuing system simulation and efficiency evaluation by Petri nets and Data Envelopment Analysis

Dragana Makajic-Nikolic, Laboratory for Operational Research, Faculty of Organization Sciences, Serbia, gis@fon.rs, *Gordana Savic*, *Mirko Vujosevic*, *Novak Novokmet*

Real postal services queuing system with two fixed channels is modelled by Petri Nets and several scenarios for distinct rules of additional channel activation are simulated in CPN Tools software. In order to decide the best rule, DEA is applied for scenarios efficiency evaluation. Total time all users spend in the system and expected number of users in all queues are considered as inputs, since the total occupation time of the fixed and the additional channels are used as DEA outputs. Described procedure is repeated several times in cases of different arrival rates queuing system.

3 - Queues with boundary assistance and the many effects of truncation

Giang Nguyen, d'informatique, ULB, Belgium, giang.nguyen@ulb.ac.be, *Peter Taylor*, *Guy Latouche*

Consider a simple system with two queues, each with its own Poisson stream of customers and its own server, of which the service time is exponentially distributed. If a server is free and its associated queue is empty, then it serves a neighboring customer, provided there is one. The service rate of a server does not change regardless of whether it is serving its own or a neighbouring customer.

This system is an example of queues with boundary assistance and may be modeled by a Quasi-Birth-and-Death process, with the level being the minimum queue length and the phase the difference between the two queue lengths. We investigate the asymptotic behavior of the level in the original infinitely-many-phase system and in its finite approximations where the queue length difference is bounded. In the infinite system, we determine the convergence norm of the rate operator of the QBD, and consequently the interval in which the decay rate of the minimum queue length lies.

We consider four finite approximations: one is the infinitely-many-phase system truncated without augmentation, and three are obtained from different augmenting schemes such that stochasticity is preserved. We show that the first has a monotonically increasing decay rate that approaches the convergence norm of the rate operator in the infinite system, as the truncation size tends to infinity. All three truncated and augmented systems have decay rates that are independent on the truncation size. Finally, we observe that the stability regions for the original system and the aforementioned finite approximations are nonequivalent.

4 - Analytical study of a queueing system with non-geometric tail behaviour

Mark Van Lokeren, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussel, mvlokere@vub.ac.be, *Bart Steyaert*, *Herwig Brunceel*

We consider a queueing system with two types of customers. Arriving customers of type A enter the system surely, whereas the probability that an arriving customer of type B enters the system depends on the total number of customers already present in the system (discouraged arrivals). Service times do not depend on the type of customer. We obtain analytical expressions for several performance measures of the system. The non-geometric tail behaviour of the total number of customers in the system (and the queue length) is discussed in detail.

■ MD-19

Monday, 14:00-15:20

1.3.20

Industrial Organization

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Bruno M.P. M. Oliveira*, FCNAUP, R. Dr. Roberto Frias, 4200-465, Porto, Portugal, bmpmo@fcna.up.pt

Chair: *Luis Ferreira*, Matemática, Escola Superior de Estudos Industriais e de Gestão, IPP, ESEIG, Rua D Sancho I, número 981, 4480-876, Vila do Conde, Porto, Portugal, migferreira2@gmail.com

1 - Edgeworthian economies with selfish participants

Bruno M.P. M. Oliveira, FCNAUP, R. Dr. Roberto Frias, 4200-465, Porto, Portugal, bmpmo@fcna.up.pt, *Luis Ferreira*, *Alberto A. Pinto*, *Athanasios Yannacopoulos*, *Barbel Finkenstadt*

A key problem of economic theory is the convergence of the prices in a market to their equilibrium values. We show that under some fairly general and easy to check symmetry conditions, depending on the initial distribution of endowments and the agents preferences, the sequence of Edgeworthian prices in a random matching economy converges to the Walrasian prices for this economy. We associate a selfishness factor to each participant which brings up a game alike the prisoner's dilemma. We observe that the fraction of selfish participants is related to their increase in utility.

2 - Patents in new technologies

Luis Ferreira, Matemática, Escola Superior de Estudos Industriais e de Gestão, IPP, ESEIG, Rua D Sancho I, número 981, 4480-876, Vila do Conde, Porto, Portugal, migferreira2@gmail.com

We present a new R&D investment function in a Cournot competition model inspired in the logistic equation. We do a full characterization of the associated game and study the short and long term economical effects derived from using this new R&D investment function. For low production costs, that can correspond to the production of old technologies, the long term economical effects are not very sensitive to small changes in the efficiency of the R&D programs. However, for high production costs, that can correspond to the production of new technologies, the long term economical effects are very sensitive to small changes in the efficiency of the R&D programs.

3 - A Stochastic Competitive R&D Race Where Winner-Takes-All

Boaz Golany, Industrial Engineering & Management, Technion - Israel Institute of Technology, Technion City, 32000, Haifa, Israel, golany@ie.technion.ac.il, *Inbal Mund*, *Uriel G. Rothblum*

The paper considers an environment in which multiple firms compete over the development of a certain product. Each firm needs to decide whether to launch the required R&D project and how much to invest in it and these decisions are known to all the competing firms. We prove the existence of a unique Nash Equilibrium solution, define the special features of that solution, provide an explicit formula that computes it and draw some managerial insights that emerge from the structure of the Nash equilibrium. Under certain assumptions, we also derive an explicit expression for the (unique) globally optimal solution and compare it with the Nash equilibrium solution.

4 - A two-ends model for the competitive firm under price uncertainty

Alberto A. Álvarez-López, Quantitative Applied Economics II, UNED (National University of Distance Education), Paseo Senda del Rey, 11, 28040, Madrid, Spain, aalvarez@cee.uned.es, *Inmaculada Rodríguez-puerta*

A competitive risk-averse firm has just produced a known amount of a perishable output. The firm can intend it for two possible ends (one with certain price, the other with uncertain price), so that the total amount is fully distributed between both of them. We find a "frontier price" for the certain end, beyond which the firm prefers to intend a positive amount for the uncertain end. We also give comparative static results (which are proved with analytic methods scarcely used in the literature) and examine a dual approach of the model which lets us enhance the scope of its applicability.

■ MD-20

Monday, 14:00-15:20

1.3.33A

Cutting and Packing 4

Stream: Cutting and Packing

Invited session

Chair: *Yuri Stoyan*, Department of Mathematical Modeling and Optimal Design, Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine, 2/10 Pozharsky St., 61046, Kharkov, Ukraine, stoyan@ipmach.kharkov.ua

1 - A strategic neighborhood search approach for the cylinder packing problem

Shigeyuki Takahara, Kagawa Prefectural Industrial Technology Center, 587-1 Goto-cho, 761-8031, Takamatsu, Japan, takahara@itc.pref.kagawa.jp

This paper is concerned with the problem of packing cylinders of different sizes into a rectangular container. In order to solve this problem, a strategic neighborhood approach is proposed. This approach is based on a greedy cylinder allocation algorithm and several improvement heuristics. The strategic procedure determines the arrangement of each cylinder with reference to search process. The effectiveness of the proposed approach is shown by comparing the results obtained with the approaches presented in literature by using benchmark problems.

2 - A formulation space search heuristic for the circle packing problem

Claudia Lopez, Brunel University, United Kingdom, claudia.lopez@brunel.ac.uk, *J. E. Beasley*

We present a heuristic algorithm based on the formulation space search (FSS) method to solve the circle packing problem (CPP). The CPP considered is of finding the maximum radius of a specified number of identical circles without overlaps into a two-dimensional container. The problem is formulated as a nonlinear optimisation problem involving both Cartesian and polar systems. FSS consists of moving through different formulations of the same problem. Our heuristic improves on previous results based on same method, is a computationally effective approach when compared with other work.

3 - Covering a non-convex polytope by minimal number of congruent parallelepipeds

Yuri Stoyan, Department of Mathematical Modeling and Optimal Design, Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine, 2/10 Pozharsky St., 61046, Kharkov, Ukraine, stoyan@ipmach.kharkov.ua, *E.s. Sosurcka*

The problem of covering a non-convex polytope by a minimal number of congruent parallelepipeds is considered. A mathematical model of the problem on the ground of phi-functions and special covering functions is constructed and its characteristics are investigated. These characteristics allow the search of approximate solutions of the problem to be reduced to solving a sequence of linear programming problems. These sequences are chosen either randomly or by a special way including a branch and bound algorithm. A number of numerical results are given.

4 - An Efficient Mechanism for Solving Two Phase Packing Problems

Arik Sadeh, Management of Technology, Holon Institute of Technology, 52 Golomb Street, P.O. Box 305, 58102, Holon, Israel, sadeh@hit.ac.il, *David Raz*

Packing problems are NP complete even for a small scale problem. A procedure for finding a solution for a two phase packing problem is proposed. First, the mechanism conducts a pseudo efficient frontier of solutions, while in the second phase a scaled down packing problem is solved. There is a considerable reduction in the number of feasible solution to be calculated. The concept is applied to transporting a daily portfolio of goods, characterized by volume, weight and predetermined allowable weight. Transporting bins are associated with set up cost and extra weight cost, if any.

■ MD-21

Monday, 14:00-15:20

6.2.47

Optimization Modeling II

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

1 - Recent enhancements in GAMS

Jan-Hendrik Jagla, GAMS Software GmbH, 50933, Cologne, Germany, jhagla@gams.com, *Lutz Westermann*

We will demonstrate new features and improvements recently added to the General Algebraic Modeling System (GAMS). Continuously improving the system while maintaining our commitment to backward compatibility makes the development of optimization-based decision support applications efficient and productive. Among others we will present recently added solvers, enhanced interfacing with other applications through our APIs, and more hidden features that users might not know about, yet!

2 - MPL for Python - Introducing new scripting and library interfaces for the MPL Modeling Language

Sandip Pindoria, Maximal Software Ltd, Boundary House, Boston Road, W7 2QE, London, United Kingdom, sandip@maximalsoftware.co.uk, *Bjarni Kristjansson*

MPL has been distributed with a standard GUI interface for development and object-oriented library for deployment for many years now. With the advent of scripting language frameworks such as Python, that are becoming increasingly popular, there are now new opportunities for integrating optimization into real-world applications. With "MPL for Python" we are introducing a new scripting and component library interfaces for MPL, that takes full advantage of the many powerful features of Python.

3 - Fast & flexible modeling with AIMMS

Frans de Rooij, AIMMS, Paragon Decision Technology B.V., Schipholweg 1, 2034 LS, Haarlem, Netherlands, frans.de.rooij@aimms.com

AIMMS is software for developing and deploying optimization models. We will demonstrate how AIMMS enables fast model formulation, without having to learn a programming language. The integrated GUI allows you to visualize and interpret results. AIMMS offers flexible, advanced algorithmic capabilities: column generation, outer approximation for MINLP, multi-start for NLP, Stochastic Programming, Robust Optimization, etc. Industry cases will show how AIMMS models are deployed, either as complete optimization application, or as optimization engine integrated with existing applications.

■ MD-22

Monday, 14:00-15:20

3.1.10

OR in Education II

Stream: Teaching OR/MS

Invited session

Chair: *Ruy Costa*, Mathematics Dept, FCT-UNL, Campus de Caparica, 2829-516, Caparica, Portugal, rcosta@fct.unl.pt

1 - OR education at European level: a case of cooperation Portugal-Romania

Joao Miranda, Technologies and Design, ESTG/IPPortalegre, Lugar da Abadessa, Apt 148, 7301-901, Portalegre, Portugal, jlmiranda@estgp.pt, *Mariana Nagy*

European cooperation is a relevant subject nowadays, when there is the common purpose to build a competitive and knowledge-based economy in the European Union. In this communication, it is presented a case of Erasmus mobility between the most significant institutions of higher education in Portalegre (Portugal) and Arad (Romania), which addresses OR topics. It is proposed a module of 8 lecturing hours based on 4 sessions of 2 hours each: i) an Introductory Session, to focus the basics of computational Linear Algebra, Linear Programming, Integer Programming, with computational support (Excel and MATLAB); ii) an Interim Session, to address modelling subjects on a drop-and-by session; iii) an Advanced Session, on the sequence of first one, to treat uncertainty and also using multi-criteria decision making methods; iv) an Ending Session, to perform the evaluation of learning outcomes. It is targeted the exploitation of this cooperation at European Level, which also includes curricula normalization and adjustments, cultural exchanges, and research lines sharing in the sense to promote the mobility of students and faculty. This mobility case thus contributes for the growth and sustainability of international cooperation that is necessary onto the foreseen network of higher education institutions at European level.

2 - The challenge of teaching OR

Gertjan de Lange, Sales & Marketing Director, AIMMS (Paragon), PO Box 3277, 2001 DG, Haarlem, NH, Netherlands, g.de.lange@aimms.com

Teaching an OR is a challenge for both universities and companies acting in OR. Our educational program and related activities are in place to promote easy access and co-operation. This includes free access to AIMMS for students, development of OR games in co-operation with universities, optimization modeling competitions, and supporting open source initiatives such as COIN-OR. In this session, we want to share our experiences and challenges.

3 - Forecasting the overall academic performance of university undergraduates using neural networks

Ruy Costa, Mathematics Dept, FCT-UNL, Campus de Caparica, 2829-516, Caparica, Portugal, rcosta@fct.unl.pt

We used data from FCT-UNL and considered neural networks with one hidden layer with a number of neurons varying from 1 to 4 with four input variables (MAT — the summation of passing grades in Mathematics courses in the first year (or first two years) in the University; PHY — sum for Physics courses; CHE — sum for Chemistry courses and OTH — sum for other area courses) and only one output variable (DUR, the total number of years an undergraduate spent in university). We will present results and discuss further improvements in the models.

■ MD-23

Monday, 14:00-15:20

6.2.49

MOO: Multi-Objective Combinatorial Optimization

Stream: Multi-Objective Optimization

Invited session

Chair: *Matthias Ehrgott*, Engineering Science, University of Auckland, Private Bag 92019, 1001, Auckland, New Zealand, m.ehrgott@auckland.ac.nz

1 - On the computation of all supported efficient solutions in multi-objective integer network flow problems

Augusto Eusébio, Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Leiria, Morro do Lena — Alto Vieiro, 2411-901, Leiria, Portugal, aeusebio@estg.ipleiria.pt, *José Rui Figueira*

We present a new algorithm for identifying all supported non-dominated vectors in the objective space, as well as the corresponding efficient solutions in the decision space, for multiobjective integer network flow problems. Our approach is based on a negative-cycle algorithm used in single objective minimum cost flow problems, applied to a sequence of parametric problems. The proposed approach uses the connectedness property of the set of supported non-dominated vectors/efficient solutions to find all integer solutions in maximal non-dominated/efficient facets.

2 - A multi-objective branch-and-cut algorithm and its application to the multi-modal traveling salesman problem

Nicolas Jozefowicz, LAAS-CNRS, 7 avenue du Colonel Roche, 31077, Toulouse, France, nicolas.jozefowicz@laas.fr, *Gilbert Laporte*, *Frédéric Semet*

We will present a generic branch-and-cut algorithm applicable to a wide class of multi-objective optimization problems for which a lower bound can be defined as a polynomially (or pseudo-polynomially) solvable multi-objective problem. It is applied to and implemented for the Multi-Modal Traveling Salesman problem. Computational experiments are conducted and the method is compared to the classical epsilon-constraint algorithm.

3 - Analyzing optimal paths in coloured-edge graphs with Euclidean weights

Felipe Lillo, School of Computing and Mathematical Sciences, AUT university, AUT Tower, WT406, cnr Wakelfield & Rutland Street, Auckland CBD, 1142, Auckland, Auckland, New Zealand, flillovi@aut.ac.nz, *Andrew Ensor*

The weighted coloured-edge graph is a tool that allows the modelling of multimodal networks by assigning to each edge both a weight for optimization criteria and a colour for transport mode. The shortest path between two points is computed by imposing a partial order relation on the path weights in each colour resulting in a Pareto set of optimal paths. This work experimentally studies the order of this set for coloured-edge graphs whose edge weights are determined by Euclidean distance. Computational results indicate the tractability of the model is linked to the level of randomness as well as the dimension of the Euclidean space.

4 - Tight upper bound on the number of optimal paths in weighted coloured-edge graphs

Andrew Ensor, School of Computing and Mathematical Sciences, AUT University, AUT University. AUT Tower, Level 1, 2-14 Wakefield St, 1010, Auckland, Auckland, New Zealand, aensor@aut.ac.nz, *Felipe Lillo*

A weighted coloured-edge is a graph for which each edge is assigned both a positive weight and a discrete colour, and can be used to model transportation and computer networks in which there are multiple transportation modes. In such a graph paths are compared by their weight in each colour, resulting in a Pareto set of optimal paths from one vertex to another. This paper will give a tight upper bound on the cardinality of the Pareto set and explain some results toward establishing the average case cardinality.

■ MD-24

Monday, 14:00-15:20

6.2.50

Bioinformatics IV

Stream: Computational Biology, Bioinformatics and Medicine

Invited session

Chair: *Ceyda Oguz*, Department of Industrial Engineering, Koc University, Rumeli Feneri Yolu, Sariyer, 34450, Istanbul, Turkey, coguz@ku.edu.hk

1 - Manhattan Hamiltonian Path in NMR study

Marta Szachniuk, Institute of Bioorganic Chemistry, PAS, Noskowskiego 12/14, 61-704, Poznan, Poland, Marta.Szachniuk@cs.put.poznan.pl

Defining a good graph model is often a very important aspect of dealing with a novel problem. It allows for the theoretical analysis of a problem and introducing new methods to solve it. Structural bioinformatics provides many tasks which require modeling via graph tools. Here, we present the problem of transfer pathway reconstruction within NMR spectrum, recorded for RNA molecule during its tertiary structure determination. The characteristics of the problem made us transform it to a version of Hamiltonian path, which we named Manhattan Hamiltonian path.

2 - A study of different hyper-heuristics for sequencing by hybridization problem

Aleksandra Swiercz, Institute of Computer Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, aswiercz@cs.put.poznan.pl, *Wojciech Mruczkiewicz*, *Jacek Blazewicz*, *Graham Kendall*, *Edmund Burke*

Hyper-heuristic is a new searching technology, which goal is to raise the level of generality at which optimization system can operate. A Hyper-heuristic works with a set low-level heuristics and does not have a knowledge about the problem it is solving. The low-level heuristics are dedicated to a given problem and search the solution space. A hyper-heuristic chooses in intelligent way which heuristic should be called at each moment. A hyper-heuristic framework has been constructed for the DNA sequencing by hybridization and traveling salesman problems.

3 - Petri net based model of atherosclerosis

Piotr Formanowicz, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, piotr@cs.put.poznan.pl, *Dorota Formanowicz*, *Tomasz Nowak*

Atherosclerosis is one of the leading death cause in developed countries. It is a very complex process whose nature is not well understood. In this paper a Petri net based model of the main part of this process is presented. An application of the Petri net theory to the description of biological processes allows for a very precise analysis of the resulting models. Here, such an analysis of the atherosclerosis model from a mathematical point of view is given. The model allows also for a simulation of the process, since Petri net theory provides a lot of analysis techniques and tools.

4 - Mathematical Model of Blood Flow and Nutrients Delivery

Trishna Fadjrir, Medicine, University of Sumatera Utara, Jl. Ampera, Jl. Dr Mansur, 20155, Medan, Indonesia, tfadjrir@yahoo.com, *Herman Mawengkang*

Abstract The placenta is a round, flat organ that forms during pregnancy to give the baby food and oxygen from the mother. During a normal pregnancy, the placenta stays firmly attached to the inside wall of the uterus until the baby has been born. The placenta provides the baby with nutrients and oxygen from the mother and carries away fetal waste. This paper proposes a mathematical model which could describe blood flows to the exchange of oxygen, nutrients and waste products between the fetus and the mother. The structure of placenta was explored, particularly the flow patterns of fetal arteries. The basic equation was developed using a compartment model in order to investigate the effect blood jetting out of a maternal spiral artery. Analysis the model could lead estimating nutrient delivery to the fetus.

■ MD-25

Monday, 14:00-15:20

6.2.48

Financial Dynamics and Bubbles

Stream: Financial Mathematics and OR

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - New Unified Approaches on Identification and Optimization of Financial Processes

Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

This presentation contributes to an improved modeling, risk management and optimization of financial processes, with environmental aspects included. We model stochastic differential equations and estimate parameters with the help of (generalized) additive models, splines, our new CMARS and nonlinear regression. We embed the related goals on accuracy and stability with the minimization of risk and the maximization of utility, by generalized approaches in portfolio optimization. With a discussion of structure, frontiers and an outlook we conclude.

2 - Stability investigation of key Czech banks by means of the financial modelling

Petr Gurný, Department of Finance, VSB -TU Ostrava, Sokolska tr. 33, 70121, Ostrava, Czech Republic, petr.gurny@vsb.cz

The paper is devoted to the investigation of the Czech banks health, which we can regard as one of the most important tasks in time of the financial crisis. The main goal of the paper is an estimation of the future probability of default (PD) for three key Czech banks. At first the revised model (built on the basis of the linear discriminant analysis) for prediction of bank failure will be presented. Afterwards the relevant financial indicators needed for estimation of the future PD will be simulated via Lévy processes (VG, NIG) and their dependencies will be captured via copula functions.

3 - Modelling Financial Bubbles by Stochastic and Ellipsoidal Calculus and Copulas

Efsun Kürüm, Financial Mathematics, Institute of Applied Mathematics, METU, Institute of Applied Mathematics, 06531, Ankara, Turkey, efsun.kurum@gmail.com, *Gerhard-Wilhelm Weber*

To diagnose bubbles is a very important issue in finance, where copulas have been considered the last decade. By copulas we model bubbles which are known as upward price movements over extended range that implode. In copula-based modelling we deal with bubbles by stochastic differential equations. We also model the dynamics of bubbles by ellipsoidal calculus and topology. We test the model by a large database from a central bank. We conclude with a structural features, discussions of future applications and research challenges.

4 - Determination of Trade Based Manipulation in Istanbul Stock Exchange

Melik Kamisli, Bozuyuk Vocational School, Bilecik University, Bilecik University Vocational School, Yeni Mahalle Cerrahlar Sokak No:11, 11300, Bozuyuk/Bilecik, Turkey, melik.kamisli@bilecik.edu.tr, *Nuray Girginer*

The trade based manipulation has negative effects on investors, stock market and so, depending on them on whole economy. Consequently, a study based on determination of manipulation will provide information to related individuals. The aim of this study is evaluating the usability of financial ratios in trade based manipulation as an indicator when the investors make the stock selection decision. The results show that, Return on Assets and Book Value per Share are important financial ratios to determine the trade based manipulation in Istanbul Stock Exchange.

■ MD-26

Monday, 14:00-15:20

3.1.11

Machine Learning for Multiple Sources

Stream: Machine Learning and Its Applications

Invited session

Chair: *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

Chair: *Zakria Hussain*, Computer Science, University College London, Gower Street, WC1E 6BT, London, United Kingdom, Z.Hussain@cs.ucl.ac.uk

1 - Exploring relations of entities via common space representation

Sandor Szedmak, ISIS, Electronics and Computer Science, University of Southampton, Highfield, Building 1, SO17 1BJ, Southampton, United Kingdom, szedmak777@gmail.com

We are facing the following problem, there are given classes of entities with different distributions, e.g. enzymes, chemical reactions controlled by the enzymes, chemical molecules participating in the reactions, and medical diagnostic data. The question is that: how can one explore the highly complex interdependencies of these entities and predict the relations of new unseen entities? Directly attacking problems with several data sources by the known machine learning methods is mostly intractable. Several alternatives have been developed to visualise the potential relations between the entities by embedding them into a common space, e.g. recommendation systems, but the learning capabilities of these approaches are rarely addressed. Our question is that: can we learn the common space and its structure to provide a learner with good predicting power and with acceptable computational complexity? Simple examples can show that the known learning methods, e.g. Support Vector Machine, can be reinterpreted as common space problem of the input and output entities. Similarly the structural learning can be described in this way too. These methods can then be reduced into a nearest neighbour predictor working in a properly chosen common space. Going further on this road an approach which is able to handle incomplete data sources is presented as well.

2 - Selecting Rows and Columns of Large Datasets for Training Support Vector Regression Models

Kübra Yaman, Graduate School of Science and Engineering, Koc

University, Rumelifeneri Yolu, 34450 Sariyer, Istanbul, Turkey, kyaman@ku.edu.tr, *Ozden Gur Ali*

We propose the Row and Column Selection Algorithm to identify the most informative points and variable subsets from large datasets to train SVR models. This algorithm consists of two steps. First we identify few support vectors by penalizing the support vector weights, next we select a subset of features by penalizing the feature weights in linear models. We show that the test set accuracy of RBF-SVR model trained on the set selected by the algorithm is significantly better than the accuracy of the same model trained on the benchmark random sampling model.

3 - Adapted Infinite Kernel Learning by Multi-Local Algorithm

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, *Gürkan Üstüncü*, *Gerhard-Wilhelm Weber*

The interplay of machine learning (ML) and optimization methods is an emerging field of artificial intelligence. Kernel selection for classification models is an important task for ML algorithms. One of the recent kernel learning methods is developed for multiple source data called infinite kernel learning (IKL) modelled by semi-infinite optimization. In this study, we improved IKL by multi local algorithm and adaptive simulated annealing (ASA) algorithm. Experiments on high dimensional biological data show significant improvement both in running time and error percentage.

4 - Sparse Convex One-Class Kernel Fisher Discriminant Analysis

Tom Diethe, Department of Computer Science, University College London, Gower Street, WC1E 6BT, London, United Kingdom, t.diethe@cs.ucl.ac.uk, *Janaina Mourão-Miranda*, *John Shawe-Taylor*

Outlier detection is a classical topic in robust statistics. This paper describes a convex formulation of One-Class Fisher Discriminant Analysis (OC-FDA), which can be solved using off-the-shelf optimisers. Sparsity is enforced through an l_1 -norm constraint on the weight vector. The size of the enclosing hypersphere is varied using quantile values of the estimated posterior, adjusted by a single parameter. We compare with the One-Class SVM (OC-SVM) on a toy example and a real-world neuroimaging dataset. The extension to the multiview setting is also given, with some empirical results.

■ MD-27

Monday, 14:00-15:20

8.2.06

Financial Optimization 4

Stream: Financial Optimization

Invited session

Chair: *Christina Erlwein*, Department of Financial Mathematics, Fraunhofer ITWM, Fraunhofer Platz 1, 67663, Kaiserslautern, Germany, christina.erlwein@itwm.fraunhofer.de

1 - Sharpe Ratios and Implied Risk Free Rates

Michael Best, C&O, University of Waterloo, N2L 2H43G1, Waterloo, ON, Canada, mjbest@uwaterloo.ca

For a mean-variance Markowitz portfolio optimization model having just a budget constraint, the choice of a market portfolio implies a unique risk free rate. However, practical portfolio optimization problems have a variety of additional linear inequality constraints. These constraints may cause kinks or points of non-differentiability on the resulting efficient frontier. In terms of linear programming terminology, these kinks are principally caused by extreme points. We show that choosing a kink point as a market portfolio results in a continuum of implied risk free rates and give a formula for them.

2 - Optimal Trading of Algorithmic Orders in a Liquidity Fragmented Market Place

Natasa Krejic, Department of Mathematics and Informatics, University of Novi Sad, Trg Dositeja Obradovica 4, 21000, Novi Sad, Serbia, natasak@uns.ac.rs, *Miles Kumaresan*

An optimization model for execution of atomic orders at multiple trading venues is proposed and analyzed. The optimal trajectory consists of both market and limit orders, and takes advantage of any price or liquidity improvement at a particular market. The complexity of multi-market environment yields a bi-level nonlinear optimization problem. The lower level problem admits a unique solution and hence the second order conditions are satisfied under a set of reasonable assumptions. The model is computationally affordable and the simulation results show its effectiveness using real trade data.

3 - HMM-based investment strategies for asset allocation

Christina Erlwein, Department of Financial Mathematics, Fraunhofer ITWM, Fraunhofer Platz 1, 67663, Kaiserslautern, Germany, christina.erlwein@itwm.fraunhofer.de, *Rogemar Mamon*, *Matt Davison*

We develop and analyse investment strategies based on hidden Markov models. Filtering techniques are utilised to decide whether to invest in growth or value stocks. We develop two investment strategies based on filtered information within the multi-dimensional HMM, one switching strategy and one mixed strategy. Using datasets on Russell 3000 growth and value indices from 1995 to 2008, the switching strategy yields high Sharpe ratios compared to those obtained from pure index strategies and the mixed strategy. The performance of the mixed strategy is compared to the classical mean-variance approach. A simulation analysis further shows a higher performance stability of the HMM strategies.

■ MD-28

Monday, 14:00-15:20

8.2.10

Stochastic Programming Algorithms

Stream: Stochastic Programming 1

Invited session

Chair: *Katarina Vla*, Department of Mathematics and Informatics, University of Novi Sad, Trg Dositaja Obradovica 3, 21000, Novi Sad, Serbia, katarinav@dmi.uns.ac.rs

1 - Scenarios and events in multi-stage stochastic linear programming

Cesar Beltran-Royo, Estadística e Investigación Operativa, Universidad Rey Juan Carlos, Calle Tulipán, s/n, 28933, Móstoles, Madrid, Spain, cesar.beltran@urjc.es, *Laureano Fernando Escudero*, *Romy-Elena Rodriguez-Ravines*

To solve the multi-stage linear programming problem, one may use a deterministic or a stochastic approach. The drawbacks of the two techniques are well known: the deterministic approach is unrealistic under uncertainty and the stochastic approach suffers from scenario explosion. We introduce a new technique whose objective is to overcome both drawbacks. The focus of this technique is on events instead of scenarios and for this reason we call it multi-stage Event Linear Programming (MELP). As we show in our results, the MELP approach represents a promising compromise between the stochastic and the deterministic approach, regarding capacity to deal with uncertainty and computational tractability.

2 - Solution Procedures for Probabilistically Constrained Problems

Ebru Mevlude Angun, Industrial Engineering Department, Galatasaray University, Ciragan Cad. Ortakoy, 34357, Istanbul, Turkey, eangun@gsu.edu.tr

In this talk, we consider stochastic programming problems with probabilistic constraints. These problems are usually very hard to solve, because the feasible set defined by even a single probabilistic constraint may happen to be nonconvex. We consider the probabilistically constrained problem and its convexified version, and apply scenario approximation and sample average approximation methods combined with deterministic optimization procedures. We apply these approaches to a disaster management problem, and obtain interesting numerical results.

3 - Integer linear stochastic programming with multiple objective

Amrouche Salima, Mathématiques, université Saad Dahlab Blida, Université SAAD DAHLAB Blida Route De Soumaa BP

270 BLIDA, amrouchesalima@gmail.com, Algeria, amrouchesalima@gmail.com

The real life decision problems have three main properties. The first one is to have conflicting objectives in the problem structure, the second one is the stochasticity in the description of problem parameters in contexts where the probability distribution of random parameters is known, and the last one is due to involvement of integer decision variables which increased dimension of the problem. Multiobjective nature with discrete variables and imprecise parameters make the mathematical expression of the problems harder to solve with the traditional approach. An efficient algorithm is developed, via extending the well-known L-shaped method using generalized benders decomposition to efficiently handle the integer variables in the first stage and the integer recourse in the second stage of the model formulation. The proposed modeling and solution methods able to identify all the integer feasible solutions that are efficient for the problem in a finite number of iterations.

4 - Sample-Path Approach to Constrained Optimization

Katarina Vla, Department of Mathematics and Informatics, University of Novi Sad, Trg Dositaja Obradovica 3, 21000, Novi Sad, Serbia, katarinav@dmi.uns.ac.rs, *Natasa Krejic*, *Natasa Krklec*

We consider simulated response problem with constraints where the objective function is computed by taking expectation over the sample response function and has no explicit form. Therefore the gradient information is also unavailable. The constraints are given as simple box constraints. We use the sample-path method within derivative free approach. A sequence of local quadratic models that approximate the objective function is constructed by interpolation. The sample sizes varies and is determined using estimations of different kind. Convergence is analyzed and numerical results are discussed

■ MD-29

Monday, 14:00-15:20

8.2.11

Boolean Optimization in Graph Theory

Stream: Boolean Programming

Invited session

Chair: *Martin Milanic*, FAMNIT, University of Primorska, Glagoljaska 8, 6000, Koper, Slovenia, martin.milanic@upr.si

1 - Optimizing Boolean functions for cryptographic applications

Enes Pasalic, FAMNIT, University of Primorska, Glagoljaska 8, 6000, Koper, Slovenia, enespasalic@yahoo.se

In this talk certain optimization problems related to the design of Boolean functions used in cryptography are discussed. Boolean functions are basic cryptographic primitives in the design of symmetric cryptographic systems, such as stream and block ciphers, and many other cryptographic algorithms. Its design is closely related to certain combinatorial problems, among others to integer optimization methods and some problems related to graph theory. We briefly overview these representations, with the emphasis on the translating a Boolean optimization problem into a graph theoretical problem.

2 - On some graph classes related to perfect graphs: a survey

Flavia Bonomo, Computer Science, University of Buenos Aires, 1428, Buenos Aires, Argentina, fbonomo@dc.uba.ar, *Guillermo Duran*, *Martin Safe*, *Annegret Katrin Wagler*

Perfect graphs form a well-known class of graphs introduced by Berge in the 1960s in terms of a min-max type equality involving two famous graph parameters. In this work, we study variations and subclasses of perfect graphs defined by means of min-max relations of other graph parameters. Our focus is on clique-perfect and coordinated graphs. We show the connection between these graph classes and both hypergraph theory and the clique graph operator. In this talk, we will present previous results, some new contributions and the main open problems.

3 - Scheduling the Argentine volleyball league: A real-world application of the Traveling Tournament Problem with couples of teams

Guillermo Duran, Ingenieria Industrial, University of Chile, Republica 701, 1000, Santiago, Chile, gduran@dii.uchile.cl, *Flavia Bonomo*, *Javier Marengo*, *Daniela Saban*

We describe the process for designing the fixture of the Argentine first division volleyball league. This league is composed by 12 teams grouped into couples of teams. The minimization of the travel distances is an important task, since the teams are located throughout the country, hence this problem is a variation of the well-known Traveling Tournament Problem. We have applied integer programming techniques and a tabu search heuristic to tackle these issues, and the resulting fixtures have been successfully used in the 2007/2008, 2008/2009, and 2009/2010 leagues.

4 - Complexity results for equistable graphs and related classes

Martin Milanic, FAMNIT, University of Primorska, Glagoljaska 8, 6000, Koper, Slovenia, martin.milanic@upr.si, *Jim Orlin*, *Gabor Rudolf*

The class of equistable graphs is defined by the existence of a cost structure on the vertices such that the maximal stable sets are characterized by their costs. In this talk, we will discuss some complexity results for equistable graphs and related classes. A simple pseudo-polynomial-time dynamic programming algorithm is given that solves the maximum weight stable set problem along with the weighted independent domination problem in equistable graphs. These results are obtained within the wider context of Boolean optimization; corresponding hardness results are also provided.

■ MD-30

Monday, 14:00-15:20
8.2.13

MCDA II: Sorting Models, theoretical aspects and other issues.

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

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: *Michael Doumpos*, Dept. of Production Engineering and Management, Technical University of Crete, University Campus, 73100, Chania, Greece, mdoumpos@dpem.tuc.gr

1 - Multi-criteria relational clustering: An empirical analysis of the relation's properties

Julien Roland, CoDE-SMG, Université Libre de Bruxelles, 1050, Bruxelles, Belgium, julien.roland@ulb.ac.be, *Stefan Eppe*, *Yves De Smet*

Recently, the authors have proposed a method to address the problem of relational multi-criteria clustering. In this presentation, we will focus on the properties of the relations between the clusters. Based on artificial and real data sets, we will highlight some pathological results that will help us define desirable features. Properties such as transitivity and totality are helpful to simplify the structure of a relational partition. Finally, this discussion will lead to identify ways to improve the current method.

2 - Learning Non-monotone Additive Value Functions for Multicriteria Decision Making

Michael Doumpos, Dept. of Production Engineering and Management, Technical University of Crete, University Campus, 73100, Chania, Greece, mdoumpos@dpem.tuc.gr

Multiattribute additive value functions constitute an important class of models for multicriteria decision making. Such models are often used to rank a set of alternatives or to classify them into pre-defined groups. Disaggregation techniques have been used to construct such models using linear programming techniques based on the assumption of monotone preferences. This paper presents a methodology to construct non-monotone models for classification purposes, using an evolutionary optimization approach.

3 - A group decision making procedure and its incorporation in the MMASSI/TI DSS.

Teresa Pereira, Engenharia e Gestão Industrial, ESEIG-IPP (Escola Superior de Estudos Industriais e de Gestão do Instituto Politécnico do Porto, Rua D. Sancho I, 981, 4480-771, Vila do

Conde, Porto, Portugal, teresapereira@eu.ipp.pt, *Sameiro Carvalho*

MMASSI/TI — Multi-criteria Methodology for Selection of Information Technologies — is a DSS that incorporates a multi-criteria model to support the decision making process. The DSS was tested in different organizations contexts. Although the DSS has shown effectiveness in the support of decision making, one of the main difficulties encountered in its application was related with group decision support. We present a group decision making procedure and its incorporation in the MMASSI/TI DSS.

4 - Negotiation template analysis with ELECTRE-TRI based scoring system

Tomasz Wachowicz, Operations Research, Karol Adamiecki University of Economics in Katowice, Katowice, Poland, tomasz.wachowicz@ae.katowice.pl

Electronic negotiation experiments show that negotiators quite often reject the notion of compensation that is fundamental to additive scoring system most frequently used for evaluation of negotiation template. We present a novel method rejecting compensation that derives from ELECTRE-TRI model, which parameters are determined basing on the examples evaluation. To increase the precision of the scoring system the limiting profiles are scored in terms of satisfaction units and the whole negotiation space is calibrated and divided into sub-categories. Simple supporting software is also presented.

■ MD-31

Monday, 14:00-15:20
8.2.15

Societal Complexity and Education

Stream: Methodology of Societal 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 - Religious-Political 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 uses Nomology, the science of the laws of the mind, to explain Religious-Political Conflict Resolution, in terms of an Adapting system, aspects of which include Body, Mind, Soul and Spirit. It suggests that people of all religions and none will have to do a lot of "soul-searching" before progress can be made to reduce the causes of religious-political conflict. The paper endorses the direction of the discussion about the separation of church and state that took a path from Hegel to Rawls, to Habermas, and uses the meta-framework to propose where the discussion should go in the future. It suggests that this will involve cooperative inter-religious examination and challenging of religious texts.

2 - Basic Social Math

Jared Hanson, Saïd Business School, Oxford University, Al Yamamah University, PO Box 45180, 11512, Riyadh, Saudi Arabia, jared.hanson@sbs.ox.ac.uk

In order to establish a new perspective that can foster innovation in the management sciences, better tools are needed at the fundamental level of math that is used for social analysis. This project seeks to consolidate principles and techniques used in the more sophisticated quantitative methods of Operations Research and extend these tools downward to their fundamental, but still rigorous, level where they cross into the linguistic frameworks that are used to interpret and understand data in managerial, financial, and educational systems.

■ MD-32

Monday, 14:00-15:20
8.2.17

OR in Forestry III

Stream: OR in Agriculture and Forest Management

Invited session

Chair: *Ola Eriksson*, Forest Resource Management, SLU, Skogsmarksgränd, SE-901 83, Umeå, Västerbotten, Sweden, ola.eriksson@srh.slu.se

1 - A stochastic dynamic programming approach to optimize short-rotation coppice systems management scheduling under fire risk. An application to eucalypt plantations.

Liliana Ferreira, Rua do Convívio, nº 156 Telheiro - Barreira, 2410-333, Leiria, liliana.ferreira@estg.ipleiria.pt, *Miguel Constantino*, *Jose Borges*, *Jordi Garcia_Gonzalo*

We present a management scheduling model for short rotation coppice systems that may take into account the risk of wildfire. A stochastic dynamic programming (SDP) is proposed to determine the policy (e.g. fuel treatment, stool thinning, coppice cycles and rotation length) that maximizes expected financial revenues, considering alternative wildfire occurrence and damage scenarios. SDP stages are defined by the number of harvests and state variables include the number of years since the plantation. A typical *Eucalyptus globulus* Labill stand in Central Portugal was used as a test case.

2 - Integrating fire risk considerations in landscape level forest planning

José González-Olabarria, Centre Tecnològic Forestal de Catalunya, 25280, Solsona, Spain, jr.gonzalez@ctfc.es, *Timo Pukkala*

In this study, economic revenue and the overall fire resistance of a landscape, were combined to generate optimal forest plans for a forest landscape in Catalonia. The risk of fire was integrated into the economic objective by considering potential fire, and a fire resistance index was calculated for each stand from the properties of the stand and its adjacent neighbors. The optimal forest plans for each combination of objectives were generated using simulated annealing as optimization method, and the resistance to fire of the resulting landscapes were tested using a fire spread simulator.

3 - Accountability on forest fires: Evidence of social responsibility

Rute Abreu, Business and Economics, Guarda Polytechnic Institute, 6300-559, Guarda, ra@ipg.pt, *Fátima David*

This research studies the influence of social responsibility to forest management and explores, direct and indirect, consequences of forest fires in Portugal that promotes the development of pioneering practices and bring greater accountability, improve transparency and increase sustainability. This research presents dual theoretical framework: organisational and accountability and assures the link of SR with forest protection and environment preservation. The trilogy: prevention, detection and surveillance provides explanations for economic and social decisions of forest management.

4 - European forest decision support systems - what do we have and what is missing?

Ola Eriksson, Forest Resource Management, SLU, Skogsmarksgränd, SE-901 83, Umeå, Västerbotten, Sweden, ola.eriksson@srh.slu.se

The FORSYS COST Action has set out to define requirements for forest decision support system (DSS) implementation and use. This involves, among other things, to give a comprehensive account of existing forest DSSs. At the moment more than 50 systems are registered. This forms the basis for an analysis, with a European focus, of what kind of planning problems the DSSs deal with, what planning phases they support, with what methods they do it, and what seems to be missing capabilities. The presentation also includes a short oversight of FORSYS.

■ MD-33

Monday, 14:00-15:20
8.2.19

Environmental Management I

Stream: Energy, Environment and Climate [c]

Contributed session

Chair: *Marta Castilho Gomes*, CESUR, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001, Lisboa, Portugal, marta.gomes@ist.utl.pt

1 - Study of Electronic Ballast for Lighting Systems from the viewpoint of Electromagnetic Compatibility and

Power Quality issues: A contribution to Efficiency Analysis

William Vianna, Production Engineering, Federal University at Santa Catarina (UFSC) - BRAZIL, Rua Cônego Bernardo, 100. ap. 202, Trindade, 88036570, Florianópolis, Santa Catarina, Brazil, wpwilliam@hotmail.com, *Raul Eduardo Fernandez*

The study aims to reduce the impact of electronic ballasts for lighting systems used in large-scale business, commercial and residential buildings with a view to optimizing the technical and economic such equipment from the viewpoint of electromagnetic compatibility and power quality. The results evidence non-compliance of applicants conducted electromagnetic emissions, the need for improvement in product designs and increased legal and industrial regulation and monitoring.

2 - A cost optimization model for hazardous medical waste management

Marta Castilho Gomes, CESUR, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001, Lisboa, Portugal, marta.gomes@ist.utl.pt, *João Nunes de Almeida*, *João Quinhones Levy*

This work presents a Mixed Integer Linear Programming model for managing hazardous medical waste (HMW). In Portugal, HMW is divided into two groups depending on whether it must be incinerated or decontaminated before being transported to landfills. Both groups are considered in the model, which optimizes construction and operating costs regarding the location of facilities (transfer stations and disposal sites) as well as the waste flows between the nodes. Real data were used and the results may support decision regarding the urgent need to expand the HMW incineration capacity in the country.

3 - Integral model of entrepreneurship for regional waste management

Zoran Rakicevic, Faculty of Organization science, Belgrade University, Jove Ilica 154, 11000, Belgrade, Serbia, zoran.rakicevic@gmail.com, *Jasmina Omerbegovic-Bijelovic*

Waste management (WM) is becoming increasingly important — because of draining of the natural resources and of polluting the environment, as well as the opportunities for creating new value/jobs and for networking. This paper points out three levels of networking models for WM: global, regional and local, each one of which has its efficiency and effectiveness, „its“ stakeholders (interests); this paper shows also how it is possible to incorporate aims and limitations of the global and local in regional WM-models. Also, it points to the concept of entrepreneurial value creation.

■ MD-34

Monday, 14:00-15:20
8.2.23

Model Formulations and Real World Applications of Lot Sizing and Scheduling I

Stream: Lot-sizing and Scheduling, Economic Order Quantity

Invited session

Chair: *Alistair Clark*, Dept of Mathematics and Statistics, University of the West of England, Frenchay Campus, Coldharbour Lane, BS16 1QY, Bristol, United Kingdom, Alistair.Clark@uwe.ac.uk

1 - A multi-objective mixed integer linear programming approach to shelf-life integrated lot-sizing and scheduling in yogurt production

Pedro Amorim, Industrial Engineering and Management, Faculty of Engineering of Porto University, Rua Doutor Roberto Frias, 4200-465, Porto, Portugal, amorim.pedro@fe.up.pt, *Bernardo Almada-Lobo*

The lot sizing and scheduling problem with parallel lines and shared buffers, arising in a fresh dairy plant producing yogurt, is addressed in this work. Yogurt production is very complex with perishable intermediate products and final products pushed towards just-in-time due to freshness. To target this problem a multi-objective mixed integer linear programming model is proposed. The model takes into account the main concerns in yogurt production: integration of shelf-life, sequence-dependent times and costs, limitations of the fermentation phase, inventory costs and operational efficiency.

2 - Solving the stochastic single-level capacitated lot sizing problem with a scenario approach

Florian Sahling, Department of Production Management, Leibniz University Hannover, Koenigswoerth Platz 1, 30167, Hannover, Germany, sahling@prod.uni-hannover.de, *Stefan Helber*, *Katja Schimmelpfeng*

We present a non-linear model formulation for the stochastic single-level, multi-product dynamic lot sizing problem with a gamma service level constraint. Based on demand forecasts, the subject is to determine an efficient, robust and stable production schedule which minimizes the expected setup and holding costs. The proposed model formulation is approximated by a mixed-integer linear program using a scenario approach. A numerical investigation of synthetic problem instances shows under which conditions precise demand forecasts are particularly useful.

3 - A Multi-Level Capacitated Lot Sizing Problem considering discounts, set-ups and line assignment using a MIP based heuristic and Column Generation

Philipp Thurnher, V-Research Center for Tribotronics and Technical Logistics, Stadtstraße 33, 6850, Dornbirn, Vorarlberg, Austria, Philipp.Thurnher@v-research.at, *Hubert Missbauer*

We develop a MLCLSP based on a case study of a metalworking company. The model has two levels where raw materials are ordered regarding discounts and products are made at high set-up costs on five partly exchangeable lines constrained by production times and stock capacity. The decomposition is done using column generation. Columns are generated applying both a Dantzig-Wolfe and a Lagrangean decomposition as dual coordination techniques. Additionally an LP-Relaxation as primal coordination is used to allocate capacities to the sub-problems. The sub-problems are solved with CPLEX.

4 - Integrated production planning of a portuguese pulp and paper mill

Maristela Santos, Department of Applied Mathematics and Statistics, University of Sao Paulo, Av. Trabalhador São-carlense, 400 - Centro, Caixa Postal: 668, 13560-970, São Carlos, São Paulo, Brazil, mari@icmc.usp.br, *Andre Alves*, *Bernardo Almada-Lobo*

We deal with a production planning problem that arises in an integrated Portuguese Pulp and Paper mill. We propose a new model considering several critical production units such as the digester, paper machine, tanks and the units designed to produce energy. Simple Mathheuristics are developed to obtain feasible solutions that enable the analysis of the production process as a whole. The proposed approaches are tested on real-world data. The expected cost savings and the performance of the generated plans are benchmarked against real ones.

■ MD-35

Monday, 14:00-15:20

6.2.46

Soft OR and Problem Structuring Methods III

Stream: Soft OR and Problem Structuring Methods

Invited session

Chair: *Vesna Cancer*, Faculty of Economics and Business, University of Maribor, Razlagova 14, 2000, Maribor, Slovenia, vesna.cancer@uni-mb.si

Chair: *Victor Vidal*, IMM, Technical University of Denmark, 2800, Lyngby, Denmark, vvv@imm.dtu.dk

1 - Creative Thinking Techniques in Multi-Criteria Decision-Making

Vesna Cancer, Faculty of Economics and Business, University of Maribor, Razlagova 14, 2000, Maribor, Slovenia, vesna.cancer@uni-mb.si

The paper presents several example cases of business Creative Problem Solving showing the mutual assistance of the creative thinking tools and approaches for probortunity finding and definition, for the generating, decomposing and analyzing of ideas, and the multi-criteria decision-making methods for their evaluation, selection and verification. Creative approaches are not limited to problem definition and problem structuring only. This paper introduces the use of the techniques based on questions, with an emphasis on the 5Ws&H Technique, in the establishing of the criteria weights.

2 - Innovation, Creativity and Soft Systems Methodology

Giles Hindle, Operational Research, Warwick Business School, University of Warwick, CV4 7AL, Coventry, United Kingdom, giles.hindle@wbs.ac.uk

Soft Systems Methodology is characterised as an approach to tackling messy, ill-structured problems. However, a recent set of organisational innovation projects, plus my own sympathy with Ackoff's arguments for the utility of Idealized Design, has led me to explore the use of design thinking within SSM. I argue the expression stage using Rich Picturing is vital for helping participants 'step back' and look holistically at the situation. This secures a platform for creativity. The modelling stage of SSM is then perfectly suited to support organisational and process innovation through design thinking. Case vignettes are presented based upon projects from both the public and private sectors.

3 - Systemic strategy development and implementation using the example of a lead brokerage financial service provider

Paul Flachskampf, Institut für Management Cybernetics, Schurzelterstr. 25, 52074, Aachen, NRW, Germany, paul.flachskampf@ifu.rwth-aachen.de

This paper examines systemic strategy development using the example of a lead brokerage financial service provider. To do so, different elements of several systemic and cybernetic induced theories are combined to a three step approach: 1) system diagnosis to derive redesign actions, 2) identification of critical system variables, 3) creation of a modular software prototype with the help of a control loop model. This approach is induced by action research building on an interactive inquiry process that balances problem solving and actions implemented in a collaborative context.

4 - On the dynamics of Value Networks

Bent Erik Bakken, St. Georgs vei 4, 0280 OSLO, 0280 OSLO, Norway, Oslo, beerikba@online.no

Corporate strategic research increasingly question the ubiquity of value chains as drivers for strategic design. Value networks has been proposed as an alternative useful configuration. This paper shows that value chains have been a mainstay of system dynamics applications, from "Industrial Dynamics" (Forrester, 1961) onwards, yet value chains show even more complex dynamics. Implications for reserach in strategy and systems dynamics as well as for practice is discussed.

■ MD-36

Monday, 14:00-15:20

3.1.05

Fuzzy Optimization

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence

Invited session

Chair: *Joao Miguel da Costa Sousa*, Dept. of Mechanical Engineering, Technical University of Lisbon, 1049-001, Lisboa, Portugal, jmsousa@ist.utl.pt

Chair: *Susana Vieira*, Center of Intelligent Systems - IDMEC, Instituto Superior Técnico, Pav. Eng. Mec. III - sala 3.8, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, susana@dem.ist.utl.pt

1 - Multi-objective Optimization of Feature Selection Problems using Fuzzy Models

Ozlem Turksen, Dept. of Mechanical Engineering, CIS/IDMEC-LAETA, TU Lisbon, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, turksen@science.ankara.edu.tr, *Susana Vieira*, *Joao Miguel da Costa Sousa*, *Aysen Apaydin*

Feature selection is one of the most important techniques in data preprocessing for data mining. In this paper, the feature selection optimization problem is defined as a multi-objective problem addressing simultaneously two goals: minimize classification error and reduce the number of features. The problem is addressed by using an NSGA II approach to find the multiple Pareto optimal solutions. Therefore, in this paper the solutions are evaluated using fuzzy models, as they are universal approximators and can be interpretable under certain conditions.

2 - Fuzzy Criteria for Multi-objective Ant Feature Selection

Susana Vieira, Center of Intelligent Systems - IDMEC, Instituto Superior Técnico, Pav. Eng. Mec. III - sala 3.8, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, susana@dem.ist.utl.pt, *Joao Miguel da Costa Sousa*

Feature selection has been an active research area in data mining, pattern recognition and statistics communities. In this paper, a multi objective ant feature selection algorithm is proposed to cope with the difficulty of finding optimal solutions for the feature selection optimization problem, and is compared with the previous aggregated multi-criteria approach. The objectives are described using fuzzy optimization, since it allows for an easier and more transparent description of the criteria used in the feature selection process.

3 - A New Filter-wrapper Method for Large Databases by Optimizing Fuzzy Classification Models

Joao Miguel da Costa Sousa, Dept. of Mechanical Engineering, Technical University of Lisbon, 1049-001, Lisboa, Portugal, jmsousa@ist.utl.pt, *Federico Cismondi*, *Andre Fialho*, *Susana Vieira*, *Shane Reti*, *Michael Howell*, *Stan Finkelstein*

Large databases require significant and frequently impractical computer processing times while selecting the relevant subset of features. We propose using first a filter method to reduce the number of features, and then applying a wrapper method to develop an accurate classification model. Tested filter methods were Fisher's rank, variance and entropy, while used wrappers were a tree search bottom-up and an ant colony feature selection. The results for a fuzzy classification algorithm show better computational times and classification performance when filters are used preceding wrappers.

4 - An Integrated Evaluation Framework for Customization Strategies

Gulcin Buyukozkan, Industrial Engineering, Galatasaray University, Ciragan cad. no.36, 34357, Istanbul, Turkey, gulcin.buyukozkan@gmail.com

The need for product customization during product development (PD) processes continues to increase. Mass customization (MC) relates to the ability to provide customized products or services through flexible processes in high volumes and at reasonably low costs. There exist different strategies for the degree of customization in PD. Determining the right strategy of MC is essential to the competitiveness of a company. To support managerial decision making, this study proposes an integrated strategic evaluation framework to assess effectively MC strategies in PD process with a real case study.

■ MD-37

Monday, 14:00-15:20

3.1.09

OR for Development and Developing Countries I

Stream: OR for Development and Developing Countries

Invited session

Chair: *Honora Smith*, School of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, honora.smith@soton.ac.uk

1 - Passengers air transport system with mini and major hubs: a case study applied to Brazil

Nelio D Pizzolato, Industrial Engineering, Catholic University of Rio de Janeiro, R. Marques de Sao Vicente, 225, 22453-900, Rio de Janeiro, RJ, Brazil, ndp@puc-rio.br, *Rafael M. A. de Figueiredo*, *Morton E. O'Kelly*, *Madiagne Diallo*

This research deals with a hub-and-spoke model that includes mini hubs. In an extended country such as Brazil, in which the population is mostly concentrated around a few areas, while large extensions generate low volumes but long distances, regional mini hubs might be a way to make the operation more economical and attractive for the passengers. This paper has two purposes: one is to identify regional clusters in order to locate mini hubs, and second is to articulate these with countrywide major hubs.

2 - Engineering research in developing countries, some reflections based on scientific publications

Víctor Bucheli Guerrero, Industrial Engineering, Universidad de los Andes, Carrera 1 N 18A - 12, Bobotá, D.C., Colombia, vbucheli@uniandes.edu.co, *Roberto Zarama Urdaneta*

In developing countries universities have important challenges. A key challenge is to increase their indexed publications. In this paper we study the dynamics of the knowledge production in engineering and their relations with context. With that in mind, we observed the Academic Ranking of World Universities in Engineering/Technology and Computer Sciences (ARWU-ENG). For this purpose, we construct a Bayesian Network Model to explore some strategies to increase the scientific performance. Based on the model we propose a journal selection strategy. We illustrate the strategy with a case study.

3 - Dynamic modelling of the usage of a rural community health centre in a developing country: the growth of trust

Honora Smith, School of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, honora.smith@soton.ac.uk, *Paul Harper*

Community health centres are being used in the developing world as a means of delivering accessible, low-cost service. A major management issue is level of uptake of services and its effect on sustainability. We present a model for spatio-temporal spread of usage of a community health centre, in a rural developing region. We include a trust factor in the modelling. Trust in the provider is built through word-of-mouth contacts and development activities. As a case study, we analyse data collected a community health centre in a rural region of northern India.

■ MD-38

Monday, 14:00-15:20

6.2.44

Recent Advances in the Economics Supported by OR II

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

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Sustainability screw: role of relative time scales

Jerzy Filar, Mathematics and Statistics, University of South Australia, Mawson Lakes Blvd, 5095, Mawson Lakes, SA, Australia, j.filar@unisa.edu.au, *Jacek Krawczyk*, *Manju Agarwal*

We postulate a time scales' conjecture stating that most reasonable notions of sustainability must include a suitable synchronisation of time scales of both the processes of human development and those of the natural environment. We analyse a coarse, five variable, model of man nature interactions expressed as a system of differential equations where production and human capital are coupled with both renewable and non-renewable natural resources. A "sustainability screw" phenomenon is demonstrated describing a spiral like trajectory of three key variables.

2 - The Gambler's Ruin Problem: Simulation

Silvana Ligia Vincenzi Bortolotti, Matemática/Estatística, UTFPR/UFSC, Rua Jornalista Tito de Carvalho, 155, 88040480, Florianópolis, Santa Catarina, Brazil, sligie@globo.com, *Fernando Moreira Junior*, *Afonso Farias Sousa Junior*

The gambler's ruin is a classical problem of stochastic processes used to calculate the probability of a gambler who has a certain amount of financial resources, fall into ruin. In this paper, it were simulated and analyzed various situations and verified that it is worthwhile the company enter the market. We considered the three possible scenarios. The results also allow the company to know what proportion of the market that it should be to have a desirable probability of survival, as well as what should be the initial capital needed.

■ MD-39

Monday, 14:00-15:20

6.2.45

Dynamic Programming Approach to Optimal Control Problems

Stream: Optimal Control

Invited session

Chair: *Fausto Gozzi*, Dipartimento di Scienze Economiche e Aziendali, Luiss University - Roma - Italy, viale Romania 32, 00197, Roma, RM, Italy, fgozzi@luiss.it

1 - Optimal mix in the interconnection of drinking water sources

Alessandra Buratto, Department of Pure and Applied Mathematics, University of Padova, Via Trieste, 63, 35121, Padova, Italy, buratto@math.unipd.it, *Chiara D'Alpaos*

We formulate and solve a stochastic optimal control model in order to determine the optimal feedback abstraction policy for a provider of water services who has invested in the interconnection of two different sources (e.g. ground-water vs river abstraction). The interconnection of water abstraction plants gives, de facto, the provider the option to strategically decide the optimal mix of different water sources to be used in supplying water to a community. Our aim is to show that this operational and technical flexibility is economically relevant if optimally exercised.

2 - Optimal population problem: the role of finite life

Giorgio Fabbri, Department of Economic Studies, University of Naples "Parthenope", Via Medina 40, 80133, Napoli, Italy, giorgio.fabbri@uniparthenope.it, *Raouf Boucekkine*, *Fausto Gozzi*

Most of the literature on optimal population size does not mention the finite characteristic of human lifetime. The fact that our lives are finite changes the nature of the optimal population problem. We study the optimal dynamics of a finite life optimal population size model with procreation and education costs. We show how the optimal policy is influenced by the preferences parameters of the planner and the duration of the lifetime. The finite-lifetime makes gives a infinite dimensional structure to the problem. We study it using the dynamic programming in a suitable Hilbert space setting

3 - On the sub-optimality cost of immediate annuitization in DC pension funds

Elena Vigna, Dipartimento di Statistica e Matematica Applicata, Università di Torino and Collegio Carlo Alberto, corso Unione Sovietica 218 bis, 10135, Torino, Italy, elena.vigna@econ.unito.it, *Marina Di Giacinto*

We investigate the optimal annuitization time for a retiree of a DC pension fund who takes programmed withdrawals. We exploit the model of GHV (2010), who formulate the problem as combined stochastic control and optimal stopping problem with a quadratic loss function. We prove a theorem that assesses whether immediate annuitization is optimal or not. With numerical simulations we investigate optimal annuitization time, ruin frequency, comparison between optimal and immediate annuitization. The cost of sub-optimality of immediate annuitization is measured with financial and actuarial criteria.

■ MD-40

Monday, 14:00-15:20

6.2.52

Network design 2

Stream: Network Optimization

Invited session

Chair: *Bernard Fortz*, Département d'Informatique, Université Libre de Bruxelles, CP 210/01, Bld du Triomphe, 1050, Bruxelles, Belgium, bfortz@euro-online.org

1 - A Cutting Plane Algorithm for the RSAP

Paula Carroll, Management Information Systems, UCD, Quinn Business School, Belfield, 4, Dublin, paula.carroll@ucd.ie, *Bernard Fortz*, *Martine Labbé*, *Seán McGarraghy*

We describe the Ring Spur Assignment Problem (RSAP) which arises in the design of hierarchical two layer ring/spur telecommunications networks. We describe this NP Hard problem and relate it to problems described in the literature. We present a complete Integer Programming (IP) formulation for the full two layer network topology. We present a cutting plane algorithm and describe the inequalities added and their separation. We present initial computational results obtained using XpressMP on benchmark problems. Finally, we present some conclusions and recommendations.

2 - Optimal streaming network with relay nodes

Eric Gourdin, CORE/TPN/TRM, Orange Labs, 38 rue du General Leclerc, 92794, Issy-les-Moulineaux, France, eric.gourdin@orange-ftgroup.com, *Fabien Mathieu*

In a streaming network, a source node sends a multimedia file to several identified customers and the file is played in real-time. The capacity of such a network relies heavily on the upstream capacity of the server (the maximum bandwidth it can send into the network). If this capacity is limited, then the server can use some relay nodes to increase its streaming capacity. Indeed, a relay node can duplicate the received data before sending them back into the network. In this talk, we will propose several mixed integer models related to the design of an optimal streaming network.

3 - Transmission Expansion Planning with Re-design

Michael Poss, Computer Science Department, Université Libre de Bruxelles, Boulevard du Triomphe CP 210/01, 1050, Brussels, Belgium, mposs@ulb.ac.be, *Claudia Sagastizabal*

Expanding an electrical transmission network requires heavy investments that need to be carefully planned, often at a regional or national level. We show that the problem is NP-hard and that, unlike the so-called Network Design Problem, a transmission network may become more efficient after cutting-off some of its circuits. For this reason, we introduce a new model allowing for the network to be re-designed when it is expanded. We then turn into different reformulations of the problem, that replace the bilinear constraints by using a "big-M" approach. Computational results are presented.

4 - A New Demand Uncertainty Set Definition and The Robust Network Loading Problem

Aysegul Altin Kayhan, Industrial Engineering, TOBB University of Economics and Technology, TOBB Ekonomi ve Teknoloji Universitesi Endustri Muhendisligi Bolumu, Sogutozu Caddesi No=43 Sogutozu, 06560, Ankara, Turkey, aaltin@etu.edu.tr, *Hande Yaman*, *Mustafa Pinar*

We consider the Robust Network Loading Problem, which includes the private network design problem as a special case. We study the problem from service provider's perspective, who wants to lease private lines in the most cost-efficient manner. Rather than assuming that the communication demands are known, we introduce a genuine polyhedral demand model, which inherits the strengths of two known polyhedral demand definitions. We develop two compact mixed integer programming formulations of the problem and provide some experimental results for several well-known instances to discuss the economic and performance implications of incorporating the robustness dimension in our design efforts.

■ MD-41

Monday, 14:00-15:20

3.1.06

Advances in Revenue Management

Stream: Revenue Management

Invited session

Chair: *Ayşe Kocabiyikoglu*, Department of Business Administration, Bilkent University, Bilkent, 06800, Ankara, Turkey, aysekoca@bilkent.edu.tr

1 - Decision Making in Revenue Management: An Experimental Study

Mert Hakan Hekimoğlu, Bilkent University, 06800, Ankara, mhkekim@bilkent.edu.tr, *Ayşe Kocabiyikoglu*, *Itir Gogus*

In the standard two-class revenue management model, the firm allocates a fixed capacity between two market segments with hierarchical willingness to pay. If the firm allocates too much to the higher priced segment, it is left with unused capacity at the end of the selling period; if it allocates too little, demand from the more valuable segment is unmet. The revenue maximizing allocation is given by Littlewood's Rule, but little is known about how managers actually make these decisions. We describe results from a study that investigates revenue management decisions across different conditions. We also investigate the impact of varying problem parameters on the decision maker's allocation choice.

2 - Performance-Based Contracts for Outpatient Medical Services

Houyuan Jiang, Judge Business School, University of Cambridge, Trumpington Street, CB2 1AG, Cambridge, United Kingdom, h.jiang@jbs.cam.ac.uk, *James Z. Pang*, *Sergei Savin*

Under the principal-agent framework, we analyze Payment by Results (PbR) and Performance-based Contract (PBC) approaches for the study of contract design in the context of outpatient medical services. We gain important insights by comparing PbR and PBC under different information structures: complete information, asymmetric information, and private actions. We show that when the agent's capacity allocation decisions are observable and contractible, PbR and PBC approaches produce the same outcomes. However, if agent's decisions are not observable and contractible, PBC outperforms PbR.

3 - Dynamic Pricing of High Speed Rail with Transport Competition, Substitutable Schedule and Overbooking

Kimitoshi Sato, Graduate School of Business Administration, Nanzan University, ksato@nanzan-u.ac.jp, 466-8673, Nagoya, Japan, ksato@nanzan-u.ac.jp, *Katsushige Sawaki*

In this paper, we present a revenue management model of dynamic pricing of HSR (high speed rails)'s fares in which the passengers are allowed to choose among other transport modes by taking account of Air-HSR competition. Each transport mode offers the multiple substitutable schedules. We use the MNML model to describe the customer's discrete choice. The passengers choose an alternative transport mode based on the comfort, total trip time, the total price and the frequency. Furthermore, we allow cancellation, no-shows and overbooking, and show the existence of Nash equilibrium.

■ MD-42

Monday, 14:00-15:20

3.1.07

Theory of Bilevel Programming

Stream: Variational Inequalities, Complementarity Problems and Bilevel Programming

Invited session

Chair: *Joydeep Dutta*, Math and Stat, Indian Institute of Technology, Office : Room No 575, Faculty Building, Academic Area, 208016, Kanpur, Uttar Pradesh, India, jdutta@iitk.ac.in

1 - Optimality conditions for bilevel programming problems

Stephan Dempe, Mathematics and Computer Sciences, Technische Universitaet Freiberg, 09596, Freiberg, Germany, dempe@math.tu-freiberg.de, *Alain B. Zemkoho*

In the talk, an overview of different transformations of the bilevel programming problem into a one-level programming problem and related necessary conditions for local optimal solutions will be given. Special emphasis is on the question which constraint qualifications are suitable in relation to which transformations.

2 - Bilevel programming in Hilbert space

Ayalew Getachew Mersha, Optimization and Optimal control group, Austrian Academy of Sciences, Johann Wilhelm Klein Strasse 9, 4040, Linz, Upper Austria, Austria, ayalew.mersha@oeaw.ac.at

In this talk the bilevel programming problems in a Hilbert space is considered. After reformulations of classes of these problems we use the idea of optimal control theory. We give conditions for the existence and uniqueness of the solution. A numerical algorithm based on the idea of semi-smooth Newton method is proposed. We also discuss the associated difficulty in solving such problems in functional spaces.

3 - Optimality conditions for a simple bilevel programming problem

Joydeep Dutta, Math and Stat, Indian Institute of Technology, Office : Room No 575, Faculty Building, Academic Area, 208016, Kanpur, Uttar Pradesh, India, jdutta@iitk.ac.in

In this talk we consider a simple bilevel programming problem of a single decision variable. The upper level problem consists of a convex function which is to be minimized over a convex set which in turn is the solution of another convex optimization problem which we call the lower-level problem. We study the optimality conditions for this class of problems.

■ MD-43

Monday, 14:00-15:20

8.2.02

Algorithmic Decision Theory 4

Stream: Algorithmic Decision Theory [c]

Contributed session

Chair: *Sasa Pekec*, Fuqua School of Business, Duke University, 1 Towerview Road, 27708-0120, Durham, NC, United States, pekec@duke.edu

1 - Management and development of profiles by learning for Multicriteria Decision Support

Arnaud Martin, Institut de Recherche en Informatique de Toulouse, Toulouse University, 118 Route de Narbonne, IRIT, Université Paul Sabatier, F-31062, Toulouse CEDEX 9, France, amartin@irit.fr, *Pascale Zaraté*, *Guy Camilleri*

As part of the development of Cooperative DSS, users' profiles, which are defined by several criteria whose quantity which evolves dynamically, are modeled and implemented. The purpose of this work consists in bringing the best support to activity of the user according to his profile. These users' profiles will evolve thanks to existent automated techniques in learning domain, especially reinforcement, in order to get the profile of a user according to his answers and actions. The support brought to the user by the system will also evolve according to the evolution of his profile.

2 - Aggregation operations in multi-criteria simple games

Luisa Monroy, Economía Aplicada III, Universidad de Sevilla, Avda. Ramon y Cajal, 1, 41018, Sevilla, lmonroy@us.es, *Francisco Ramon Fernandez*

Multi-criteria simple games provide an appropriate general framework within which to analyze group decision problems, especially voting systems and collective choice procedures where more than one alternative can be simultaneously chosen and where numeric utility values are either inappropriate or impossible to derive. We study extended multi-criteria simple games obtained from different aggregation operations, such as union, intersection, marginalization, and composition, all defined for multi-criteria simple games. Real voting systems are modeled as extended multi-criteria simple games. We show that a voting system can be established when these operations are applied to complex voting systems.

3 - Preconditions for Information Aggregation in Prediction Markets

Sasa Pekec, Fuqua School of Business, Duke University, 1 Towerview Road, 27708-0120, Durham, NC, United States, pekec@duke.edu

We study necessary and sufficient conditions for information to aggregate in a highly stylized one-shot unit-demand uniform-price prediction market. We show that the market price properly aggregates information if and only if (i) the number of realized trades is non-negligible compared to number of market participants and (ii) proportion of buyer offers is asymptotically matching the proportion of seller offers. These conditions prevail in more general prediction market models that include the model studied here as a special case.

4 - Bidding Strategies for Real-Life Small Loan Auctions

Hannele Wallenius, Industrial Engineering and Management, Helsinki University of Technology, P.O. Box 9500, 02015 HUT,

02015 HUT, Espoo, Finland, hannele.wallenius@tkk.fi, *Lauri Puro, Jyrki Wallenius, Jeffrey Teich*

We define and identify bidding strategies in real-life small loan auctions (Prosper.com). In this auction, lenders bid for borrowers' loan listings and the winners get to fund the loan at an interest rate determined by the auction. The exceptionally large empirical database provided by Prosper.com offers a unique opportunity to test and further develop the theory of online auctions. This study shows that bidding behavior is not homogeneous among bidders, as the traditional auction theory suggests. Instead, bidders use many different bidding strategies. Moreover, learning and bidders' consistency over time in different auctions is studied.

■ MD-44

Monday, 14:00-15:20
8.2.03

Modelling complex systems

Stream: SD Modeling in Sustainable Development
Invited session

Chair: *Pierre Kunsch*, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, pkunsch@vub.ac.be

1 - A systemic dynamic approach of the financial crisis

Pierre Kunsch, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, pkunsch@vub.ac.be

This paper presents a system-dynamics modelling of the world crisis, its origin, consequences, and macro-economic remedies proposed by governments. The specific case of Belgium is analysed in more details

2 - Use of Management Science Systemic Methodologies in Environmental Management and Sustainability

Alberto Paucar-Caceres, Business School, Manchester Metropolitan University, Aytoun Building, Aytoun Street, M1 3GH, Manchester, United Kingdom, a.paucar@mmu.ac.uk

This paper investigates and discusses the use of systemic methodologies (SM) developed in management science/operational research (MS/OR), in particular, those SM that have been informing the complexity inherent in environmental management and sustainable (EM/S) practices. By surveying a sample of the top MS/OR and systems journals, we assess the extent to which systemic management science methodologies developed recently have been used in tackling EM/S problems. By critically reviewing applications in EM/S the paper hopes to raise awareness amongst environmentalists, operational researchers and management scientists of the benefits of using systemic approaches developed in MS/OR.

3 - Closed Loop Supply Chains: A Systems Dynamics Model for Analyzing Sustainable Business Policies for Shared Partners in a 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

We propose and implement a system dynamics approach to study the problem space and generate policy insights for managing the overall closed loop chain partners. Our work is unique in addressing a holistic approach that includes initial pricing and sales of products, designing products for manufacturer and specified recycling rates, and looking at a holistic revenue stream of initial retailers, recyclers and remanufacturers. We address the following questions: Is the closed loop economically sustainable? What is the impact of product design in closing the loop?

4 - Collective animal manure management simulation and environmental impact

Francois Guerrin, CA, Inra/Cirad, Station de la Bretagne - BP 20, 97408, Saint-Denis, France, francois.guerrin@cirad.fr, *Jean-Marie Paillat*

This contribution uses Systems Dynamics for simulating pig slurry spreading plans in Brittany (France), and their harmful environmental impacts on ground-water and coastal waters. Individual pig farmers use part of their slurry to fertilise their own crops; they export their excess slurry to remote crop farms. The model dynamically simulates the slurry stock evolutions at the pig farms and the spreading fluxes on crops, both at the pig farms and the remote crop farms. It also simulates several indicators for assessing the environmental impact of this spreading.

■ MD-45

Monday, 14:00-15:20
8.2.12

Novel opportunities of DC programming and DCA for Industry and Finance

Stream: Nonconvex Programming: Local and Global Approaches

Invited session

Chair: *Hoai An Le Thi*, Computer Science, University Paul Verlaine - Metz, Ile du Saulcy., 57 045 , Metz, France, lethi@univ-metz.fr

1 - Solving the Min m-Dominating Set Problem by a Continuous Optimization Approach based on DC Programming and DCA

Julien Schleich, Computer Science, University of Luxembourg, 5, rempart Saint-Thiébault, 57000, METZ, France, julien.schleich@uni.lu, *Hoai An Le Thi, Pascal Bouvry*

We propose a new optimisation approach based on DC (Difference of Convex functions) programming and DCA (DC Algorithm) to the graph problem minimum m-Dominating Set. This problem is beforehand recast as a polyhedral DC program with the help of exact penalty in DC programming. The related DCA is original and computer efficient because it consists of solving a few linear programs and converges after a finite number of iterations to an integer solution while working in a continuous domain. Numerical simulations show the efficiency and robustness of DCA and its superiority with respect to standard methods.

2 - A DC programming approach for constrained two-dimensional non-guillotine cutting

Mahdi Moeini, Computer Science, University Paul Verlaine - Metz, 57045, METZ, France, moeini@univ-metz.fr, *Hoai An Le Thi, Tao Pham Dinh*

We investigate a new application of DC (Difference of Convex functions) programming and DCA (DC Algorithm) in solving the constrained two-dimensional non-guillotine cutting problem. This problem consists of cutting a number of rectangular pieces from a large rectangular object. The cuts are done under some constraints and the objective is to maximize the total value of the pieces cut. We reformulate this problem as a DC program and solve it by DCA. The performance of the approach is compared with the standard solver CPLEX.

3 - Power Control in Cellular Networks via DC Programming and DC Algorithms (DCA)

Anh Son Ta, LMI, INSA de Rouen, LMI, INSA de Rouen, +33, Rouen, France, taanh_son@yahoo.com, *Hoai An Le Thi, Tao Pham Dinh*

Power control is typically used in wireless cellular networks in order to optimize the transmission subject to quality of service (QoS) constraints. It has been shown early that this problem can be efficiently solved by using the so-called geometric programming. In this paper, we investigate a new and efficient algorithm based on DC (Difference of Convex functions) programming and DCA (DC Algorithms) for solving it. Preliminary numerical simulations demonstrate the efficiency of DCA and its superiority compared to the geometric programming algorithm.

4 - Scheduling of lifting vehicle and Quay Crane in automated port container terminals

Le Hoai Minh, LMAH, Université Le Havre, France, France, mlehoai@yahoo.fr

Container terminals, are continuously facing the challenge of strong competition between ports. In this study, we present the terminal of Normandy; Le Havre port. We consider a mixed integer programming problem for the problem of assigning optimal delivery tasks to Lifting Vehicles. There are a lot of algorithms designed for this problem such as B&B method, cutting plane,... By using an exact penalty technique we treat this problem as a DC program in the context of continuous optimization. Further, we combine the DCA with the classical Branch and Bound method for finding global solutions.

■ MD-46

Monday, 14:00-15:20

8.2.14

Semi-Infinite Optimization I

Stream: Semi-Infinite Optimization

Invited session

Chair: *Vladimir Shikhman*, Dept. Mathematics, RWTH Aachen University, Templergraben 55, 52056, Aachen, Germany, shikhman@mathc.rwth-aachen.de

1 - Generalized Semi-Infinite Programming: the Nonsmooth Symmetric Reduction Ansatz

Vladimir Shikhman, Dept. Mathematics, RWTH Aachen University, Templergraben 55, 52056, Aachen, Germany, shikhman@mathc.rwth-aachen.de, *Hubertus Th. Jongen*

We introduce the Nonsmooth Symmetric Reduction Ansatz (NSRA) on the closure of the feasible set $cl(M)$ in GSIP. $cl(M)$ is given by infinitely many constraints of maximum-type. Under NSRA it is the feasible set in Disjunctive Optimization given by finitely many such constraints. The new issue is: the Lagrange polytope at the lower level is not a singleton. The "full-dimensionality" of its vertices is given. We introduce nondegenerate KKT points and GSIP-index. NSRA is generic and stable at KKT points. All KKT points are generically nondegenerate. We discuss the critical point theory for GSIP.

2 - Robustness modulation and chance-constrained optimization with application to control: Making it easy through randomization

Simone Garatti, Dept. of Electronics and Information, Politecnico di Milano, p.zza L. da Vinci 32, 20133, Milan, Italy, sgaratti@elet.polimi.it, *Marco Campi*

Robust control can lead to overconservative designs because all emphasis is placed on safe-guarding the closed-loop against all possible negative occurrences. In many applications, 100% robustness is not necessary and accepting a small compromise in robustness guarantees along a chance-constrained optimization approach can often lead to a huge improvement in performance. Yet, the real stumbling-block is the lack of computationally tractable algorithms able to trade robustness guarantees for performance. This talk aims at opening new directions to solve this problem through randomization.

3 - Multiobjective programming problems with fuzzy random coefficients

Monga K Luhandjula, Decision Sciences, University of South Africa, Muckleneuk Campus, Pretoria, 0003, Pretoria, Gauteng, South Africa, luhanmk@unisa.ac.za

Neither Stochastic Optimization nor Fuzzy Mathematical Programming is adequate for capturing hybrid situations where fuzziness and randomness co-occur in a multiobjective programming setting. In this paper, we propose an approach for finding a satisfying solution of a multiobjective program with fuzzy random coefficients. The key idea behind our approach is to explore, with good reasons, correspondences between fuzzy random variables and random closed sets. A numerical example is carried out for the sake of illustration. It shows the efficiency of the proposed method.

■ MD-47

Monday, 14:00-15:20

8.2.16

OR in Oil Sector I

Stream: OR in Oil Sector

Invited session

Chair: *Irina Dolgoplova*, Economics and Administrative Sciences, Middle East Technical University, Odu Kent, Konuk Evi 1, B Block, 108, Ankara, Turkey, 06420, Ankara, Turkey, irina.dolgoplova@gmail.com

1 - Network Design of Petroleum Supply Chains

Leão Fernandes, Centro de Estudos de Gestão, Instituto Superior Técnico, Av.Rovisco Pais, 1049-001, Lisboa, Lisboa, Portugal,

leao.fernandes@clc.pt, *Ana Paula Barbósa-Póvoa*, *Susana Relvas*

Petroleum supply chain (PSC) is a strategic sector of modern economy, known for huge network of investments and complex infrastructures. While the former confers strategic business risk, the later reveals the need of optimization tools for decision making at design, planning and operational levels. This investigation focus the design level and presents a mixed integer programming model to optimize PSC structure while considering its characteristics and the business risk associated. Test results based on factual logistic data for the Portuguese PSC network and research directions are presented

2 - A simulated annealing approach for scheduling workover rigs on onshore oil production

Geraldo Mauri, Rural Engineering, 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*

Onshore oil wells are dependent of maintenance services such as cleaning and reinstatement. Wells need maintenance services and a scheduling of the workover rigs (WR) must be defined. The WR scheduling problem consists of finding the best schedule for the limited number of WR, minimizing the production loss associated with the wells waiting for maintenance service. We present a Simulated Annealing (SA) algorithm for solving this problem. Computational results on real problems obtained in Brazil are reported and SA presents better solutions than all those approaches reported in the literature.

3 - Multiproduct Pipeline Scheduling Systems

Susana Relvas, DEG, IST, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, susanaicr@ist.utl.pt, *Ana Paula Barbósa-Póvoa*, *Henrique Matos*

Petroleum supply chain comprehends complex logistics operations, to ensure supply and demand at several nodes. Transportation is critical since large quantities of products are required with high reliability. Pipelines constitute an adequate transportation mode, but represent a complex problem, due to products' competition for a unique resource. To adequately schedule the pipeline pumping sequence, proper inventory management policies must be met at the destination tank farm. This problem is addressed in a Mixed-Integer Linear Programming Model and tested for a real Portuguese Company setting.

4 - Novel continuous nonlinear optimization approach for refinery scheduling

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, *Fabio Fagundes*, *Adilson Elias Xavier*

We present a novel continuous nonlinear optimization approach for crude oil operations in a refinery, from tankers to crude distillation units. The schedule is modeled as a sequence of refinery states, where the contents of the equipment (tanks, pipelines, and tankers) are mapped to state variables and crude oil flows from an equipment to another are mapped to control variables, which change the refinery states. Schedule discrete decisions are modeled with complementarity constraints. Recent examples from the literature are solved in reasonable computing times (seconds).

■ MD-48

Monday, 14:00-15:20

8.2.04

Multi-objective optimization

Stream: Optimization for Sustainable Development

Invited session

Chair: *Nora Touati Mounjla*, LIX, Ecole Polytechnique, École polytechnique, Laboratoire d'informatique (LIX), 91128, Palaiseau, Cedex, France, France, touati@lix.polytechnique.fr

1 - Computation of best-compromise route for cycling

Gaël Sauvanet, Laboratoire d'Informatique de l'Université de Tours, Polytech'Tours, 64 avenue Jean Portalis, 37200, TOURS, France, gael.sauvanet@univ-tours.fr, *Emmanuel Néron*, *Hervé Baptiste*

Today, for environmental reasons, the use of alternative transportation such as cycling is expanding. Communities have initiated several programs to adapt the network to cycling because users are seeking to be able to move along safely. Indeed, for a cyclist, traveling time and distance are not the only criteria to consider: security, difficulty and touristic attraction may be taken into account. We propose methods for designing touristic, safe and short route for cycling. We propose methods both for determining Pareto set, as well as best compromise solution using user's preferences.

2 - New insights of preference modeling in multiobjective optimization

Souhila Kaci, CRIL, 16 rue de l'Université, SP 16, 62307, Lens, France, kaci@cril.fr, *Nora Touati Moun gla*

Multi-Objective Optimization (MOO) problems consist of selecting solutions w.r.t. multiple objectives. It generally returns Pareto-optimal solutions, i.e., there is no solution that is better to these solutions w.r.t. all objectives. Pareto-optimality based optimization assumes that all objectives have equal importance, however a user may express preferences over objectives. Therefore preferences act as a filter and select the "preferred" solutions among Pareto-optimal ones. We investigate different ways to incorporate and reason about preferences in MOO problems.

Monday, 15:40-17:00

■ ME-01

Monday, 15:40-17:00

Aula Magna

Plenary Talk 1

Stream: Keynote Speakers

Invited session

Chair: *Dominique de Werra*, IMA, EPFL, FSB, EPFL, CH 1015, Lausanne, Switzerland, dominique.dewerra@epfl.ch

1 - The Agencies Method for Modeling Coalitions and Co-operation in Games

John F. Nash, Jr., Department of Mathematics, Princeton University, Fine Hall, Washington Road, NJ 08544-1000, Princeton, United States, kjfnj@math.princeton.edu

Our work in this research project represents the beginning of an effort to study the game-theoretic phenomenon of cooperation in cooperative games (that is, in games where it is understood that the players MAY cooperate whenever they would naturally desire to do that so as to realize mutually advantageous benefits). (This project of work could be described as work along the lines of the (old) "Nash program", seeking to reduce the study of "cooperative games" to the area of the (theoretically simpler) study of "equilibrium" in "non-cooperative games".) The theoretical key for the inter-linking of these areas is the concept of the "evolution of cooperation" (in Nature) which has been studied both by theoretical biologists and by game theorists. Our key idea for the reduction of a process realized through cooperation to a process achieved by actions taken independently (and separately) by the Players that are involved in the game context lies in the introduction of moves (or actions) of "acceptance" together with the supposition of an indefinitely repeated game context in which the Players may react (in punishing fashions) against unfavorable actions on the part of other Players. Our model designed for this purpose has the players strategically making "demands" in relation to the behavior of the other players. And at the same time any Player also chooses, strategically, how he (or she) will allocate the resources available to a coalition if he (or she) has become accepted (through acceptance elections) to have that power. As it happens, in short, the studied model, for a game with three players, involved 39 strategic parameters to be controlled by the players, and we represented it in terms of 42 variables. There was a substantial challenge of computation to find game theoretic solutions. These were sought in terms of PURE STRATEGIES. And the game example itself, although being described by a characteristic function giving rise to three numerical parameters setting the payoff benefits accessible by specific coalitions, was an "NTU game" rather than a game with "transferable utility". However we have compared solution results with corresponding indications for the games deriving from the Shapley value or from the nucleolus. The general context of computations is found to be quite challenging. We have used Mathematica in the connection with the work done up to now. There seem to be possibilities for refinements in the model structure and games of more than three players can also be studied.

Monday, 17:20-18:40

■ MF-02

Monday, 17:20-18:40

3.2.14

Flexible shop scheduling by Metaheuristics and solutions for real problems

Stream: Combinatorial Optimization

Invited session

Chair: *Lorena Pradenas*, Industrial, Universidad de Concepción, Barrio Universitario, Concepción, casilla 160 C, correo 3, Concepción, Concepción, Concepción, Chile, lpradena@udec.cl

1 - A genetic algorithm for the flexible job shop problem

Lorena Pradenas, Industrial, Universidad de Concepción, Barrio Universitario, Concepción, casilla 160 C, correo 3, Concepción, Concepción, Concepción, Chile, lpradena@udec.cl, *Rosa Medina*, *Víctor Parada*

The Flexible Job Shop Problem is part of the family of scheduling problems. It extends the job shop problem in order to optimize the use of resources in a flexible production system, that is, those with machines that can process more than one type of operation. This problem has been studied by many authors, who have proposed mathematical models and heuristics approaches. Due to its combinatorial complexity, the exact methods that solve the mathematical models only solve small instances. Among the heuristics approaches, the metaheuristics of local search have demonstrated a better performance. In this study, a sequential genetic algorithm is presented to solve The Flexible Job Shop Problem. The proposed algorithm is tested using literature instances. The results show that the algorithm is effective for finding good solutions for the problem.

2 - The inverse power index problem

Sascha Kurz, Mathematics, Physics and Informatics, University of Bayreuth, Universitätsstraße 30, 95440, Bayreuth, Bavaria, Germany, sascha.kurz@uni-bayreuth.de

Weighted voting games are frequently used in decision making. Each player has a weight and each proposal is accepted if the weight sum of the supporting players exceeds a quota. One line of research is the efficient computation of so-called power indices measuring the influence of a player. We treat the inverse problem: Given an influence vector and a power index, determine a weighted voting game such that the distribution of influence among the players is as close as possible to the given target value. We present exact algorithms and computational results for the Shapley-Shubik index.

3 - Signal decoding in multi-antenna systems using second-order cone programming

Edmund Burke, School of Computer Science & IT, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, ekb@cs.nott.ac.uk, *Jakub Marecek*, *Andrew J. Parkes*

Receivers in modern wireless communications (WiFi N, WiMAX, LTE, LTE Advanced) all implement a solver for integer least squares, a problem in integer non-linear programming. We first present an overview of solvers currently implemented, and subsequently compare them to a solver of our own, based on second-order cone programming cuts. Extensive computational results are presented.

4 - A binary programming model to the Dynamic Search Problem

Carlos Diego Rodrigues, Informatique, Université d'Avignon, 334, Chemin des Meinajaries, Agroparc, 84411, Avignon, PACA, France, cdiegor@gmail.com, *Boris Detienne*, *Dominique Quadri*, *Philippe Michelon*

Search problems are among the first problems studied by Operations Research in several fields (game theory, graph theory, stochastic programming, etc). They are associated to many practical applications, notably in security. We present the first binary programming model to this problem and how this model can be adapted to most of the cases already appearing in the literature. A statistical validation process, that can evaluate any given solution plan, is also shown and used to corroborate with our model, allowing us to establish some numerical results concerning its performance.

■ MF-03

Monday, 17:20-18:40

3.2.15

Population-based metaheuristics for routing problems

Stream: Metaheuristics

Invited session

Chair: *Caroline Prodhon*, University of Troyes, 12 rue Marie Curie, 10000, Troyes, France, caroline.prodhon@utt.fr

Chair: *Philippe Lacomme*, Université de Clermont-Ferrand, 63177, Clermont Ferrand, France, placomme@sp.isima.fr

1 - Memetic algorithm with diversity enhancement: an efficient approach for hard multi-attribute vehicle routing problems

Thibaut Vidal, Informatique et recherche opérationnelle, Université de Montréal / Université de Technologie de Troyes, 5536 chemin de la Cote des Neiges, apt 4, H3T1Y9, MONTREAL, QC, Canada, thibaut.vidal@cirrelt.ca, *Teodor Gabriel Crainic*, *Michel Gendreau*, *Nadia Lahrichi*, *Walter Rei*

We introduce a new memetic algorithm for a hard class of multi-depot periodic vehicle routing problems with time-windows, where very few efficient algorithms could be found. New genetic operators for periodic problems are proposed. Furthermore, in contrast with other population management methods operating solely during survivor selection, our algorithm favors diversity through the very evaluation of individuals, which is driven by fitness as well as contribution to the population diversity. Comparative studies underline the efficiency of our "diversity enhancement" method on these problems.

2 - A new Ant Colony Optimization on Vehicle Routing Problem with heterogeneous fleet, mixed backhauls, and time windows

Farah Belmecheri, LOSI, University of Technology of Troyes, 12, Rue marie curie, 10010, Troyes, France, France, farah.belmecheri@utt.fr, *Christian Prins*, *Farouk Yalaoui*, *Lionel Amodeo*

This paper presents a new Ant Colony Optimization to solve the Vehicle Routing Problem (VRP) with: Heterogeneous fleet (H), Mixed Backhauls (MB), Time Windows (TW) which is called HVRPMBTW. This metaheuristic consists to construct the routes using the probabilities of insertion of customers; the local searches are added to improve the solutions. In computational results, this method is applied on the sets of instances of HVRPMBTW and the classical HVRP with limited and unlimited vehicles (instances of Taillard 1996). The results confirm the efficiency of this new ACO.

3 - An Artificial Bee Colony Algorithm for the Capacitated Vehicle Routing Problem

Sin C. Ho, Department of Business Studies, Aarhus School of Business, Aarhus University, Fuglesangs Allé 4, 8210, Aarhus V, Denmark, sinch@asb.dk, *Wai Yuen Szeto*, *Yongzhong Wu*

This paper introduces an artificial bee colony heuristic for the capacitated vehicle routing problem. The artificial bee colony heuristic is a swarm-based heuristic, which mimics the foraging behavior of a honey bee swarm. The performance of the heuristic is evaluated on two sets of benchmark instances. A new scheme is also developed to improve the performance of the artificial bee colony heuristic. Computational results show that the heuristic with the new scheme produces good solutions.

4 - A Hybrid Genetic Algorithm (HGA) for the Multi-Depot Pickup and Delivery Problem (MDPDP)

Pairoj Chaichiratikul, Imperial College Business School, Imperial College London, 18, Elvaston Place, SW7 5QF, London, United Kingdom, pairoj.chaichiratikul06@imperial.ac.uk, *Eleni Hadjiconstantinou*

The problem of serving a number of pickup and delivery locations using a heterogeneous fleet of vehicles located at several depots is formulated as a mixed-integer linear programming problem. The objective is to find minimum-distance routes subject to precedence, capacity and maximum-route length constraints. This is an NP-hard problem and we use ILOG CPLEX for optimally solving instances of small size only. A new meta-heuristic approach (HGA) is proposed, implemented and computationally tested on various test instances from the literature. Competitive near-optimal solutions are reported.

MF-04

Monday, 17:20-18:40

3.2.13

Shop scheduling with metaheuristics

Stream: Metaheuristics

Invited session

Chair: *André Rossi*, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr

Chair: *Nicolau Santos*, INESC Porto and University of Porto, Portugal, nicolausantos@gmail.com

1 - A solution approach for flexible job shop scheduling problem using artificial immune system

Aydin Sipahioglu, Industrial Engineering, Osmangazi University, Meselik, 26480, Eskisehir, Turkey, asipahi@ogu.edu.tr, *Alper Aladag*

Flexible Job Shop Scheduling Problem (FJSSP) is one of the hardest NP-hard class problems in combinatorial optimization. Therefore, lots of heuristic and meta-heuristic methods are used to solve this problem. In this study, a new hierarchical Artificial Immune System (AIS) solution approach inspired by biological immune system has been developed for FJSSP. Empirical results on 10 benchmark problems known as BRdata in the literature indicate that the proposed approach can obtain better solution results than former approaches and it is very efficient to solve FJSSP.

2 - Master-slave multicore metaheuristic 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, *Gema Escrivá*

In this work a cooperative metaheuristic for the permutation flowshop problem with the objective to minimize the total tardiness is proposed. The method is based on the master-slave model and uses recent technologies, where more than one core is available in the processor of the computer. Each core runs the algorithm and communications are allowed between the master and the slaves. A comparative evaluation against the serial counterparts and other multicore algorithms is carried out, using different sending strategies. Results show that the multicore method outperforms the remaining ones.

3 - Permutation flowshop scheduling with makespan and tardiness objectives by GRASP

Iryna Yevseyeva, UESP, INESC Porto, Portugal, Campus da FEUP, Rua Dr. Roberto Frias, 378, 4200-465, Porto, -, Portugal, irynayev@yahoo.com, *Jorge Pinho de Sousa*, *Luis Guardao*

In this work, permutation flowshop scheduling problem is considered taking into account two conflicting objectives: makespan and tardiness. For this scheduling problem, a multi-start metaheuristic, GRASP, is extended for optimizing several objectives. As a result of applying construction and local search phases of GRASP, a Pareto front of efficient solutions is obtained at each GRASP iteration. An external archive of elite solutions is kept. For intensification and diversification goals path-relinking between elite solutions is performed. The approach is tested on benchmark problems.

4 - Metaheuristics For Minimizing Total Tardiness in the Permutation Flowshop With Release Dates

Nicolau Santos, INESC Porto and University of Porto, Portugal, nicolausantos@gmail.com, *João Pedro Pedroso*

The permutation flowshop scheduling problem is a widely studied combinatorial problem with many applications in real life problems. In this work we focus on minimizing the total tardiness, given a release and a due date for each job. We propose metaheuristics based on local search with the insertion neighborhood, and provide computational results for assessing their quality. We compare our methods to several well-known heuristics adapted for this problem.

MF-05

Monday, 17:20-18:40

3.2.16

EURO Doctoral Dissertation Award

Stream: EURO Doctoral Dissertation Award

Invited session

Chair: *Mikael Rönnqvist*, Department of Finance and Management Science, Norwegian School of Economics and Business Administration, NO-5045, Bergen, Norway, mikael.ronnqvist@nhh.no

1 - Operating room planning and scheduling: solving a surgical case sequencing problem

Brecht Cardoen, Vlerick Leuven Gent Management School & Faculty of Business and Economics, Katholieke Universiteit Leuven, Reep 1, B-9000, Gent, Belgium, brecht.cardoen@vlerick.be

We present the main results of the author's PhD dissertation, which was defended at the Katholieke Universiteit Leuven and supervised by E. Demeulemeester. The thesis studies the impact of planning and scheduling procedures on a hospital's operating room performance. It incorporates an extensive review of both scientific contributions and the current practice of hospitals in Flanders (Belgium). The emphasis of the research, though, is directed towards the development, the testing and the application of exact and heuristic algorithms, such as dedicated branch-and-bound procedures or mixed integer linear programming approaches, for surgery sequencing in a day-care environment.

2 - Application-oriented Mixed Integer Non-Linear Programming

Claudia D'Ambrosio, DEIS, Università di Bologna, 40136, Bologna, Italy, c.dambrosio@unibo.it

The main topic of the thesis is Mixed Integer Non-Linear Programming, with focus on non-convex problems (i.e., problems for which the feasible region of the continuous relaxation is a non-convex set) and real world applications. Different kinds of algorithms are presented: linearization methods, heuristic and global optimization algorithms. Also, different kinds of real-world applications are solved, arising, for example, from Hydraulic and Electrical Engineering problems. The last part of the thesis is devoted to software and tools for mixed integer non-linear programming problems.

3 - A mathematical contribution of statistical learning and continuous optimization using infinite and semi-infinite programming to computational statistics

Sureyya Ozogur-Akyuz, Department of Mathematics and Computer Science, Bahcesehir University, Bahcesehir University, Dept of Mathematics and Computer Science, Ciragan cad. Besiktas, 34353, Istanbul, Turkey, sureyya.akyuz@bahcesehir.edu.tr

In Machine Learning algorithms, one of the crucial issues is the representation of the data. As the data become heterogeneous and large-scale, single kernel methods become insufficient to classify nonlinear data. Convex combinations of kernels were developed to classify this kind of data. Nevertheless, selection of the finite combinations of kernels is limited up to a finite choice. In order to overcome this discrepancy, we propose a novel method of "infinite" kernel combinations by infinite and semi-infinite programming regarding all elements in kernel space. This provides to study variations of combinations of kernels when considering heterogeneous data in real-world applications.

MF-06

Monday, 17:20-18:40

8.2.30

DEA Methodology V

Stream: DEA and Performance Measurement

Invited session

Chair: *Marcos Estellita Lins*, Production Engineering, Federal University of Rio de Janeiro, Rua Belisário Távora 80 ap 506, Laranjeiras, 22245-070, Rio de Janeiro, Rio de Janeiro, Brazil, lins@pep.ufrj.br

1 - Ratio-Based Efficiency Analysis (REA)

Antti Punkka, Systems Analysis Laboratory, Aalto University School of Science and Technology, SAL, Aalto University, P.O.Box 11100, 02150, Espoo, Finland, antti.punkka@tkk.fi, *Ahti Salo*

A DMU's efficiency can be defined as the ratio between the sum of its weighted outputs and that of its weighted inputs. The resulting efficiency ratio depends on what aggregation weights are employed. We develop results for REA which show what other DMUs a given DMU dominates by having a higher efficiency for all feasible weights; what rankings the DMU can attain among all DMUs; and how efficient the DMU can be relative to the most and least efficient DMU across the set of feasible weights. We formulate LP/MILP models from which these results can be computed for realistically large problems.

2 - Measuring the balance of DEA efficiency scores: The balance score Beta

Nadia Vazquez Novoa, Institute of Management Control and Business Accounting, TU Braunschweig, Pockelsstraße 14, 38106, Braunschweig, Lower Saxony, Germany, n.vazquez-novoa@tu-bs.de, *Heinz Ahn, Ludmila Neumann, Juan Pablo De Francesco*

The endogenous weight determination is one of the main advantages of DEA, but it also leads to cases where the efficiency scores result from extreme criteria weights. A common approach to avoid such "unbalanced" results is to integrate weight constraints into the DEA models. However, weight restrictions require additional — more or less subjective — information. As an alternative approach, a balance score is presented. This measure endogenously identifies DMUs with unbalanced efficiency scores, quantifies their (un-)balance, and leads to recommendations of how to improve their balance.

3 - Three way decomposition of the Efficiency of Andalusian Economy

Antonio F. Amores, Department of Economics, Quantitative Methods and Economics History, Pablo de Olavide University, Ctra. Utrera Km.1, Ed. 3, 2º, Despacho 16, 41013, Seville, Spain, afamoher@upo.es, *Thijs ten Raa*

Ten Raa (2006) proposes a model for the efficiency evaluation of an industrial organization that singles out firm, industry and organization efficiency. We extend this approach to tackle the whole economy efficiency and its decomposition into: firm, industry, organization, allocation and economy efficiencies. This analysis is applied to the Andalusian economy (Spain).

4 - The use of Problem Structuring Methods in health policy and performance assessment

Marcos Estellita Lins, Production Engineering, Federal University of Rio de Janeiro, Rua Belisário Távora 80 ap 506, Laranjeiras, 22245-070, Rio de Janeiro, Rio de Janeiro, Brazil, lins@pep.ufrj.br, *Angela Silva, Maria Stella Castro Lobo, Roberto Fiszman, Leonardo Pessoa, Nilo Chagas*

Integrating soft and hard OR as seemingly conflicting paradigms provides a better communication among decision makers regarding the several stages of applied OR problem solving. This is particularly true when public policy is concerned. While this is well developed in OR, the same is not true in the DEA field, where a pioneering research was done by Mingers in 2009 using PSM to help selecting DEA variables. In this work we use cognitive maps to help understanding the causal relationship and weaknesses of DEA when reflecting performance and supporting decisions concerning public policy.

MF-07

Monday, 17:20-18:40

8.2.47

DEA Application IX

Stream: DEA and Performance Measurement

Invited session

Chair: *Meryem Duygun Fethi*, School of Management, University of Leicester, University Road, LE1 7RH, Leicester, Leicestershire, United Kingdom, m.fethi@le.ac.uk

1 - Reallocating agricultural greenhouse gas emissions among European countries through a Zero Sum Gains DEA Model

Amílcar Serrão, Management Department, Evora University, Largo dos Colegiais, 7000-550, Evora, Alentejo, Portugal, aserrao@uevora.pt

This research work uses a ZSG-DEA BCC model, which represents a situation similar to a zero sum game. This model is applied to EU15 countries, considering one output (agricultural greenhouse gas emissions) and two inputs (livestock units and utilized agricultural area). Using the smoothed frontier for the 3-dimensional DEA BCC scores, we determine new targets for this ZSG-DEA BCC model, reallocating agricultural greenhouse gas emissions among EU15 countries. A uniform BCC DEA frontier is built, where all DMUs are 100% efficient. After emissions reallocation, all DMUs became efficient.

2 - Efficiency Study of Indian Banks during the Reforms — A Data Envelopment Analysis Approach

Debaprosanna Nandy, COMMERCE, A.C. COLLEGE OF COMMERCE, D.B.C. ROAD, 735 101, JALPAIGURI, WEST BENGAL, India, dp_nandy@yahoo.com

Indian Banks are going through a transitional phase. An important objective of reforms measures is to increase the efficiency of the banking sector. Policy makers have clearly recognized that inefficiency is an important factor contributing to the high level of cost of banking services. Indian banks have to be more efficient and competitive to cope with the financial crisis as well as global challenges in the near future. This paper attempts to measure the efficiency of Indian Banks using a variety of efficiency measures computed by the nonparametric method of Data Envelopment Analysis.

3 - Efficiency analysis of the MFIs in Bolivia

Elena Sanchez, Economics, Self employee, Calle Waldo Ballvian 1018, n.a, Cochabamba, Bolivia, elenas55@hotmail.com

The DEA was used to measure the efficiency of 12 MFIs in Bolivia, by using 3 types of efficiency: technical, pure technical, and scale efficiency, under IOM and OOM, assuming CRS and VRS. 2 variables are evaluated: gross loan portfolio and number of borrowers. The findings are: 4 MFIs are on the efficient frontier when GLP is evaluated, inefficiencies are due to scale inefficiency, 5 MFIs are on the EF when No. of borrowers is evaluated, inefficiencies are due to PTE. In overall, TI is due to PTI rather than SI in both approaches. The main conclusion: 64% of MFIs seems to be efficient.

4 - Efficiency, capital structure and institutional shareholders

Tsai Lien Yeh, International Business, Ming Chuan University, 2F, No. 9, Lane 17, Yung-Kang St., Taipei, Taiwan, 10650, R.O.C., 10650, Taipei, Taiwan, tlyeh@mail.mcu.edu.tw, *Jhu-Ning Jhang*

By employing a sample of 37 Taiwanese banks, this study investigates the relationship among banks efficiency, capital structure and institutional shareholders. The data envelopment analysis approach is used to measure technical efficiency as the firm performance indicator. Empirical outcomes support that: first, banks can mitigate agency cost to increase firm efficiency by decreasing the debt ratio. Second, debt and the presence of institutional shareholders may be deemed as substitute disciplinary devices, the share of institutional holdings is negatively associated with debt ratio.

MF-08

Monday, 17:20-18:40

6.1.36

Scheduling: Algorithms and practical cases

Stream: Project Management and Scheduling

Invited session

Chair: *Mario Vanhoucke*, Faculty of Economics and Business Administration, Ghent University and Vlerick Leuven Gent Management School, Tweekerkenstraat 2, 9000, Ghent, Belgium, mario.vanhoucke@ugent.be

1 - A meta-heuristic optimization approach for job shop scheduling and its practical applications

Veronique Sels, Faculty of Economics and Business Administration, Ghent University, Faculteit Economie en Bedrijfskunde, Tweekerkenstraat 2, 9000, Gent, Oost

Vlaanderen, Belgium, veronique.sels@ugent.be, *Mario Vanhoucke*

In this presentation we present a comparison of different meta-heuristic optimization approaches for the well-known job shop scheduling problem. A detailed comparison of these procedures will be made based on benchmark test instances from literature and their solution quality will be compared with state-of-the-art results. Moreover, the practical use of these procedures will be illustrated in a simulation experiment used during a consultancy project in a Belgian production company.

2 - Managerial Insights in Reactive Personnel Re-rostering

Broos Maenhout, Business Informatics and Operations Management, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, Broos.Maenhout@Ugent.be, *Mario Vanhoucke*

In case of schedule disruptions caused by unplanned personnel absences, the personnel scheduler must restore feasibility by reconstructing the personnel roster. This rescheduling is a complex task as the personnel scheduler should take multiple objectives and many constraints into account. In order to reduce the complexity, we explore the boundaries of the time horizon and the personnel staffing size that will be considered by the re-rostering process based on computational experiments in a real-life problem environment.

3 - An Experimental Investigation of Meta-heuristics for the Multi-mode Resource-constrained Project Scheduling on new Dataset Instances

Vincent Van Peteghem, Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, vincent.vanpeteghem@ugent.be, *Mario Vanhoucke*

An overview is presented of the existing meta-heuristic solution procedures available in literature to solve the multi-mode resource-constrained project scheduling problem, in which multiple execution modes are available for each of the activities of the project. A fair comparison is made between the different meta-heuristic algorithms on the existing benchmark datasets and on a newly generated dataset. Computational results are provided and recommendations for future research are formulated.

4 - Audit-staff scheduling with alternative audit teams and setup times

Vincent Van Peteghem, Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000, Gent, Belgium, vincent.vanpeteghem@ugent.be, *Mario Vanhoucke*

In this paper, an algorithm is presented for the medium term audit-staff scheduling problem, in which teams of auditors are assigned to a set of audit engagements, with varying auditors' availability, alternative audit teams and variable setup times, dependent on the audit team efficiencies. This algorithm is applied on real-life data from a small Belgium audit firm, with 15 auditors and more than 250 audit engagements per year.

■ MF-09

Monday, 17:20-18:40
6.2.53

Discrete and Continuous Optimization for Gas Networks

Stream: Mathematical Programming

Invited session

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

1 - Checking Feasibility in Stationary Models of Gas Transportation

Claudia Stangl, Mathematics, University of Duisburg-Essen, Butlerstrasse 10, 47058, duisburg, Germany, claudia.stangl@uni-due.de, *Rüdiger Schultz*

Checking the 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 exit points. In the stationary case, we obtain a very big (nonlinear, mixed-integer, finite dimensional) inequality system. We present elimination and approximation techniques so that the remaining system gets within the reach of standard NLP-solvers.

2 - High Accuracy Stationary Optimization in Gas Networks

Martin Schmidt, Institute of Applied Mathematics, Leibniz Universität Hannover, Welfengarten 1, 30167, Hannover, Lower saxony, Germany, mschmidt@ifam.uni-hannover.de, *Marc Steinbach*, *Bernhard Willert*

Stationary optimization of fuel gas consumption is an important task in current planning processes for gas networks. We consider detailed models of large networks with gas dynamics described by a system of ODEs including gas temperature and gas quality parameters. Additionally, we incorporate compressor stations with several compressor types in high detail. Discrete decisions are addressed at a separate MIP level and fixed in our nonlinear program. We discuss the NLP model and present numerical results on real life network sizes.

3 - Topology Planning in Gas Distribution Networks

Jesco Humpola, Zuse Institute Berlin, Germany, humpola@zib.de

A procedure of topology planning within large-sized, real-world gas distribution networks is presented. Given a budget, we decide which combination of network extensions like pipelines, compressors or valves should be added to the gas network to increase its capacity as well as its flexibility. We present a nonlinear mixed-integer model for this problem. To solve this large scale instance, every nonlinearity undergoes a linear outer approximation. We present computational results obtained by a special tailored version of the MILP solver SCIP.

4 - Large-scale decomposition with Fejer processes for convex programming

Andrey Velichko, Institute of Automation and Control Processes, Radio, 5, 690041, Vladivostok, Russian Federation, vandre@dvo.ru

Fejer processes with projection operator studied by Eremin and small decreasing disturbances approach analysed by Nurminski are used to design iterative and parallel algorithms for convex programming with large quantity of linear inequality constraints. Convex hull of projections onto disjoint subsets of a feasible region is used as Fejer operator. Selection of initial point, step adjustments and feasible set decomposition strategies are proposed to get linear convergence and nearly polynomial (in constraints) algorithm complexity of degree 4-5. MPI Toolbox package for Octave software is used.

■ MF-10

Monday, 17:20-18:40
6.2.56

Multi-index Assignment Problems

Stream: Graphs and Networks

Invited session

Chair: *Frits Spieksma*, of Operations Research and Business Statistics, Katholieke Universiteit Leuven, Naamsestraat 69, B-3000, Leuven, Belgium, frits.spieksma@econ.kuleuven.be

1 - On the Completability of Incomplete Latin Squares

Reinhardt Euler, Informatique, Université de Brest, 20 av. Le Gorgeu, B P 817, 29285, Brest, France, reinhardt.euler@univ-brest.fr

Latin squares correspond to the solutions of the planar 3-index assignment problem. The question whether an incomplete latin square is completable, arises as a special case, and establishing necessary and sufficient conditions for the completability of such squares is a major research direction. In this talk we focus on minimally non-completable incomplete latin squares and - point out their relationship with polyhedral theory; - answer the completability question for incomplete (3,n)-latin rectangles. We also discuss some consequences for class-teacher time-table problems.

2 - On the Multi-level Bottleneck Assignment Problem

Trivikram Dokka, Operations Research and Business Statistics, KATHOLIEKE UNIVERSITEIT LEUVEN, Naamsestraat 69,

B-3000, Leuven, Belgium, trivikram.dokka@yahoo.co.uk, *Frits Spijksma, Gautam Appa, Anastasia Kouvela*

We consider the multi-level bottleneck assignment problem (MBA). This problem is described in the recent book "Assignment Problems" by Burkard et al. (2009) on pages 188 - 189. One of the applications described there concerns bus driver scheduling. We view the problem as a special case of a bottleneck m -dimensional multi-index assignment problem. First, we note that problem MBA is NP-hard even for $m = 3$. Further, we describe a method for MBA that consists in solving iteratively bottleneck matching problems, and we show that this method is a 2-approximation algorithm.

3 - Characterising odd-hole inequalities related to Latin squares

Yiannis Mourtos, Management Science & Technology, Athens University of Economics & Business, Greece, mourtos@aub.gr, *Dimitris Magos*

The convex hull of binary vectors representing Latin squares is the polytope of the 3-index planar assignment problem. We study the facial structure of P by examining valid inequalities induced by the odd holes. We define the concept of the lifting set of an odd hole, present an efficient algorithm for identifying it and derive tight bounds on the left-hand side coefficients of an induced odd-hole inequality. Hence, we characterise the class of odd holes that yield maximal inequalities without lifting and show that they are facet-defining, thus unifying and generalising previous. Finally, we show how these inequalities can be generalised to planar multi-index assignment problems.

4 - The Focus of Attention Problem

Frits Spijksma, of Operations Research and Business Statistics, Katholieke Universiteit Leuven, Naamsestraat 69, B-3000, Leuven, Belgium, frits.spijksma@econ.kuleuven.be, *Dries Goossens, Sergey Polyakovskiy, Gerhard J. Woeginger*

We consider the problem of assigning sensors to track targets so as to minimize the error in the resulting estimation for target locations. This so-called Focus of Attention problem is a special case of a three index assignment problem. We provide a complete complexity and approximability analysis of this Focus of Attention problem: We establish strong NP-hardness, and we construct a polynomial time approximation scheme.

MF-11

Monday, 17:20-18:40
8.2.38

Structural Equation Modelling Approach in User Acceptance of Information Technology I

Stream: Emerging Applications of OR
Invited session

Chair: *Sevgi Ozkan*, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, İsmet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr

1 - Analysis of the User Acceptance for Implementing ISO/IEC 27001:2005 in Turkish Public Organizations

Tolga Mataracioglu, Department of Information Systems Security, TUBITAK UEKAE, Tunali Hilmi Cad. Binnaz Sok. 2/3., Kavaklıdere/Cankaya, 06700, Ankara, Turkey, mataracioglu@uekae.tubitak.gov.tr, *Sevgi Ozkan*

This study aims to develop a model for the user acceptance for implementing the information security standard (i.e. ISO27001) in Turkish public organizations. The results of the surveys performed within four public organizations in Turkey reveal that the legislation on information security public which organizations have to obey is significantly related with the user acceptance during ISO27001 implementation process. The fundamental components of our user acceptance model are perceived usefulness, attitude towards use, social norms, performance expectancy and effort expectancy.

2 - Information Technology Assessment of Organizations

Emre Sezgin, Information System, Informatics Institute, Middle East Technical University, Informatics Institute, 06531, Ankara, Turkey, esezgin1@gmail.com, *Sevgi Ozkan*

The aim of the study is proposing a model for IT assessment that can be applied to companies to evaluate their condition of IT and to determine their IT level in comparison with their rivals. For this reason, Information Technology Assessment Model has been developed to assess the information technology use, advancements and potentials of a company. The model is based on specific research criteria retrieved from best practices (COBIT, ITIL, CMMI) and standards (ISO 38500, ISO 27002) considering technology management assessment procedure (Gregory, 1995) as the academic framework of the study.

3 - Investigating Technology acceptance Model in context of Mobile Health Care

Can Peker, IS, METU, METU, ANKARA, Çankaya, Turkey, cpeker@gmail.com, *Sevgen Yazarli, Sevgi Ozkan*

Healthcare industry is one of the most challenging industries considering the new Information technologies. Mobile healthcare systems are evolving for distance information. IT applications like global positioning systems and wireless technologies offer remote connection to Information. Mostly the systems cannot be adopted because of insufficient user acceptance. In this work Technology Acceptance Model (Davis, 1989) will be studied. The related social and individual factors will be served for the acceptance of Mobile healthcare Systems.

4 - Analysis of the Possible Adoption Behaviors of Cloud Services in Turkish Public Organizations

Bilge Karabacak, Informatics Institute, METU, METU Informatics Institute, İnönü Bulvarı, 06531, Ankara, TR, Turkey, e171018@metu.edu.tr, *Sevgi Ozkan*

Cloud computing is the final era of the Internet in which applications and data resides at remote sites of the cloud providers. Since data is processed at remote location, cloud computing raises some concerns on privacy of information. Some public organizations in United States are already using services for a while. Similar models of usage can be applicable for Turkish public bodies. Considering these models, our study aims to examine the possible adoption behaviors of the cloud services in public bodies of Turkey by taking the regulations, organizational politics and culture into account.

MF-12

Monday, 17:20-18:40
8.2.39

AHP 05

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 - Influence of the Criteria in the Bayesian AHP

Pilar Gargallo, Facultad de Económicas, Universidad de Zaragoza, Gran Vía 2, 50005, Zaragoza, Spain, pigarga@unizar.es, *José María Moreno-jimenez, Alfredo Altuzarra, Manuel Salvador*

This work proposes different methodologies for measuring the influence of a set of criteria on the final priorities of the Analytic Hierarchy Process (AHP) in a global context (a hierarchy). The priorities have been obtained by means of the Bayesian prioritization procedure of Altuzarra et al. (2007). Cross-validation methods have been used when measuring the influence. The methodology is illustrated by means of an empirical example.

2 - Multiple Criteria Decision Making in Management Accounting and Control — State of the Art and Research Perspectives

Judith Huelle, Chair of Management Accounting and Control, University of Goettingen, Platz der Göttinger Sieben 3, 37073, Goettingen, Lower Saxony, Germany, Judith.Huelle@wiwi.uni-goettingen.de, *Ralf Kaspar, Klaus Moeller, Tobias Klatt*

The study's purpose is to examine to what extent MCDM methods are used in the context of management accounting and control. Therefore, an extensive bibliometric analysis covering the last three decades was conducted using Business Source® Complete database. The results indicate an increase in MCDM's importance. Furthermore, the majority of publications deal with the areas of strategic and performance management, more specifically with strategic planning and performance evaluation. Hereby, AHP is the most popular tool for supporting the management in complex decisions.

3 - Analysis of Investments in Alternate Energy Resources: AHP and DEA Approach

Josef Jablonsky, Dept. of Econometrics, University of Economics Prague, W.Churchill sq. 4, 13067, Prague 3, Czech Republic, jablon@vse.cz

Recoverable energy resources are of high interest in many countries as one of the possibility to ensure their energy needs. They are often supported in different ways by governments. The paper analyses possible investments in five energy resources (wind power, small water, photovoltaic, geothermal, and biomass energy power plant). The alternatives are evaluated according to five groups of criteria (technical, ecological, economic, social, and strategic) by means of AHP model. Except the AHP model we use DEA analysis for evaluation of efficiency of private investments in given field.

MF-13

Monday, 17:20-18:40

2.2.21

Discrete Location II

Stream: Location Analysis

Invited session

Chair: *Antonio Manuel Rodríguez-Chía*, Estadística e Investigación Operativa, Universidad de Cádiz, Facultad de Ciencias. Pol. Río San Pedro., 11510, Puerto Real, Cádiz, Spain, antonio.rodriguezchia@uca.es

1 - Solving discrete location problems 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, *Jose Muñoz*

This paper presents a new bidirectional neural model for solving discrete location problems. The proposed neural model (NELOC) is based on a bidirectional architecture composed by two layers. NELOC have been successfully applied to diverse discrete location problems. In addition, the effectiveness and efficiency of NELOC have been analyzed in comparison to other heuristics methods. Results show that the proposed neural network generates good solutions for different discrete location problems with a reasonable computational effort.

2 - Facility location planning for a multi-layer biofuel production chain

Frank Schwaderer, Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT), Germany, frank.schwaderer@kit.edu, *Magnus Fröhling*, *Frank Schultmann*

The considered biofuel production chain consists of the following process steps: preparation, pyrolysis, gasification and synthesis. As the pyrolysis product is transportable the pyrolysis unit can be operated at independent production sites. In order to identify the number of production sites and steps as well as capacities at each location, a WLP is formulated regarding economies of scale through special ordered sets of type 2. The model considers energy balances of the single process steps and regional conditions such as biomass potentials and is exemplarily applied to a specific region.

3 - Solving the the uncapacitated hub location problem with a row generation algorithm

Sergio García Quiles, Department of Statistics, University Carlos III of Madrid, Escuela Politécnica Superior, Avenida de la Universidad, 30, 28911, Leganés, Madrid, Spain, sergio.garcia@uc3m.es, *Mercedes Landete*, *Alfredo Marín*

In hub location problems, some product must be sent between the nodes (customers) of a network through some special transshipment points called hubs: nodes which benefit from a economy of scales. It has many applications in fields such as Telecommunications, Air Transport or postal delivery. This work shows how the uncapacitated hub location problem can be solved by using an initial reduced formulation and adding rows dynamically as they are needed. A computational study shows the performance of this model.

MF-14

Monday, 17:20-18:40

2.2.15

Supply Chain Planning

Stream: Supply Chain Planning [c]

Contributed session

Chair: *Shabnam Rezapour*, Industrial Engineering, Urmia university of Technology, 14185-671, Urmia, Vest Azarbaijane, Iran, Islamic Republic Of, shabnam_rezapoor@yahoo.com

1 - The effect of workload constraints in periodic order release models

Michiel Jansen, Industrial Engineering, Eindhoven University of Technology, Postbus 513, Paviljoen E.14, 5600 MB, Eindhoven, Netherlands, m.jansen@tue.nl, *Ivo Adan*

We study periodic capacitated models for Supply Chain Operations Planning (SCOP) within a hierarchical planning concept. The SCOP problem is one of timing the release of orders to production units (PU). An important instrument in the coordination of order releases is the planned lead time, i.e. the time between order release and the planned availability of goods. In capacitated models for SCOP, the planned lead time is made conditional on some (restriction of) the work-in-process (WIP). The choice of the planned lead time and WIP constraints heavily influences WIP levels and how efficient resources can be utilized. We explore these relations for a PU that is represented by a single server with generic service times. We find that there is a simple, intuitive relation between the planned lead time, WIP constraints, and the maximum utilization of a production unit. We explore this relation further using a generating function approach. We also develop accurate approximations for mean and variance of the WIP and the order flow times. Finally, we show for a simple case, how these results can be applied to find the efficient combinations of planned lead time and the capacity constraint.

2 - Operative planning of resources and operations in long-term planning context

Jasmina Omerbegovic-Bijelovic, Operations management, Faculty of organizational sciences, Jove Ilica 154, 11040, Belgrade, Serbia, omeja@fon.rs, *Zoran Rakicevic*

One of the most significant problems of Operations Man-t is the breaking down of the long-term (a few years/months) plans into operative ones (monthly, weekly). It manifests because of the set of limitations in resources, which limit the exit (products/services scope) from the system in question. In practice, that problem solves by convention: long-term plans are agreements about potential needs for resources, and the operative plans are realised as business agreements (order for suppliers). Theoretically, the solution lies in shorter time frames, simulations, statistical methods, fuzzy sets.

3 - A critical analysis of optimisation models for "Clicks-and-Mortar" integration

Kathrin Fischer, Institute for Operations Research and Information Systems, Hamburg University of Technology (TUHH), TU Hamburg-Harburg, Schwarzenbergstrasse 95 D, D-21073, Hamburg, Germany, kathrin.fischer@tu-harburg.de

In recent publications, inventory management and delivery strategies for "Clicks-and-Mortar" firms were studied. Using optimisation models, it was found that deliveries to online customers should either be made only from the stores, or exclusively from an online depot. It is shown here that these results hold true only under very simplifying assumptions. Under realistic assumptions, combined solutions can be optimal. Moreover, it is discussed how the respective supply chain optimisation models can be adapted in order to develop strategies applicable to real-life planning situations.

4 - Strategic Design of Competing Supply Chain Network for Markets with Stochastic Demands

Shabnam Rezapour, Industrial Engineering, Urmia university of Technology, 14185-671, Urmia, Vest Azarbaijane, Iran, Islamic

Republic Of, shabnam_rezapoora@yahoo.com, Reza Zanjirani Farahani

In this paper we consider a new two-stage model for competitive supply chain network designing with anticipating variable prices and service levels competition in markets under stochastic price and service level dependant elastic demands and with existing external rivals presence. The objective is to design the new entrant chain's network under a capacity constraint in order to maximize its future income in the competing markets. The structure of the new chain's network is assumed to be set "once and for all" but further price and service level adjustments are possible.

MF-15

Monday, 17:20-18:40

2.2.12

Shortest Path Problems with Resource Constraints

Stream: Vehicle Routing

Invited session

Chair: *Simon Spoorendonk*, DTU Management Engineering, DTU Technical University of Denmark, Produktionstorvet, Building 426, 2800, Kgs. Lyngby, Denmark, spoo@man.dtu.dk

1 - Resource Constrained Shortest Path found by Parallel Labeling Algorithm

Bjørn Petersen, DTU Management Engineering, Technical University of Denmark, Produktionstorvet 424, 2800, Kongens Lyngby, Denmark, Denmark, bjorn@diku.dk

Resource Constrained Shortest Path Problems are often solved with labeling algorithms. Modern hardware trends go toward more and more parallelization. This talk shows how to parallelize a labeling algorithm. Various other aspects of making a modern labeling algorithm perform is also shown, including search structures, bounding, and dominance rules. Extensive computational results based on test data from Vehicle Routing Problems are presented.

2 - A New State Space Relaxation for Computing Bounds to Routing Problems

Roberto Roberti, DEIS, University of Bologna, Via Sacchi, 3, 47521, Cesena, Italy, roberto.roberti6@unibo.it, *Roberto Baldacci*, *Aristide Mingozzi*

We introduce a new state space relaxation (SSP), called ng-path relaxation, for computing bounds and solving Vehicle Routing Problems (VRPs). We present the theoretical aspects of the new SSP and show that, computationally, it outperforms other SSPs proposed in the literature to solve VRPs (i.e., q-routes and t-routes relaxations). Extensive computational results over the main instances from the literature of the Capacitated VRP, the VRP with Time Windows, and the TSP with Time Windows show the effectiveness of the new relaxation.

3 - Pricing Non-Elementary Routes for the Capacitated Arc-Routing Problem

Stefan Irnich, Logistics Management, Johannes Gutenberg University, Jakob-Welder-Weg 9, 55128, Mainz, Germany, irnich@uni-mainz.de

Traditional exact methods for the CARP rely on branch-and-cut or the transformation into the CVRP. An alternative exact approach is the solution of the CARP by column generation. Letchford and Oukil (Comp. & OR, 2009, vol. 36, p. 2320–2327) price out elementary routes using a MIP formulation with directed flow variables. In contrast, we propose solving the subproblem directly as an undirected postman problem. We present a new sparse formulation for this subproblem and a branch-and-cut algorithm for its solution.

4 - A branch-and-cut algorithm for the elementary shortest path problem with resource constraints

Simon Spoorendonk, DTU Management Engineering, DTU Technical University of Denmark, Produktionstorvet, Building 426, 2800, Kgs. Lyngby, Denmark, spoo@man.dtu.dk

The elementary shortest path with resource constraints have commonly been solved with dynamic programming algorithms. Assuming an undirected graph, we present a compact formulation of this problem and a branch-and-cut algorithm to solve it. Two types of resources are discussed: a capacity and a fixed charge resource. The former is the subproblem of the capacitated vehicle routing problem and the latter is from the split delivery version. Computational results are presented and compared to dynamic programming algorithms.

MF-16

Monday, 17:20-18:40

2.2.14

Vehicle and crew rostering

Stream: Public Transport

Invited session

Chair: *Ana Paiais*, DEIO/CIO, University of Lisbon, Portugal, ampaiais@fc.ul.pt

Chair: *Marta Mesquita*, ISA / CIO, Technical University of Lisbon, Tapada da Ajuda, 1349-017, Lisboa, Portugal, marta@math.isa.utl.pt

1 - The integrated vehicle-crew-roster problem with days-off pattern

Marta Mesquita, ISA / CIO, Technical University of Lisbon, Tapada da Ajuda, 1349-017, Lisboa, Portugal, marta@math.isa.utl.pt, *Margarida Moz*, *Ana Paiais*, *Margarida Pato*

In this talk we present a new mathematical model for the integrated vehicle-crew-roster problem that follows the days-off pattern of a specific group of drivers from a bus company. We propose an heuristic approach with embedded column generation and branch-and-bound techniques within a Benders decomposition. Taking advantage of the mathematical model structure, the decomposition approach alternates between the solution of an integrated vehicle-crew scheduling problem and the solution of a rostering problem. We report on computational experience with data from a bus company operating in Lisbon

2 - Robust Airline Schedule Planning: Minimising Propagated Delay in an Integrated Routing and Crewing Framework

Gary Froyland, Mathematics and Statistics, University of New South Wales, School of Mathematics and Statistics, University of New South Wales, 2052, Sydney, NSW, Australia, g.froyland@unsw.edu.au

The airline scheduling problem has traditionally been decomposed into stages with the decisions from one stage imposed upon decisions made in subsequent stages. This unfortunately fails to capture the many dependencies between the stages. As delays are commonly transferred between late running aircraft and crew, it is important that aircraft routing and crew pairing decisions are made together. We introduce a new approach to accurately calculate and minimise the total cost of propagated delay, in a framework that integrates aircraft routing and crew pairing.

3 - Heuristic for Multiple Trips Vehicle Routing and Scheduling Problem with Time Window

San Nah Sze, Econometrics & Business Statistics, University of Sydney, Room 282, The Economics&Business Building (H69), 2006, Sydney, New South Wales, Australia, susana_sze@hotmail.com, *Suk Fung Ng*

In this study we investigate on how to apply heuristic effectively into Multiple Trips Vehicle Routing and Scheduling Problem with Time Window (MTVRSTW). The problem consists of establishing start-times for the customers and creating a roster for serving teams. Two-staged heuristic is proposed to solve MTVRSTW due to its fast responses of solution generation and good result for large size instances. Since solving this problem can be financially significant, the primary objective of this study is to minimize the number of servicing teams required to fulfill all the operational constraints. Computational results are given to demonstrate the robustness and efficiency of the insertion algorithm.

4 - A maximum covering formulation for the integrated vehicle and crew scheduling problem

Teresa Galvão Dias, DEIG, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto PORTUGAL, 4200-465, Porto, Portugal, tgalvao@fe.up.pt, *Jorge Pinho de Sousa*, *Bruno Prata*

The Vehicle and Crew Scheduling Problem (VCSP) is a hard, widely studied Combinatorial Optimization problem. Traditionally set covering based models have been used to approach the problem. This research proposes a new mathematical formulation for the VCSP without changeovers (i.e. drivers cannot use more than one vehicle) based on the maximum covering problem. A reactive GRASP heuristic was also developed for the problem. Preliminary computational results with instances from the literature and real instances from Fortaleza (Brazil) show the potential of the developed approaches.

■ MF-17

Monday, 17:20-18:40

1.3.14

Long-term Transportation Planning

Stream: Transportation Planning

Invited session

Chair: *Rajeev Namboothiri*, CIRRELT, Montreal, Canada, C.P. 6128, succursale Centre-ville, H3C 3J7, Montreal, Quebec, Canada, rajeev@crt.umontreal.ca

1 - A comprehensive evaluation of the impact of aggregation/disaggregation of data on the strategic planning of freight transportation systems

Rajeev Namboothiri, CIRRELT, Montreal, Canada, C.P. 6128, succursale Centre-ville, H3C 3J7, Montreal, Quebec, Canada, rajeev@crt.umontreal.ca, *Teodor Gabriel Crainic*, *Michel Gendreau*, *Alexandre Savariradjou*

In this talk, we analyze the strategic national/regional planning of multi-commodity multi-modal freight transportation systems using an integrated evaluation platform. A comprehensive and realistic representation of the current state of such a system was developed, incorporating the various components of these systems and their complex interactions. Computational results provide detailed analysis of the impact of aggregation/disaggregation of data on strategic planning decisions as well as day-to-day operational decisions.

2 - The influence of subcontracting on location decisions of small package shippers

Andreas Stenger, IT-based Logistics, Goethe University Frankfurt, Grueneburgplatz 1, 60323, Frankfurt, Germany, stenger@wiwi.uni-frankfurt.de, *Michael Schneider*, *Michael Schwind*

Location routing problems (LRP) are used to determine the optimal number and location of depots considering vehicle routing. Published models still lack important characteristics of real-world delivery networks. In particular, outsourcing unprofitable areas to subcontractors is one major trend in small package shipping that strongly influences location decisions. We contribute by developing a solution method for an LRP that includes the choice between self-operating and subcontracting a depot. In numerical studies, we show the effect of subcontracting on the total network design and costs.

3 - Integrated Facility Location and Multi-Trip Vehicle Routing Problem: Solution and Value of Integration

Zeliha Akca, Investment Management, Strategic Planning and Investments, Turkish Airlines Inc., Istanbul, Turkey, zelihaakca@gmail.com, *Rosemary Berger*, *Ted Ralphs*

We investigate the problem of simultaneously determining the location of facilities and the design of multi-trip vehicle routes to serve customer demands. For a version of this problem with capacitated facilities, time- and capacity-limited vehicles, we describe two versions of a branch-and-price algorithm, a one-stage and a two-stage version which is based on the idea of restart. We demonstrate the performance of the algorithms using instances up to 40 customers and we assess the benefit of integrated optimization. We obtain results confirming our interest in integrated problem.

■ MF-18

Monday, 17:20-18:40

1.3.15

Markov Chains

Stream: Stochastic Modeling and Simulation

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: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - absorbent chains of markov: study of costs

Silvana Ligia Vincenzi Bortolotti, Matemática/Estatística, UTFPR/UFSC, Rua Jornalista Tito de Carvalho, 155, 88040480, Florianopolis, Santa Catarina, Brazil, sligie@globo.com, *Rosely Antunes de Souza*, *Afonso Farias Sousa Junior*, *Antônio Coelho*

This work brings a study and analysis of products costs of a micro-company using the absorbent chains of Markov. The data was summarized through a project of productive system, considering aspects such as production, inspection, dispatching, rejection. The analysis of products cost in this productive system is done starting from the determination and estimative of all the costs that involve the phases of production, inspection and dispatching. Using the absorbent chains of Markov it was possible to verify its efficient contribution for taking decisions in processes of costs management.

2 - Hamiltonicity-Trace Conjecture for Singularly Perturbed Markov Chains

Vladimir Ejov, Mathematics and Statistics, University of South Australia, 46 Aver Avenue, 5041, Daw Park, SA, Australia, contactways@yahoo.com, *Nelly Litvak*, *Giang Nguyen*, *Peter Taylor*

We prove that the trace of the fundamental matrix of a singularly perturbed Markov chain that corresponds to a stochastic policy, feasible for a given graph, is minimised at policies corresponding to Hamiltonian cycles.

This is joint work with Nelly Litvak, Giang T. Nguyen and Peter G. Taylor.

3 - Modelling operational decisions in start-up firms

Thomas Archibald, Management School, University of Edinburgh, 50 George Square, EH8 9JY, Edinburgh, United Kingdom, tarchibald@ed.ac.uk, *Kuangyi Liu*

A general Markov decision process model for operations management with a profit maximizing objective is presented and extended to a survival maximizing objective with a constraint on capital. It is argued that the survival maximizing objective may be more suitable for start-up firms. The model has been used to address inventory, capacity expansion and marketing decisions. Analysis of the models under different assumptions about the operating environment provides insight into the successful management of start-up firms.

4 - Prospective customer equity measurement and monitoring

Nadine Losch, Department of Management Accounting, University of Goettingen, Platz der Göttinger Sieben 3, 37073, Göttingen, Germany, nadine.losch@wiwi.uni-goettingen.de, *Klaus Moeller*

Customer equity (CE) is gaining increasing importance in both academia and practice. Companies seek to measure and monitor CE, as a key driver of their financial performance. The prediction of CE is essential in a strategic management characterized by growing uncertainty through dynamics in the customer base. A Markov chain model will be used to explicitly model the dynamics of CE over time. Furthermore the use of classification and regression trees (CART) enables to create a segment specific CE. The prospective CE enables the derivation of a monitoring system and broad strategic trade-offs.

■ MF-19

Monday, 17:20-18:40

1.3.20

Game Theory and Statistics

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Alberto Pinto*, Mathematics, University of Minho, Campus de Gualtar, 4710-057, Braga, aapinto@math.uminho.pt

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Reliability of test score

Mikhail Lutsenko, Mathematics, St. Petersburg Transport University, Moskovskij pr.9, 195257, St.Petersburg, Russian Federation, ml4116@mail.ru

Reliability of test scores without assumption about normality of levels knowledge of test takers is found. A statistical game between Statistician and Test-taker for solution of the problem is constructed. The worst a priori distribution of parameter, the best randomizer decision function of Statistician and reliability of testing are evaluated. The problems by MS Excel are solved when test has 10 items. In many important cases the reliability of assessment turns out to be very low.

2 - On k-th order arbitrage

Fabio Bellini, Department of Quantitative Methods, University of Milano - Bicocca, Piazza Ateneo Nuovo 1, 20126, Milano, Italy, fabio.bellini@unimib.it

We introduce a nested sequence of vector stochastic orderings in a space of payoffs and provide the corresponding notion of k-th order arbitrage. We characterize absence of k-th order arbitrage by means of the existence of suitable state price densities. We show the link with option pricing bounds based on stochastic dominance considerations, introduced by Perrakis and Ryan (1984), Levy (1985) and Ritchken (1985) among others. We show how these results can be generalized to markets with bid/ask spreads and provide numerical and empirical examples.

3 - SMED: statistical analysis of setup time reduction in plastic injection machines

Helena Alvelos, DEGEI, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal, helena.alvelos@ua.pt, *Telmo Correia*, *Ana Raquel Xambre*

The work was developed in a department that includes 50 plastic injection machines. In order to improve their utilization rate and increase flexibility SMED (single minute exchange of die) principles were applied to the mould changing operation. Setup times were registered, before and after SMED application, and the impact was statistically analyzed using data from 21 machines. The study is a quantitative analysis of the benefits of SMED in a real world situation and contributes to a better understanding of the impact these methods have in the reduction of waste inside organizations.

4 - Statistical analysis of Public and National accounts related with expenses of previous years

Paula Santos, Faculdade de Ciências da Economia e da Empresa, Universidade Lusfada de Lisboa, R. da Junqueira 188, Lisboa, Portugal, paula.santos@oniduo.pt, *Manuela Sarmiento*

Portugal has to comply with the ESA 95 criteria, in which expenses of previous years assume special significance since they are considered in the national accounts deficit. Thus, this paper intends to present how those expenses are being calculated. The results presented are based on surveys, carried out in General Government, in 2008. The methodology was based on the exact results of Pearson chi-square test and contingency tables. As a main conclusion, it is pointed out that the criteria adopted to recognize the expenses of previous years are not harmonized, limiting the convergence between Public and National Accounts and, especially, conditioning the calculation of the deficit reported to EU.

MF-20

Monday, 17:20-18:40

1.3.33A

Cutting and Packing 5

Stream: Cutting and Packing

Invited session

Chair: *Pedro Castro*, UMOSE, LNEG, 1649-038, Lisbon, Portugal, pedro.castro@ineti.pt

1 - An exact approach for the 1D contiguous bin packing problem

Marat Mesyagutov, Numerical Mathematics, Dresden University of Technology, Zellescher Weg 12 - 14 (C 319), 01069, Dresden, Germany, mmesyagutov@googlemail.com, *Guntram Scheithauer*, *Gleb Below*

The problem of the 1D contiguous bin packing problem is considered as the main problem of the talk. For its solution we propose an exact algorithm based on branch and bound method using linear programming. Solution of the posed problem is used to obtain improved lower bounds for the 2D strip packing problem. The computational results, which will be presented, are obtained on 2D strip packing problem instances.

2 - Codifications in Evolutionary Algorithms for the Multi-Objective 2D Guillotine Strip Packing Problem

Jesica de Armas, Estadística, I. O. y Computación, University of La Laguna, Avda. Astrofísico Francisco Sanchez, S/N, 38271, La Laguna, Spain, jdearmas@ull.es, *Gara Miranda*, *Coromoto Leon*

The 2D Strip Packing Problem can be posed as a multi-objective optimisation problem. For the problem solution, we have applied some of the most-known multi-objective evolutionary algorithms. We proposed a solution codification which is based on a complete representation of pattern layouts. This approach was promising but wasn't suitable to afford large instances. That is why we have focused on the design of a codification which can be much more competitive. So, we have proposed several hyperheuristic-based codifications covering different regions of the search space for large instances.

3 - An improvement of the Best-Fit heuristic for 2D Strip Packing Problem

Miroslav Rada, University of Economics in Prague, Czech Republic, miroslav.rada@vse.cz

Paper deals with the Best-Fit heuristic for 2D-regular-ODP (2D strip packing problem), proposed by Burke et. al in 2004. The algorithm is based on finding the lowest possible gap and placing a dynamically selected rectangle inside it, and was shown to give high quality solutions. Strategy of selecting rectangle for the placement is modified in the paper. Efficient implementation of the strategy with time complexity $O(n \cdot \log(n))$ is suggested. Original algorithm can be implemented in $O(n \cdot \log(n))$, too. The proposed modification achieves better results for more than one half benchmark problems.

4 - New MILP Model for the 2D Strip Packing Problem

Pedro Castro, UMOSE, LNEG, 1649-038, Lisbon, Portugal, pedro.castro@ineti.pt, *Jose Fernando Oliveira*

We propose a model relying on the concept of events to continuously locate the rectangles along the strip height. It is a mixed discrete/continuous-space model, continuous in the y-axis and discrete in the x-axis. The latter is divided into slots of unitary size and each partial strip can be associated to a different space grid. The location of event points will vary from one grid to the next and the challenge is to ensure that a given event point has the same y-coordinate in consecutive grids whenever there is a rectangle assigned to them. Results for a set of 29 instances are given.

MF-21

Monday, 17:20-18:40

6.2.47

Optimization Modeling III

Stream: Software for OR/MS

Invited session

Chair: *David Canca*, School of Engineers, University of Seville., Av. de los Descubrimientos s/n, Isla de la Cartuja, 41092, Seville, Spain, dco@us.es

1 - Management of loading operations in the cement industry

Tuomo Takkula, Logistics Systems Division, Inform GmbH, Pascalstraße 23, 52076, Aachen, Germany, tuomo.takkula@inform-ac.com

In a typical cement plant a variety of products is loaded onto trucks, trains and ships. The products are moved from the silos to the loading points via a mechanical transportation layer. In general, the loading of a product at one loading point prevents the loading of certain products at other loading stations, turning load scheduling into a complex problem. We present a two-stage MIP-based multicommodity flow model which deals with these and other constraints and permits the scheduling of all load operations in a cost-effective way.

2 - A Diet Planning Model for Malaysian Boarding School using Integer Programming

Suliadi Firdaus Sufahani, Applied Mathematics, University Of Sheffield, Hicks Building, Hounsfield Road, S3 7RH, Sheffield, United Kingdom, app08sfs@sheffield.ac.uk

Integer Programming is a mathematical method that can solve this type of problem and determines the most nutritious and palatable meals while considering the constraints of the Recommended Nutrient Intake for Malaysian children aged 13 to 18 years old, the cost of the menu items, the budget provided by the government, and the variety of menus. The problem is large and integer programming will be used. A system will be developed for the caterers of the Malaysian boarding schools by using LPSolve with Matlab.

3 - Diet Scheduling-A Means To Aid Rural Health Care

Sanchita Jha, CSE, PESIT, India, ruchi.superstar@gmail.com,
Suraj Agarwal, *Rishil Murukan Mypalli*, *Vinu Agrawal*

Diet scheduling is a relatively less explored problem in the field of operations research. So we have built a health care tool that takes into account the food habits, age, BMI, gender, physical activity, economical viability and nutritional requirement of any individual and outputs the minimum cost balanced diet; thereby combating ignorance and poverty, the two major problems of rural areas. This problem falls within the purview of linear programming model of operations research involving 108 decision variables and 16 constraints. We have used our own optimization algorithm to solve the same.

4 - A mixed integer programming model applied to the optimization of cleaning procedures in a sunlight collector field.

David Canca, School of Engineers, University of Seville., Av. de los Descubrimientos s/n, Isla de la Cartuja, 41092, Seville, Spain, dco@us.es, *Pedro L. Gonzalez-R*, *Gabriel Villa*

Renewable energy, and more specifically those based on solar energy, are a clear alternative to the fossil fuel energy. There are many solar energy plants that are opening throughout the world. The solar plants efficiency is closely related with an appropriate policy in cleaning and maintaining processes. Unfortunately, these aspects are not usually taken into account in the actual design of plants. This work presents a mathematical model to address this issue.

MF-22

Monday, 17:20-18:40

3.1.10

Quantitative Health Care Policy Decision Making

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 - Disaster planning for ambulance services: a training tool using DES

Marion Rauner, Dept. Innovation and Technology Management, University of Vienna, Bruennerstr. 72, A-1210, Vienna, Austria, marion.rauner@univie.ac.at, *Helmut Niessner*

Due to severity, timing, location, and number of injured people related to a disaster, emergency staff faces different disaster situations and has to best cope with them. Besides fixed rules for triage of patients and treatment prioritization, emergency officers have to decide on organizational structures and on allocating ambulance officers to triage tents or ambulance cars depending on the disaster situation. We have provided the Austrian Samaritan Organization which a graphical simulation tool for training their emergency staff to best handle decision making for numerous disaster sites.

2 - Hospital productivity and technical progress across Austrian public hospitals

Margit Sommersguter-Reichmann, Institute of Industrial Management, University of Graz, Universitaetsstrasse 15, Resowi, G2, 8010, Graz, Austria, margit.sommersguter@uni-graz.at, *Adolf Stepan*, *Mex Glawischinig*

We examine productivity changes of Austrian hospitals (1999-2007) with a Malmquist productivity index. Former studies have revealed artificial rather than actual productivity progress as a result of using credit points in the output vector. The revision of the activity based system, however, has not resulted in the re-calculation of credits based on the obsolete system so that any structural changes are directly reflected in the productivity index. We use linear regression to analyse whether productivity changes can be explained by structural changes beyond the changes in the financing system.

3 - Estimating the Impact of Stochasticity in Operating Theatres

Jean-Sébastien Tancrez, Operations Management, EPFL, Ecole Polytechnique Fédérale de Lausanne, EPFL - TOM, Odyssea 2.19, Station 5, 1015, Lausanne, Switzerland, jean-sebastien.tancrez@epfl.ch, *Benoît Roland*, *Jean-Philippe Cordier*, *Fouad Riane*

Even if it is clear, the stochastic nature of operating theatres is often bypassed in their management, or handled using simple rules. Our goal is to help managers rationalizing the consideration of stochasticity in OT. Based on the Markov theory, our approach allows estimating the impact of the randomness coming from the operating times, the unexpected emergencies and the blocking due to the recovery unit. For example, our tool evaluates the waiting time of the emergencies, the disruption of the planning, or the number of operations to plan so that the overtime is kept limited.

MF-23

Monday, 17:20-18:40

6.2.49

MOO: Network Territorial Partition Problems

Stream: Multi-Objective Optimization

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 - Models for the integration of MCDA and GIS: Usage and weaknesses

Karim Lidouh, Computer and Decision Engineering (CoDE), Université Libre de Bruxelles, Bvd du Triomphe CP210/01, 1050, Brussels, Belgium, klidouh@ulb.ac.be, *Esteban Zimányi*, *Yves De Smet*

Since a few years there has been a tendency to integrate methods from the MCDA field in geographical information systems (GIS). This integration allows taking multiple criteria into account when dealing with spatial decision problems. Several integration models have already been proposed to explain how some multicriteria methods should interact with GIS. However they often present some shortcomings and ultimately cannot be applied to any kind of spatial decision problem. In this contribution, we analyze some of the existing models and propose adaptations to broaden their domain of application.

2 - Aggregating Census Units with a Multi-Objective Genetic Algorithm: Preliminary Results of a Case Study in Canada

Dilip Datta, Mechanical Engineering, National Institute of Technology Silchar, India., Silchar, Cachar, Assam, 788010, Silchar, Assam, India, datta_dilip@rediffmail.com, *José Rui Figueira*, *Jacek Malczewski*

Small census units of London, Ontario are aggregated into census tracts (CTs) in conjunction with Statistics Canada. The aggregation aims at compactness of CTs, their population and area based homogeneities, as well as other subjective considerations. A degree of compactness is achieved, but with substantial discrepancies in the homogeneities. Therefore, a multi-objective genetic algorithm is investigated for improving the aggregation. Circular- and square-shaped CTs are studied by maximizing their compactness, as well as population and area based homogeneities. The results are considerably better than the actual CTs, in terms of all the three objectives for the two measures of compactness.

3 - Graph Partitioning by a Real-Coded Multi-Objective Genetic Algorithm

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, *Dilip Datta*

The graph partitioning problem is usually solved by problem-specific versions of an algorithm. Moreover, although various population-based metaheuristics are now in great consideration towards different problem-domains, these are yet to be studied widely to this problem. In this work, some mechanisms are proposed for handling the problem by a general real-coded multi-objective genetic algorithm. Applying to two large-size two-objective test cases, reasonably good solutions could be obtained. Moreover, the proposed real-coded algorithm is found outperforming an integer-coded genetic algorithm.

■ MF-24

Monday, 17:20-18:40

6.2.50

Natural Computation in Bioinformatics

Stream: Computational Biology, Bioinformatics and Medicine

Invited session

Chair: *Mario Pavone*, Department of Mathematics and Computer Science, University of Catania, v.le A. Doria 6, 95125, Catania, Italy, mpavone@dmi.unict.it

1 - Metabolic P Models for Biological Phenomena

Giuditta Franco, Department of Computer Science, University of Verona, Italy, Ca' Vignal 2 - Strada Le Grazie 15, 37134, Verona, Italy, giuditta.franco@univr.it, *Vincenzo Manca*

Metabolic systems are traditionally modeled by differential equations, exhibiting intrinsic limitations in the actual evaluation of kinetic reaction rates. In this work we present MP systems, which are multiset grammars regulated by flux maps, that allow to deduce, from time series observed at macroscopic temporal scales, a discrete model of the bioprocess under investigation. This methodology opens the possibility to understand systemic logic of the process. The theory of MP systems is based on algebraic and algorithmic procedures.

2 - A Formal Framework of Computational Modeling for Ecosystems Based on Membrane Computing

M. Angels Colomer, University of Lleida, 25198, Lleida, colomer@matematica.udl.es, *Antoni Margalida*, *Ignacio Pérez-Hurtado*, *Mario J. Pérez-Jiménez*

Our aim is to present a new computing bioinspired model in the formal framework of Membrane Computing, an emergent branch of Natural Computing. This new model of computation has been introduced with the aim of defining computing devices that abstract from the structure and the functioning of the living cells. Ecosystems are described by means of multienvironment P systems consisting of a finite number of environments, each of them having a specific P system with active membranes. Each rule has associated a probabilistic constant which depends on the left-hand side of the rule and the runtime.

3 - Optimization Algorithms for the Protein Structure Prediction Problem

Mario Pavone, Department of Mathematics and Computer Science, University of Catania, v.le A. Doria 6, 95125, Catania, Italy, mpavone@dmi.unict.it, *Giuseppe Nicosia*, *Vincenzo Cutello*

Discrete models for protein structure prediction embed the protein amino acid sequence into a discrete spatial structure where an optimal tertiary structure is predicted on the basis of simple assumptions relating to the hydrophobic-hydrophilic character of amino acids in the sequence and to relevant interactions for free energy minimization. A quick, state-of-the-art survey of discrete models and evolutionary algorithms for protein structure prediction is presented, and the main design and performance features of an immunological algorithm are illustrated in a tutorial fashion.

4 - Bio-Inspired Reverse Engineering Methodologies to Infer the Gene Regulatory Networks

Mario Pavone, Department of Mathematics and Computer Science, University of Catania, v.le A. Doria 6, 95125, Catania, Italy, mpavone@dmi.unict.it, *Natalio Krasnogor*

The purpose of Reverse Engineering is to elicit the internal structures of a given system from external observations. RE plays a central role in systems biology since it is important also to understand the dynamics of the genes and proteins. Identifying genes and proteins is not enough to understand the complexity of the system but need to know how these objects interact each other. Classical methods have been used to infer the genes interaction whose drawback is to map genes in a binary state. RE based on bio-inspired algorithms is able to effectively reconstruct the networks in dynamic models.

■ MF-25

Monday, 17:20-18:40

6.2.48

Financial Risk Management

Stream: Financial Mathematics and OR

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Apostolos Fertis*, IFOR, D-MATH, ETH Zurich, 101 Rämistrasse, HG G 22.1, 8092, Zürich, Switzerland, afertis@ifor.math.ethz.ch

1 - Robust Risk Management

Apostolos Fertis, IFOR, D-MATH, ETH Zurich, 101 Rämistrasse, HG G 22.1, 8092, Zürich, Switzerland, afertis@ifor.math.ethz.ch

Often, the distribution of the returns of financial assets is given in two levels. The first level comprises of the non-accurate distribution over a set of scenarios, while the second level contains the precise distributions under the scenarios. We construct the class of robust risk measures, that tackles this uncertainty by applying robust optimization in the first level and a traditional risk in the second level. We define Robust CVaR as the robust risk corresponding to CVaR and design a way to compute it. We compare optimal-RCVaR and optimal-CVaR portfolios in real NYSE and NASDAQ data.

2 - Australian Electricity Market and Price Volatility

Ghazaleh Mohammadian, School of Mathematics and Statistics, University of South Australia, School of Mathematics and Statistics, Mawson Lakes Campus, 5095, Adelaide, South Australia, Australia, ghazalehmohammadian@yahoo.com, *Jerzy Filar*, *Asef Nazari*

Australian Electricity Market has experienced high price volatility since the deregulation in early 1990's. Considering variance as a measure of price risk, we demonstrate that this risk is increasing dramatically in high demand periods. We consider two-sided risk in terms of prices exceeding, or falling below, the mean. Closer examination shows that bidding behaviour of generators increases risk of volatility in general and the left-sided risk more than right-sided risk. Finally we suggest a new bidding strategy for generators which will result in alleviating this price volatility.

3 - Forecasting Stock Index Realized Volatility with an Asymmetric HAR-FIGARCH Model: The Case of S&P 500 and DJIA Stock Indices

Dimitrios Louzis, Management Science and Technology, Athens University of Economics and Business, 3, Amerikis Str, 10564, Athens, Greece, dlouzis@aueb.gr, *Spyros Xanthopoulos*, *Apostolos Refenes*

The Heterogeneous Autoregressive (HAR) model proposed by Corsi is extended in order to account for leverage effects in the realized volatility process and the long memory of the conditional variance of the HAR residuals. Estimation results reveal a heterogeneous component structure in asymmetric effects and a significant long memory property in the "volatility of realized volatility". Compared with established HAR and ARFIMA realized volatility models, the proposed model exhibits superior out-of-sample volatility and Value at Risk forecasting performance.

4 - Dual representation of choice and aspirational preferences

David Brown, Duke University, United States, dbbrown@duke.edu, *Melvyn Sim*, *Enrico De Giorgi*

We study a general class of preferences that favor diversification, except perhaps on a subset of sufficiently disliked acts, where concentration is preferred. This structure encompasses a number of known models. We show that such preferences can be expressed in dual form in terms of a family of risk measures and a target function. One special case that we explore in detail is that of a bounded target function. This case corresponds to a type of satisficing and has descriptive relevance. The model is amenable to large-scale optimization.

MF-26

Monday, 17:20-18:40

3.1.11

Neural Network Applications

Stream: Machine Learning and Its Applications

Invited session

Chair: *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

Chair: *Gurkan Ozturk*, Industrial Engineering, Anadolu University, AU-MMF-Industrial Engineering, Iki Eylul Campus, 26480, Eskisehir, Turkey, gurkan.o@anadolu.edu.tr

1 - Performances of the ANN, SVM, and K-means clustering methods for recognizing different environmental sounds

Inci Saricicek, Industrial Engineering Dept., Eskisehir Osmangazi University, ESOGU, Bati Meselik, 26480, Eskisehir, Turkey, incid@ogu.edu.tr, *Buket Barkana, Burak Uzkent*

Automatic environmental sound classification has become a very active subject of research during last decades. This study investigates the categorization of environmental sounds using Support Vector Machine, K-means clustering and Neural Networks. With this study, we present the performances of three methods for classifying three commonly encountered sounds: Rain, engine and restaurant

2 - Optimization of the automatic manipulator trajectory using stochastic algorithm and neural networks

Alina Fedosova, Mathematics, Universidad Nacional, Cll 159 # 56-75, t 4 ap 403, 12345, Bogota, Cundinamarca, Colombia, afedosova@unal.edu.co

We present the stochastic outer approximations algorithm for robot trajectory planning. Initially, it is an automatic manipulator of three degrees of freedom. The proposed problem consists of finding total optimal time of displacements which must adjust to the trajectory using cubic splines constrained by the speed, acceleration and jerk. It's a problem of semi-infinite optimization. After we find the minimum travel time of robot using neural networks that are trained on the results of the previous algorithm. For this purpose we use three types of neural networks in MATLAB.

3 - Paraconsistent Artificial Neural Network — PANN and EEG Analysis

Jair Minoro Abe, Paulista University, Rua Dr Bacelar 1212, 04026-002, Sao Paulo, SP, Brazil, jairabe@uol.com.br, *Fábio Romeu de Carvalho*

Abstract: Since the first works on ANN, several theories have been developed. Recently, we have introduced a new ANN, namely the Paraconsistent Artificial Neural Network — PANN, based on Paraconsistent Annotated Evidential Logic Et. Such logic (and so PANN) can manipulate concepts like imprecision, inconsistency, and paracompleteness in its interior without trivialization. Some applications in pattern recognition, specifically in EEG analysis are discussed.

4 - Estimating Correlated Constraint Boundaries from timeseries data: The multi-dimensional German Tank Problem

Abhilasha Aswal, Infosys Technologies Limited, Bangalore, India, #44 Electronics City, Hosur Road, 560100, Bangalore, Karnataka, India, abhilasha.aswal@iitb.ac.in, *G. N. Srinivasa Prasanna, Sheela Siddappa*

We present a multidimensional generalization of the 1-D German Tank problem. N-D correlated data samples are drawn from a uniform distance, in a region bounded by linear constraints. These constraints have to be estimated minimizing variance without bias (UMVU estimator). Our new UMVU uses k-means clustering of the facets of the convex hull of data. Convergence time is polynomial in accuracy. We apply this to estimating constraints in robust optimization approaches to supply chain mgmt. As opposed to general MSE, our parameters are structurally limited to forming a non-empty polytope.

MF-28

Monday, 17:20-18:40

8.2.10

Stochastic Programming - General Methodology

Stream: Stochastic Programming 1

Invited session

Chair: *Martin Branda*, Department of probability and mathematical statistics, Charles University in Prague, Ke Karlovu 3, 121 16, Prague, Czech Republic, martin.branda@seznam.cz

1 - Line-search with variable-number sample size

Natasa Krklec, Department of Mathematics and Informatics, University of Novi Sad, Trg Dositeja Obradovica 4, 21000, Novi Sad, Serbia, natasa.krklec@dmi.uns.ac.rs, *Natasa Krejic, Katarina Vla*

We are dealing with simulation-based optimization. The objective function is assumed to be in the form of mathematical expectation and it is approximated by a sample mean. The sample size is updated in every iteration. Since analytical form of the objective function is unknown, the gradient is also unavailable. Therefore we are using derivative free approach, such as regression, to obtain the model and the search direction in every iteration. We are using line search techniques to determine the candidate for a next iteration. Convergence is analyzed and numerical results are discussed.

2 - Reformulation of general chance constrained problems using the penalty functions

Martin Branda, Department of probability and mathematical statistics, Charles University, Sokolovska 83, 18675, Prague, Czech Republic, martin.branda@seznam.cz

We explore reformulation of nonlinear stochastic programs with several joint chance constraints by stochastic programs with suitably chosen penalty-type objectives. We show that the two problems are asymptotically equivalent. We discuss solving both problems using Monte-Carlo simulation techniques for the case when the set of feasible solution is finite which appears in bounded integer programs. The approach is applied to the financial optimization problem with Value at Risk constraint, transaction costs and integer allocations.

3 - Some Recent Results in Stochastic Gradient Estimation

Michael Fu, Smith School of Business, University of Maryland, Van Munching Hall, 20742, College Park, MD, United States, mfu@umd.edu

We review some recent results in stochastic gradient estimation, where direct unbiased estimators are obtained for simulation models. The techniques considered are perturbation analysis, the likelihood ratio (score function) method, and weak derivatives. Applications to stochastic activity networks and in financial engineering are considered. In particular, performance measures involving indicator functions and quantiles are addressed.

MF-29

Monday, 17:20-18:40

8.2.11

Boolean methods in system analysis, learning and circuit synthesis

Stream: Boolean Programming

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 - Symbolic Model Checking of Boolean Models in Biology

Arlindo Oliveira, INESC-ID/IST, R. Alves Redol 9, 1000, Lisbon, Portugal, aml@inesc-id.pt

Boolean models of gene regulatory networks can be used to analyze and characterize the behavior of these complex systems. The application of symbolic model checking techniques, developed for the analysis of state spaces of digital systems, enables researchers to answer important questions on the nature of the state spaces of gene regulatory networks, such as the robustness of the system to perturbations and the characteristics of the basins of attraction. I will describe the application of these techniques to the gene regulatory models of two biological networks in Yeast and the fruit fly.

2 - Boolean Machine Learning as a Tool for Model Inference from Data

Diego Liberati, Elettronica e Informazione, Politecnico, CNR IEIIT, INFN MiB, Politecnico di Milano, Italy, Piazza Leonardo da Vinci 32, 20133, Milano, Italy, liberati@elet.polimi.it

Synthesis of Boolean functions can be applied to machine learning, to infer directly from data both the very salient variables, and their even nonlinear static interplay. More complex adaptive Bayesian networks just add ranking among such salient variables, useful in pathways discovery in systems biology from microarrays analysis. The analysis of the dynamic interplay among the salient variables thus identified is made easy by piecewise affine identification, providing a linearized model of the switching behaviour of the investigated plant within the hybrid systems paradigm.

3 - An Efficient Heuristic Approach to Solve the Unate Covering Problem

Fabrizio Ferrandi, Dipartimento d'Elettronica e Informazione, Politecnico di Milano, Milano, Italy, 20133, Milano, Italy, ferrandi@elet.polimi.it

We describe a constructive heuristic algorithm for two-level logic minimization that combines advances in data structures (the use of Binary Decision Diagrams) with lagrangian relaxation. This technique allows an effective choice of the elements in the solution, as well as cost-related reductions of the problem and a good lower bound on the optimum. The results show that on a wide set of benchmark problems, the algorithm nearly always hits the optimum, and in most cases proves it to be such. On the problems whose optimum is actually unknown, the best known result is strongly improved.

4 - Boolean functions in cryptography

Enes Pasalic, FAMNIT, University of Primorska, Glagoljaska 8, 6000, Koper, Slovenia, enespasalic@yahoo.se

In this talk a broad range of applications of Boolean functions in cryptography is discussed. Boolean functions are basic cryptographic primitives in the design of symmetric cryptographic systems, such as stream and block ciphers, and many other cryptographic algorithms. Its design is closely related to certain combinatorial problems, among others to integer optimization methods and some problems related to graph theory. We briefly consider this connection, and in addition different state-of-the-art approaches in designing cryptographically "secure" Boolean functions are addressed.

MF-30

Monday, 17:20-18:40
8.2.13

New issues in aggregation-disaggregation philosophies

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

Invited session

Chair: *Evangelos Grigoroudis*, Decision Support Systems Laboratory, Technical University of Crete, University Campus, Kounoupidiana, 73100, Chania, Greece, vangelis@ergasya.tuc.gr

Chair: *Yannis Siskos*, Department of Informatics, University of Piraeus, Karaoli Dimitriou 80, 18534, Piraeus, Greece, ysiskos@unipi.gr

1 - A DSS for Robustness Analysis in Multicriteria Satisfaction Evaluation

Nikos Tsotsolas, Department of Statistics and Insurance Science, University of Piraeus, 2, Feidiou Str, 15236, Penteli, Greece, ntsotsol@unipi.gr, *Yannis Siskos*

MUSA methodology, as an MCDA disaggregation approach to customer satisfaction evaluation problems, encompasses robustness concern, a necessary step towards the inference of robust satisfaction functions which shall be optimally consistent with expressed customers' judgements. This paper presents a DSS which aims in providing substantial help to MUSA users, in three levels: (1) in benchmarking different robustness procedures (analytic and heuristic ones) for a given set of data, (2) in selecting the most appropriate parameters of the method and (3) in producing the full range of MUSA results.

2 - Extensions of the MUSA method: Modeling additional preferences

Evangelos Grigoroudis, Decision Support Systems Laboratory, Technical University of Crete, University Campus, Kounoupidiana, 73100, Chania, Greece, vangelis@ergasya.tuc.gr, *Yannis Siskos*

The MUSA method is a preference disaggregation approach following the main principles of ordinal regression analysis. This study presents several 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. Finally, this study presents alternative objective functions during the post-optimality analysis process of the MUSA method.

3 - Multi-attribute Utility Theory without Preference Independence — Conception of a real multiplicative Preference Elicitation and Aggregation Method.

Johannes Siebert, Business Administration, University of Bayreuth, Universitätsstr. 30, 95440, Bayreuth, Bayern, Germany, Johannes.Siebert@uni-bayreuth.de

This paper introduces a new model called aggregate utility coefficient model (AUCM) that extends the MAUT that dependent preferences can be accounted for. Decision makers articulate their preferences relatively to an average of an alternative by means of interaction coefficients. The dimensional-specific preferences are multiplied to yield utility level on which the final decision is based. The terms obtained by a second or higher order Taylor expansion of the product at the average preference level are economically interpreted and used to model preferences and their interdependencies.

MF-32

Monday, 17:20-18:40
8.2.17

OR in Animal Production

Stream: OR in Agriculture and Forest Management
Invited session

Chair: *Anders Ringgaard Kristensen*, Department of Large Animal Sciences, University of Copenhagen, Faculty of Life Sciences, Groennegaardsvej 2, Frederiksberg C, DK-1870, Copenhagen, Denmark, ark@life.ku.dk

1 - Optimization of heifer rearing strategy in Polish beef herds

Anna Stygar, Department of Cattle Breeding, University of Agriculture in Krakow, al. Mickiewicza 24/28, 30-059, Crakow, Poland, astygar@ar.krakow.pl, *Anders Ringgaard Kristensen*, *Joanna M. Makulska*

Beef cow lifetime productivity, measured by the number and weight of the calves weaned in the whole reproductive period, is considerably affected by heifer rearing strategy. The key elements of this strategy are the decisions on heifer growth rate and the moment of her first breeding. The objective of the study was to apply the multi-level hierarchic Markov process to determine the economically optimal rearing strategy for Polish beef heifers. The optimized decisions concerned the intensity of heifer feeding, the age, body weight and season at her breeding and the time for replacement.

2 - A multistage stochastic programming model for planning piglet production

LluisM Pla, Mathematics, University of Lleida, JaumeII,73, 25001, Lleida, Spain, lmpa@matematica.udl.es, *Sara Verónica Rodríguez-Sánchez*, *Victor Albornoz*

The planning of piglet production is central into modern pig production in connection with supply chain coordination. The complexity of piglet production is mainly affected by the stochastic nature of biological processes involved, highly variability on markets and rational scheduling of tasks on farm. In this way, the farmer has to make decisions today at different levels of uncertainty that are affecting future performances of the farm and chain. Hence a preliminary multistage stochastic programming model with recourse for planning piglet production under finite time horizon is presented.

3 - Optimization of reproduction and production cycles for high yielding dairy cows

Joanna M. Makulska, Department of Cattle Breeding, University of Agriculture in Krakow, al. Mickiewicza 24/28, 30-059, Kraków, Poland, rzmakuls@cyf-kr.edu.pl, *Andrzej Węglarz*, *Anna Stygar*, *Barbara Tombarkiewicz*

The aim of the study was to use a multi-level hierarchical Markov decision process for the optimal management of reproduction and production cycles of dairy cows. The parameters of the developed model were estimated using the data records from the specific herd of high yielding cows in Poland. The optimized decisions concerned the length of days open and days dry periods in the consecutive calving intervals of a cow and the time of her replacement with a heifer. The criterion of optimality was assumed as the maximization of the total present value of the expected net returns per cow place.

4 - Replacement policies for dairy cows

Lars Relund Nielsen, Centre for Operations Research Applications in Logistics (CORAL), Aarhus School of Business, University of Aarhus, Fuglesangs Allé 4, 8210, Aarhus V, Denmark, lars@relund.dk, *Anders Ringgaard Kristensen*, *Erik Jørgensen*

In a recent paper a hierarchical Markov decision processes (MDP) with finite state and action space was formulated for the dairy cow replacement problem with stage lengths of 1 d. Bayesian updating was used to predict the performance of each cow in the herd and economic decisions were based on the prediction. The model can be used to assist the farmer in replacement decisions on a daily basis and is based on daily milk yield measurements that are available in modern milking systems. This talk will present the results of the paper and discuss directions for further research.

MF-33

Monday, 17:20-18:40

8.2.19

Environmental Management II

Stream: Energy, Environment and Climate [c]

Contributed session

Chair: *Christos Ioakimidis*, MECHANICAL ENGINEERING, INSTITUTO SUPERIOR TECNICO (IST) - UNIVERSIDAD DE LISBOA (UTL), Av. Rovisco Pais, 1049-001, LISBON, Portugal, christos.ioakimidis@dem.ist.utl.pt

1 - The effect of environmental uncertainty on operations priorities and business performance

Ahmed Attia, business management, alexandria university, elgomohoria st., 000, damanhour, elbehera, Egypt, ahmed-attia2005@hotmail.com

Operations strategy is a one of the Functional strategies which help the company to deal with the environmental uncertainty, the operations strategy could be translated into operations priorities (cost, flexibility, quality, delivery). The current research investigated the effect of environmental uncertainty on operations priorities, then the research investigated the effect of operations priorities on business performance. The current research data was collected from Egyptian Pharmaceutical industry

2 - Integrating Environmental Considerations into the Supplier Selection Criteria

Ceyda Şen, Yildiz Technical University, Turkey, cgungor@yildiz.edu.tr, *Mercan Ozturk*, *Özge Nalan Alp*

In the traditional supplier selection process, standard criteria like cost, quality and delivery performance are considered. However, growing environmental concerns have led the purchasing professionals to develop green purchasing strategies, and to rethink the supplier selection process which has neglected environmental impacts. To facilitate the process of the green supplier selection, this paper presents an extensive literature review on environmental considerations, and a hierarchical criteria structure that integrates these factors into the traditional supplier selection criteria.

3 - Airline Service Network Design for Economic and Ecologic Sustainability

Amir José Daou Pulido, Karlsruhe Institute of Technology, Klosterweg 28, Zimmer b16, 76131, Karlsruhe, Baden-Württemberg, Germany, amir.pulido@student.kit.edu, *Cornelia Schoen*

In an effort to help reduce CO₂ emissions and mitigate the climate impacts, the EU recently announced that as from 2012 the aviation sector will be included in the EU Emissions Trading Scheme. In particular, all flights starting and landing in the EU will be subject to a cap on their emissions. In preparation of this regulation, airlines are spurred to explore how they can improve their operations for economic and ecologic sustainability. We present an optimization model for airline service network design that integrates profit and environmental goals to comply with the new regulation

4 - Enhancing electric energy management decisions with an Energy box

Luis Oliveira, Mechanical Eng., Instituto Superior Técnico, Rua Sarmiento Beires n° 15 5º direito, 1900-410, Lisboa, Lisboa, Portugal, luis.jose.oliveira@gmail.com, *Christos Ioakimidis*, *Paulo Ferrao*

This study presents a future where the consumer has an Energy box, a 24/7 processor operating on a PC, to manage the electrical energy at his residence or small business, integrated in a microgrid. The considered model is a house with microrenewables production, air conditioner, and an electric vehicle that provides storage capacity. We propose an algorithm for the energy box with forecasted parameters (weather, electricity prices) and deterministic parameters (house's loads, temperatures) as input, to obtain increases in the renewable energies penetration, power quality, and cost reduction

MF-34

Monday, 17:20-18:40

8.2.23

Model Formulations and Real World Applications of Lot Sizing and Scheduling II

Stream: Lot-sizing and Scheduling, Economic Order Quantity

Invited session

Chair: *Reinaldo Morabito*, Dept. of Production Engineering, Federal University of São Carlos, CP 676, 13565-905, São Carlos, Sao Paulo, Brazil, morabito@ufscar.br

1 - A production scheduling problem on an aerospace assembly fixture

Horacio Yanasse, LAC, INPE, Av. dos Astronautas 1758, CP 515 - INPE/CTE, 12227-010, São José dos Campos, SP, Brazil, horacio@lac.inpe.br, *Bruno Silva*, *Reinaldo Morabito*

In this work we consider a production scheduling problem in an aerospace industry where workstations are located side by side in an assembly fixture. Depending on the jobs, adjacent workstations cannot process them at the same time due to space limitations. Moreover, jobs have precedence constraints, due dates, arrival times and technological constraints. The objective is to minimize the makespan. The problem is formulated as an MIP and solved by CPLEX. The solution obtained can improve significantly the production schedule when compared with the one used in practice.

2 - A hybrid general lot-sizing and scheduling formulation for a production process with a two-stage product structure

Sandra Transchel, Department of Supply Chain and Information Systems, Penn State University, 461 Business Building, 16802, University Park, PA, United States, sxt37@psu.edu

The paper is the result of a project with a chemical company. We present a hybrid mixed-binary optimization model based on the General Lot-sizing and Scheduling Problem (GLSP) for a production process characterized by a two-stage product structure. Several company-specific requirements were considered which are not found in many classic lot-sizing models. We present two alternative reformulations based on the simple-plant-location problem. An extensive computational experiment based on real industry data is presented.

3 - Apply local branching to solve lot sizing problems

Renato Paiva, ICMC - USP, 13560970, São Carlos, São Paulo, Brazil, renatodepaiva@gmail.com, *Franklina Toledo*

This work focuses on the capacitated lot-sizing problem (CLSP), which is one of the central tasks involved in production planning. The CLSP studied the following characteristics: multiple items; set-up times; capacity constraints; backlogging; carry over and overlapping. This work has two main goals: a) to study the influence of the solution of the CLSP when you consider the possibilities described above; b) to apply local branching to solve these problems. To solve the proposed instances, we used CPLEX 11 and a local branching approach proposed here. Good results were obtained.

■ MF-35

Monday, 17:20-18:40

6.2.46

Facilitated Decision Analysis I

Stream: Facilitated Modelling in OR

Invited session

Chair: *Gilberto Montibeller*, Dept. of Management (OR Group), London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.montibeller@lse.ac.uk

1 - Structuring Multicriteria Approaches to Developing Country Problems

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

We review the application of causal mapping approaches to eliciting values from various groups in diverse developmental problem settings such as fisheries rights allocation, management of informal shops in informal settlement areas, and the establishment of food banking. In each case, the resulting structure was expressed in formal multicriteria terms for purposes of evaluating future courses of action. Stakeholders in the workshops came from a variety of backgrounds, some with very little formal educational background. We shall discuss potential adaptations of the approach to link in with systems dynamics models for multicriteria policy evaluation.

2 - A multi-stage, multicriteria framework to support facilitation, problem structuring and choice in outsourcing and supplier selection

Miloslaw Fink, Département d'Informatique, Université de Fribourg, Bd de Pérolles 90, C310, 1700, Fribourg, Switzerland, miloslaw.fink@unifr.ch, *Valerie Belton*, *Marino Widmer*

Decisions about outsourcing and supplier selection can significantly impact on organisational performance. Reported applications of MCDA in this context frame the decision as a single stage choice; however, in reality the situation can be much more complex, comprising several stages and multiple considerations. This paper presents a framework, initially derived from the literature and subsequently tested with practitioners, which makes explicit and helps to structure the different stages of the decision process. A case study to explore the use of the framework in practice is also presented.

3 - Building Decision Support Systems with Facilitated Modelling

Gilberto Montibeller, Dept. of Management (OR Group), London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.montibeller@lse.ac.uk, *L. Alberto Franco*, *Victor Del Rio Vilas*

Most applications of facilitated modelling have been developed in the context of decision conferencing, to support a one-off decision. This type of approach is unsuitable for supporting repetitive decisions or those which involve a large set of options. In this paper we suggest an alternative use of facilitated modelling: to build up decision support systems (DSSs) for recurring decisions. This approach is illustrated by a real-world use, in which a DSS is being developed to aid a multi-criteria assessment of threats and vulnerabilities associated with animal health issues for Defra in the UK.

4 - Facilitated Logistics Analysis: A decision support tool for locating logistic facilities with optimisation and multi-criteria value analysis

Hugo Yoshizaki, Engenharia de Produção, Universidade de São Paulo, Av. Prof. Almeida Prado Trav 2 n.128, Cidade Universitária, 05508-900, São Paulo, SP, Brazil, hugo@usp.br, *Gilberto Montibeller*

Locating logistic facilities, such as plants and distribution centres, in an optimal way, is a crucial decision for manufacturers. We suggest a multi-criteria framework to analyse such problems, which combines the value from the topology of a network (such as total cost or resilience) with the value of its discrete nodes (such as specific benefits of a particular location). In this framework the focus is on optimising the overall logistic value of the network. A decision support tool was developed to facilitate the decision process. An illustrative case will be presented.

■ MF-36

Monday, 17:20-18:40

3.1.05

Fuzzy Optimization and Decision Analysis 1

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence

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: *Josef Vicha*, Mathematical Institute in Opava, Silesian University in Opava, Na rybníčku 1, 74601, Opava, Czech Republic, Josef.Vicha@math.slu.cz

1 - Multiple Criteria Academic Staff Evaluation Models

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, talasova@inf.upol.cz, *Jan Stoklasa*

Various academic staff evaluation models were subjected to detailed analysis. The routine use of weighted mean as a sole aggregation operator proved inappropriate for aggregating evaluations from different academic areas (lecturing, R&D, management). Even more general aggregation operators (OWA, WOWA) still leave some room for improvement. To objectively assess benefit of an individual staff member, the use of a fuzzy rule base in aggregating partial evaluations proves optimal. Our proposed linguistic fuzzy evaluation model is currently being implemented at Palacký University Olomouc.

2 - Fuzzy Models of Decision Making as a Research Tool in Architecture

Zuzana Talasova, Cabinet of Architectural Modelling, Faculty of Architecture, Czech Technical University in Prague, Jugoslavských partyzanu 3, Praha 6, 16000, Prague, Czech Republic, zuza.talasova@post.cz

This paper explores possibilities of using linguistic fuzzy models as a new research tool in the history of architecture. Namely, Adolf Loos's villas are studied applying the models. The aim is to create a linguistic fuzzy model that would characterize the designing process of a "Loosian" villa. Rules applied by A. Loos in villa design are expressed in the form of fuzzy rule bases. The formulation of rules results from the analysis of individual villa designs and is based on theoretical concepts pertaining to Loos's work - in particular, on his concept of a Raumplan (space plan).

3 - Fuzzified Choquet Integral in Multiple Criteria Evaluation Models

Iveta Bebcakova, Department of mathematical analysis and mathematical application, Palacky University Olomouc, Olomouc, Czech Republic, bebcakova.iveta@post.cz, *Jana Talasova*

Within evaluation models, the integrand of the discrete Choquet integral (CI) represents partial evaluations of an alternative with respect to given criteria, while the fuzzy measure, i.e. the generalized monotonic measure, stands for the weights of the sets of criteria. We focus on fuzzified CI. We study the first-level fuzzified CI that handles partial fuzzy evaluations. Then we employ the second-level fuzzified CI where also the weights of the sets of criteria are in the form of fuzzy numbers. The user-friendly SW pertaining to this framework will be presented.

4 - Dual Optimization Problems with Generalized Relational Inequality Constraints

Karel Zimmermann, Faculty of Mathematics and Physics, Applied Mathematics, Charles University, 11800, Prague, Czech Republic, zimmermann@seznam.cz, *Martin Gavalec*

Relational inequalities and equations on fuzzy algebras, which were introduced and applied to some medical problems [E. Sanchez] are generalized. Dual pairs of optimization problems with generalized relational inequality constraints are studied. It is proved that dual pairs possess both weak and strong duality property from the duality theory. Application of the results to finding saddle points of matrices and their relation to some games on fuzzy algebras is discussed. Perspectives of further research are outlined.

MF-37

Monday, 17:20-18:40

3.1.09

OR for Development and Developing Countries II

Stream: OR for Development and Developing Countries

Invited session

Chair: *Honora Smith*, School 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 - Recent Trend of World Productivity Growth: A Stochastic Frontier Application

Sangho Kim, Department of International Trade, Honam University, 506-714, Gwangju, Korea, Republic Of, shkim@honam.ac.kr

Based on Cuesta (2000), we develop a stochastic frontier production model that allows for different groups of countries to have patterns of technical efficiency. We apply our model to Penn World Tables's 53 countries (2000-2003) to decompose total factor productivity growth into technical efficiency change and technical progress. Our results indicate that technical inefficiency is a serious impediment to higher productivity. They also identify varying paths for countries to derive their growth from a combination of components.

2 - Export functions analysis. Czech Republic and EU.

Šárka Krkosková, Department of econometrics, University of economics, Prague, Czech Republic, xeroxy@email.cz, *Adéla Ráčková*

In this paper export functions were formulated and a case of the Czech Republic was studied. Domestic and foreign income represented by GDP, domestic and foreign prices, exchange rates, monetary aggregates, foreign direct investment, the Czech Republic's EU entry, neighbouring countries' EMU accession and start of global financial crises were used to define the functions. Models with combination of mentioned variables, different lags and time period were discussed. GDPs and exchange rates were the significant factors of the export function in most of the models. Prepared under IGA, F4/13/2010.

3 - Development of Logistic Centers in Poland

Iwona Otolá, Management Faculty, Czestochowa University of Technology, ul. Armii Krajowej 19 B, 42- 200, Czestochowa, Poland, iotola@zim.pcz.pl

The logistic centre is the most advanced form of the central unit of logistic networks. The logistic net rich in the linear and scoring infrastructure offering diverse alternatives of elastic configuring chains of supplies is an essential element of functioning of economic networks. The modern logistic centre is forced by the more and more competitive economy to apply modern technologies. Modern centers use computer systems such as expert systems and databases, which managing the object of this type isn't possible without.

4 - Supplier selection in supply chain management of accommodation enterprises (a research in the hotels of turkey)

Mehmet Sarioglan, Tourism, Social Science, Turkey, University Of Balikesir, Balikesir, University, Turkey, mehmets@balikesir.edu.tr, *Cevdet Avcikurt*, *Murat Doğdubay*

In this study, the necessity of a research on supply chain management in accommodation enterprises was detected in order to contribute to the literature and to determine the tendencies of supplier selection criteria in accommodation enterprises. For this purpose, in this research the tendencies of supplier selection criteria in supply chain management were tried to determine in 73 accommodation enterprises which operate in 26 cities of Turkey. Significant differences and similarities between the criteria, which are used by accommodation enterprises in the selection of supplier, and the size of accommodation enterprises were determined in this study.

MF-39

Monday, 17:20-18:40

6.2.45

Limit Behaviour and Approximations I

Stream: Optimal Control

Invited session

Chair: *Vladimir Veliov*, Institute of Mathematical Methods in Economics, Vienna University of technology, ORCOS, Argentinierstr. 8/119, 1040, Vienna, Austria, veliov@tuwien.ac.at

1 - Optimization Methods for Optimal Control Problems with Control and Pointwise State Constraints

Ion Chrysosoverghi, Mathematics, National Technical University of Athens, Agiou Meletiou 93, 11251, Athens, Attica, Greece, ichris@central.ntua.gr, *John Coletsos*, *Basil Kokkinis*

We consider an optimal control problem for systems defined by nonlinear ordinary differential equations, with control and pointwise state constraints. The problem is formulated in the classical and in the relaxed form. Various necessary conditions for optimality are first given for both formulations. For the numerical solution of these problems, we then propose a penalized gradient projection method generating classical controls, and a penalized conditional descent method generating relaxed controls. Using relaxation theory, we study the behavior in the limit of sequences constructed by these methods. Finally, numerical examples are given.

2 - High-Order Approximations in Optimal Control

Vladimir Veliov, Institute of Mathematical Methods in Economics, Vienna University of technology, ORCOS, Argentinierstr. 8/119, 1040, Vienna, Austria, veliov@tuwien.ac.at

The direct numerical methods for solving optimal control problems require: (i) approximation of the admissible controls by a finitely parameterized controls; (ii) discretization of the underlying differential equation. The second issue is well developed, while the error analysis in the first issue is still in a challenging issue. The talk is devoted to new ideas and results related to the last issue. In particular, we investigate the relation between the information pattern of the approximations in (i) and the accuracy of approximation, focusing on higher than first order approximations.

3 - Euler Approximation of Linear-Quadratic Control Problems with Bang-Bang Solutions

Walter Alt, Applied Mathematics, Friedrich-Schiller-Universitaet Jena, Ernst-Abbe-Platz 2, 07743, Jena, Germany, walter.alt@uni-jena.de, *Robert Baier*, *Matthias Gerdt*

We investigate Euler discretizations for a class of optimal control problems with control appearing linearly. First we show first order convergence for the optimal values. Under the additional assumption that the optimal control has bang-bang structure we also derive error estimates for the controls.

■ MF-40

Monday, 17:20-18:40

6.2.52

Telecommunications

Stream: Network Optimization [c]

Contributed session

Chair: *Andras Farago*, Computer Science, University of Texas at Dallas, 800 W. Campbell Rd., 75080, Richardson, Texas, United States, farago@utdallas.edu

1 - Suboptimal solutions to team optimization problems with statistical information structure

Marcello Sanguineti, DIST, University of Genoa, Via Opera Pia, 13, 16145, Genova, Italy, marcello@dist.unige.it, *Mauro Gaggero*, *Giorgio Gnecco*

Network team optimization problems with statistical information structure are investigated. A team of n Decision Makers (DMs), each having at disposal some information (obtained, e.g., by measurement devices or by exit polls) and various possibilities of decisions, coordinate their efforts to achieve a common goal, expressed via a team utility function. Decisions are generated by the DMs via strategies, on the basis of the available information y_1, \dots, y_n that each of them has and in the presence of uncertainties in the "state of the external world" x (which the DMs do not control). Such uncertainties are modeled via a joint probability density $p(x, y_1, \dots, y_n)$. For these problems, optimal solutions in closed form can be derived only in special cases, so a methodology of approximate solution is proposed. Suboptimal solutions are searched for, taking the form of linear combinations of elements from sets of basis functions, possibly with adjustable "inner" parameters. Upper bounds on the accuracy of such suboptimal solutions are obtained. The estimates are expressed in dependence of the number of trigonometric and Gaussian basis functions. The trade-off between the level of decentralization and the smoothness assumptions on the utility function and the probability density, required to derive the upper bounds, is investigated. Numerical results are presented for an instance of the network team optimization problem under study, which models optimal production in a multidivisional firm.

2 - On call admission control with nonlinearly constrained feasibility regions

Giorgio Gnecco, DIST, University of Genoa, Via Opera Pia, 13, 16145, Genova, Italy, giorgio.gnecco@dist.unige.it, *Marco Cello*, *Mario Marchese*, *Marcello Sanguineti*

A simple criterion is proposed to improve suboptimal coordinate-convex policies in Call Admission Control problems with nonlinearly constrained feasibility regions. To test the criterion, numerical simulation results are given. Finally, some structural properties of the optimal coordinate-convex policies are proven, which do not depend on a complete knowledge of the nonlinear boundary of the feasibility region.

3 - Evaluating downside risks in reliable networks

Megha Sharma, Production & Quantitative Methods, Indian Institute of Management Ahmedabad, D-230 IIM Ahmedabad, Vastrapur, 380015, Ahmedabad, Gujarat, India, meghas@iimahd.ernet.in, *Diptesh Ghosh*

Many real world operations require networks spread over large geographical areas. Elements of such networks are often prone to failure. Such networks are modeled as reliable networks, i.e., networks in which arcs and/or nodes can fail from time to time. If an operation is critical, it is useful to measure network performance when it is not performing well. In this paper, we propose two metrics to measure such downside performance, and develop a state-space enumeration based algorithm to evaluate the metrics. We report computational performance of our algorithm on randomly generated instances.

4 - The Multigraph Advantage and Its Application in Network Analysis

Andras Farago, Computer Science, University of Texas at Dallas, 800 W. Campbell Rd., 75080, Richardson, Texas, United States, farago@utdallas.edu, *Dung Trung Tran*

In a number of network models one has to distinguish different types of edges between the same nodes. This occurs quite often in communication networks. For example, in an optical network, the different wavelengths can define distinct logical links between the same nodes. Similar phenomenon occurs in radio networks, when more than one frequency bands are being used simultaneously. In such situations a multigraph, possibly with colored edges, is a more natural model of the network than a simple graph.

Our goal is to investigate the gain that can be obtained in some important graph parameters via allowing parallel edges in the network model. We introduce the concept of the multigraph sum, in which several simple graphs on the same node set are merged to form a multigraph. We prove that when the component graphs are chosen randomly, then the edge-connectivity of the resulting multigraph has an unexpectedly high surplus over the sum of the original connectivities. Moreover, the surplus remains significant and asymptotically non-vanishing, even if it is measured not by its absolute size, but in relative terms, as a percentage gain.

We call this phenomenon the "multigraph advantage", and show that it occurs with quite a few different graph parameters. Thus, we find several cases when "the whole is strictly more than the sum of its parts". Translating it back into the motivating communication network models, we conclude that it often pays off to implement multiple types of links in a network, and, moreover, the obtained gain can be quantified using our results.

■ MF-41

Monday, 17:20-18:40

3.1.06

Pricing in networks

Stream: Revenue Management

Invited session

Chair: *Bernard Fortz*, Département d'Informatique, Université Libre de Bruxelles, CP 210/01, Bld du Triomphe, 1050, Bruxelles, Belgium, bfortz@euro-online.org

Chair: *Houyuan Jiang*, Judge Business School, University of Cambridge, Trumpington Street, CB2 1AG, Cambridge, United Kingdom, h.jiang@jbs.cam.ac.uk

1 - A column generation approach for a bilevel pricing problem

Aurélie Casier, Département d'Informatique, ULB - Université Libre de Bruxelles, 1050, Brussels, Belgium, acasier@ulb.ac.be, *Martine Labbé*, *Bernard Fortz*

Consider the product pricing problem (PPP) in which a company sets prices for products in order to maximize its revenue and reacting to these prices the customers buy, among all products on the market, the one providing them the biggest utility. Initially modeled as a bilevel program, PPP can be reformulated as a single level nonlinear model. From this nonlinear formulation, we derive a new IP formulation containing an exponential number of variables and propose a column generation solution approach.

2 - Optimisation of forecourt fuel pricing

David McCaffrey, Research, KSS Ltd, St. James's Buildings, 79 Oxford Street, M1 6SS, Manchester, United Kingdom, mcaffreyd@kssg.com, *Barbara Jenkins*, *Tom Liprot*

We present an application of price optimisation to the sale of automotive fuel on the forecourt. We present a detailed analysis of the results of a trial of price optimisation software at a US fuel retailer. We demonstrate an increase in gross profitability of around 0.6 US cents per gallon, obtained without significant loss of volume against target. We then set out an extension to the methodology which allows for price-volume trade off between retail sites. We show how this sits as a supervisory level above the site level optimisation and present simulation results.

■ MF-42

Monday, 17:20-18:40

3.1.07

Optimization and Data Mining I

Stream: Optimization and Data Mining

Invited session

Chair: *Emilio Carrizosa*, Estadística e Investigación Operativa, Universidad de Sevilla, Matemáticas, Reina Mercedes s/n, 41012, Sevilla, Spain, Spain, ecarrizosa@us.es

1 - Support Vector Machine for Time Series Regression

Renato De Leone, Dipartimento di Matematica e Informatica, Università di Camerino, via Madonna delle Carceri 9, 62032, Camerino, MC, Italy, renato.deleone@unicam.it

Support Vector Machines (SVMs) have been extensively used in classification and regression. In this talk we will show how SVMs can be used to predict specific aggregated values from a time series. Applications in finance will also be discussed.

2 - Application of svm in the classification of ship of acoustic signals using frequency and rpm data

Mikey da Silva Neto, Departamento de Engenharia Aeronáutica e Mecânica, Instituto Tecnológico de Aeronáutica, Rua H9 B Apto 102, 12228-611, São José dos Campos, São Paulo, Brazil, mikey@ita.br, *Moacyr Machado Cardoso Junior*, *Rodrigo Scarpel*

Ship class recognition by submarine sonar is very important, for navigation safety as well as in belligerence situations. The aim of this paper is to analyze sound frequency and propeller-axle revolutions per minute (RPM) gained through acoustic signal, through Lofogram-Demogram for classification purpose. Support vector machine (SVM) techniques were used in conjunction of grid search algorithm in order to extract kernel function optimal parameters. The results showed a good performance of ship classification using the features selected, as well as, a relative low computational cost.

3 - An Online Monitoring Procedure Using Support Vector Regression

Seong-Jun Kim, Industrial Eng., Gangneung-Wonju National University, 120 Univeristy Road Gangneung, 210702, Gangneung, KW, Korea, Republic Of, sjkim@gwnu.ac.kr, *inyong Seo*, *Sungho Choi*

Online monitoring (OLM) is becoming widespread in power plants. It is essential to secure both efficiency and safety in the plant operation. Many OLM systems make use of an auto-associative model in order to estimate operation parameters from transferred signals. This paper deals with model building for the auto-association. A support vector regression is employed for the modeling in this paper. The monitoring performance of the proposed OLM technique is compared with feedforward neural network. An illustration will be given by real-world example.

MF-43

Monday, 17:20-18:40

8.2.02

Revenue Management I

Stream: Demand, Pricing and Revenue Management

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

1 - A Dynamic Programming Decomposition for Revenue Management with Substitution

Jochen Goensch, Department of Analytics & Optimization, University of Augsburg, Universitätsstraße 16, D-86159, Augsburg, Germany, jochen.goensch@wiwi.uni-augsburg.de, *Claudius Steinhardt*

In markets with highly uncertain demand, supply-side substitution between resources (e.g. through opaque products) can help firms to improve capacity utilization and revenue. This talk presents an extension of a standard capacity control approach making use of the additional flexibility. We show that the underlying decomposition yields a tighter upper bound than the widely used DLP. In numerical experiments the approach is applied to airline network revenue management with opaque products. It shows that the approach is tractable and outperforms widely used bid price approaches.

2 - Capacity Control with Planned Upgrades in the Car Rental Industry

Claudius Steinhardt, Department of Analytics & Optimization, University of Augsburg, Universitätsstraße 16, 86159, Augsburg,

Germany, claudius.steinhardt@wiwi.uni-augsburg.de, *Jochen Goensch*

Even though upgrades are common in car rental, practical revenue management implementations usually resort to rather simple heuristics, like successive planning, and use virtual capacity as given for standard capacity control. In this talk, we present approaches that extend the traditional decomposition for capacity control by simultaneously considering upgrades as well as capacity control decisions. Based on data from a major car rental company, we perform computational experiments which show that the proposed approaches are tractable and outperform widely-used successive planning approaches.

3 - Examples illustrating the importance of integrating revenue management and supply chain decision making.

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

We examine two firms with traditional supply chain issues (excess capacity, high transportation costs, and highly seasonal demand) and show that these issues can be profitably resolved using revenue management tools. We also show that management of these firms will likely make inappropriate strategic and tactical decisions unless their decision model integrates both revenue management and supply chain decision variables.

4 - Nucleolus Based Revenue Sharing in Airline Alliances

Alf Kimms, Mercator School of Management, University of Duisburg-Essen, Lotharstr. 65, LB 125, 47057, Duisburg, Germany, alf.kimms@uni-due.de, *Demet Cetiner*

A major problem in airline alliance revenue management operations is to construct allocation rules which define how the alliance revenue should be shared among the airline partners. In this paper, we provide fair revenue proportions for airlines based on the nucleolus solution concept. Through a computational study on randomly generated alliance networks, we show that the nucleolus revenue proportions provide reasonable allocation rules for airline alliances and may serve as a benchmark for decentralized approaches.

MF-44

Monday, 17:20-18:40

8.2.03

SD modelling of Scarcity and Sustainable Development

Stream: SD Modeling in Sustainable Development

Invited session

Chair: *Erik Pruyt*, Policy Analysis, Delft University of Technology, Visitors Address: Jaffalaan 5, Delft, The Netherlands, Correspondence Address: P.O. Box 5015, 2600 GA, Delft, Zuid-Holland, Netherlands, E.Pruyt@tudelft.nl

1 - Scarcity of Minerals and Metals: Making Sense of Generic and Specific Exploratory System Dynamics Models

Erik Pruyt, Policy Analysis, Delft University of Technology, Visitors Address: Jaffalaan 5, Delft, The Netherlands, Correspondence Address: P.O. Box 5015, 2600 GA, Delft, Zuid-Holland, Netherlands, E.Pruyt@tudelft.nl

Possible short, medium and/or long term scarcity of minerals/metals may actually pose a threat to modern societies. Its potentially disruptive societal consequences qualify this issue for exploration from a world/regional security point of view. An generic exploratory System Dynamics model that could be used to explore the dynamic complexity of potential mineral/metal scarcity under deep uncertainty is presented. The generic model is turned into specific models for answering particular questions.

2 - Scarcity of Minerals and Metals: An Application of Exploratory Modelling and Analysis

Caner Hamarat, Policy Analysis, Delft University of Technology, Jaffalaan 5, 2628 BX, Delft, Netherlands, c.hamarat@tudelft.nl, *Erik Pruyt*

Possible short, medium and/or long term scarcity of minerals/metals may actually pose a threat to modern societies. Its potentially disruptive societal consequences qualify this issue for exploration from a world/regional security point of view. Different exploratory SD models are used here as alternative scenario generators for Exploratory Modelling and Analysis to explore the dynamic complexity of potential scarcity under deep uncertainty. Tens of thousands of scenarios are analysed and used to determine the effectiveness and robustness of promising policies.

3 - System Dynamics Modeling for the Urmia Saline Lake Management

Mahdi Zarghami, Faculty of Civil Engineering, University of Tabriz, 29 Bahman Blvd., 51664, Tabriz, zarghaami@gmail.com, *Elmira Hassanzadeh*, *Yousef Hassanzadeh*

About five millions of people are living in Urmia lake basin, Iran. Because of the intensive irrigation, the water resources are overused and then the regional water companies require the simulation of the lake future. This study is defined to partition the impact of climate change and hydrostructures by using the System Dynamics approach. The model includes water supply sources, evaporation, demand sources and management tools, modeled by Vensim software. Several scenarios have been studied, which provide sensitive results needed for the effective evaluation of the Urmia Lake problem.

MF-45

Monday, 17:20-18:40

8.2.12

Recent developments from Nonconvex Programming

Stream: Nonconvex Programming: Local and Global Approaches

Invited session

Chair: *Tao Pham Dinh*, INSA Rouen, 76131, Rouen, France, pham@insa-rouen.fr

1 - New DC Programming Approaches for BMI and QMI Feasibility Problems

Yi-Shuai Niu, LMI, INSA de Rouen, BP08 - Avenue de l'Université, 76801, Rouen, France, niuyishuai@hotmail.com, *Tao Pham Dinh*

We propose new DC programming approaches for solving BMI and QMI Feasibility Problems which are important in robust control. The inherent difficulty lies in the nonconvexity of the feasible set. We reformulate QMI as a DC program, and then using an efficient DC Algorithm (DCA) for the numerical solution. A hybrid method combining DCA with an adaptive B&B is proposed for guaranteeing the feasibility of QMI. A partial solution concept is proposed for reducing the computational time and for solving more large-scale problems. Some numerical simulations and comparison with PENBMI are also reported.

2 - Siting and Sizing of Facilities under Probabilistic Demands

Luís Fernandes, Matemática, IPT/IT, Estrada da Serra - Quinta do Contador, 2300 - 313, Tomar, Portugal, luism@ipt.pt, *Joaquim Judice*, *Hanif Sherali*, *Antonio Antunes*

We describe a discrete location model for non-essential service facilities planning which seeks the number, location and size of facilities that maximizes the total expected demand attracted by the facilities. Demand for service is assumed sensitive to distance and size. Facilities are assumed to satisfy a threshold level of demand. An MINLP model is proposed and a branch-and-bound algorithm designed for solving the MINLP; convergence is established. Numerical results are reported to illustrate its efficacy and efficiency in practice.

3 - A new approach for solving Value-at-Risk constrained Optimization using the DC programming and DC Algorithm (DCA)

Manh Nguyen Duc, LMI, INSA de Rouen, France, Poussin 107, Cite du Bois, 76130, Rouen, Rouen, France, duc.nguyen@insa-rouen.fr, *Hoai An Le Thi*, *Tao Pham Dinh*

In this paper, we will consider a well-known problem in the Markowitz style portfolio selection: maximize the rate return with Value-at-Risk constrain when the distributions of returns of the considered assets are given in the form of finite scenarios. The problem is initially reformulated as a DC (Difference of Convex functions) program. In the next step, the problem is then written in the form minimizing a polyhedral concave function on a convex polyhedron via a new penalty technique. Finally, DC programming and DCA (DC algorithm) have been investigated to solve the resulting DC program.

MF-46

Monday, 17:20-18:40

8.2.14

Semi-Infinite Optimization II

Stream: Semi-Infinite Optimization

Invited session

Chair: *Shunsuke Hayashi*, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp

1 - Polyhedral cells of a Voronoi diagram

Ina Voigt, Fakultät für Mathematik, Technische Universität Dortmund, Vogelpothsweg 87, 44227, Dortmund, Nordrheinwestfalen, Germany, ina.voigt@tu-dortmund.de, *Stephan Weis*

We identify a cell of a Voronoi diagram, i.e. a nearest neighbor region, with the feasible set of a semi-infinite system. Utilizing a theorem from the theory of semi-infinite programming, we investigate the geometry of a Voronoi cell. We prove that a Voronoi cell of an infinite discrete point set is polyhedral if and only if its corresponding characteristic cone is a polyhedron. This connects computational geometry with semi-infinite optimization.

2 - Optimality conditions and regularized explicit exchange method for convex semi-infinite programs with infinitely many conic constraints

Shunsuke Hayashi, Graduate School of Informatics, Kyoto University, Yoshida-Honmachi, Sakyo-Ku, 606-8501, Kyoto, Japan, shunhaya@amp.i.kyoto-u.ac.jp, *Takayuki Okuno*, *Masao Fukushima*

Although the semi-infinite program is normally represented with infinitely many "inequality" constraints, we focus on a problem with infinitely many "conic" constraints, say SICIP for short. We first show that, under a generalized Slater constraint qualification (GSCQ), an optimum of the SICIP satisfies the KKT conditions that can be represented only with a finite subset of the conic constraints. We next propose a hybrid algorithm combining the regularization technique with the explicit exchange method, and show that the algorithm is globally convergent under the GSCQ.

3 - Semi-infinite Optimization of Probe Placement in Radiofrequency Ablation

Sabrina Haase, CeVis, University of Bremen, Universitaetsallee 29, 28359, Bremen, Bremen, Germany, sabrina.haase@mevis.fraunhofer.de, *Anton Winterfeld*, *Tobias Preusser*, *Karl-Heinz Küfer*

Radiofrequency ablation is a minimally invasive therapy for the treatment of tumors. A needle-shaped probe is placed in the tumor and connected to an electric generator. Thus the induced electric current causes tumor cell death due to the evolving heat. Since the whole tumor is supposed to be destroyed, an optimal probe placement is needed where the presence of structures that must not be harmed (blood vessels, colon) has to be taken into account. This task results in a semi-infinite optimization problem which is presented in the talk together with some first numerical results.

■ MF-47

Monday, 17:20-18:40

8.2.16

Advances in Discrete-Continuous Optimal Control 1

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: *Dmitrii Lozovanu*, Institute of Mathematics and Computer Science, Academy of Sciences of Moldova, Academiei 5, IMI, MD-2020, Chisinau, Moldova, Moldova, Republic Of, lozovanu@math.md

1 - Regularity conditions in discrete optimal control problems

Boban Marinkovic, Applied Mathematics, University of Belgrade, Faculty of Mining and Geology, Djusina 7, 11000, Belgrade, Serbia, mboban@verat.net

We consider general optimal control problems for discrete-time systems with equality type of constraints on endpoints and control. We discuss different types of regularity conditions for such problems. We present first-order necessary optimality conditions which are meaningful under the new nontriviality condition. Note that by nontriviality we mean that the Lagrange multiplier that corresponds to the cost functional is nonzero.

2 - Solving discretized degenerate optimal control problems with state constraints

Catarina Avelino, Mathematics, UTAD, Departamento de Matemática, Edifício das Ciências Florestais, Quinta de Prados, 5001-801, Vila Real, Vila Real, Portugal, cavelino@utad.pt

We consider a class of nonlinear optimization problems that arise from the discretization of optimal control problems with bounds on both state and control variables. We are particularly interested in degenerate cases, i.e., when the linear independence constraint qualification is not satisfied. We analyse the basic global convergence properties and the numerical behaviour of a multiplier method that updates multipliers corresponding to inequality constraints. Numerical results are included and indicate that this method is robust on degenerate cases.

■ MF-48

Monday, 17:20-18:40

8.2.04

OR/MS: Beyond Mathematics I

Stream: OR/MS: Beyond Mathematics

Invited session

Chair: *Heiner Müller-Merbach*, Wirtschaftswissenschaften, Universität Kaiserslautern, Postfach 3049, 67653, Kaiserslautern, Germany, hmm@bior.de

1 - A.K. Erlang — my distinguished relative

Jakob Krarup, Dept. of Computer Science, University of Copenhagen, Ydervang 4, DK-3460, Birkerød, Denmark, krarup@diku.dk

Agner Krarup Erlang (1878-1929), Head of the laboratory (Copenhagen Telephone Company, 1908-29) and pioneer in the application of probability theory to problems of telephone traffic, is among the inductees in IFORS's Operational Research Hall of Fame (Intl. Trans. in Op. Res. 11, 2004), and recognized as the first operational researcher in Denmark. A brief account of his works is provided ... together with fragments of his genealogical tree.

2 - OR/MS — Beyond Mathematics

Heiner Müller-Merbach, Wirtschaftswissenschaften, Universität Kaiserslautern, Postfach 3049, 67653, Kaiserslautern, Germany, hmm@bior.de

Traditional OR/MS used to have its focus on interdisciplinary problem solving — far beyond mathematics. Promoters of this kind of OR/MS were pioneers such as C. West Churchman, Hugh Miser, Russell L. Ackoff, Samuel Eilon etc. "OR/MS — Beyond Mathematics" has its emphasis on the understanding of man-machine systems with their technical (mechanical, thermodynamic, chemical, other physical) aspects and their social and economic aspects well as their ethical aspects. Most important in the interdisciplinary OR/MS approach are the steps to analyse the system under study.

3 - Estimating Business and Management Journal Quality from the 2008 Research Assessment Exercise in the UK

John Mingers, Kent Business School, Kent University, CT2 7PE, Canterbury, Kent, United Kingdom, j.mingers@kent.ac.uk,
Maria Paola Scaparra

The 2008 UK RAE peer reviewed over 10,000 journal articles. Each output was graded on a 5-point scale. These grades were accumulated for each department to provide an overall quality profile. This data provides the possibility of reconstructing the judgements made by the Panel. We have used linear programming to produce the best estimate of the grades awarded to papers from each journal that had more than three entries. This provides both a grade profile for each journal and a single quality estimate.

Tuesday, 9:00-10:20

■ TA-01

Tuesday, 9:00-10:20

Aula Magna

Keynote Talk 5

Stream: Keynote Speakers

Invited session

Chair: *Jose Fernando Oliveira*, Faculty of Engineering / INESC Porto, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465, Porto, Portugal, jfo@fe.up.pt

1 - You want them to Remember? Then Make it Memorable!

James Cochran, Department of Marketing and Analysis, Louisiana Tech University, PO Box 10318, 71272, Ruston, LA, United States, jcochran@cab.latech.edu

Each of us has key concepts we want our students to understand and remember, but lecturing to students on these concepts often fails to engender their deep comprehension or long term retention. So how can instructors of operations research/management science effectively accomplish these pedagogical goals? In this session Professor Cochran will discuss the use of several interesting and novel active learning exercises, classroom cases, and live projects that can dramatically improve student comprehension and retention of key concepts. Throughout the session Professor Cochran will emphasize his points with live demonstrations of active learning exercises. Card tricks, classroom versions of television game shows, and a teaching case with integrated active learning will be featured. Because many of these exercises are easily transferable across topics, instructor/classroom styles, cultures, national borders, institutions, faculties, programs, levels of technology, and class sizes, it is very likely you will walk away from this session with ideas on how to improve your own teaching (indeed, Professor Cochran will be very disappointed if you don't!).

■ TA-02

Tuesday, 9:00-10:20

3.2.14

Advanced Combinatorial Optimization 2

Stream: Combinatorial Optimization

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

1 - Theoretical investigations on maximal dual feasible functions

J. M. Valério de Carvalho, Departamento de Produção e Sistemas, Universidade do Minho, 4710 053, Braga, Portugal, vc@dps.uminho.pt, *Jürgen Rietz*, *Cláudio Alves*

Dual feasible functions are used to get valid inequalities and lower bounds for integer linear problems. We illustrate their use in some examples, we provide a simpler proof for maximality, and we describe new results concerning the extremality of functions of the literature. Extremal functions are a dominant class of dual feasible functions.

2 - Monoidal Cut Strengthening Revisited

Andrea Qualizza, Tepper School of Business, Carnegie Mellon University, 5000 Forbes Avenue, 15213, Pittsburgh, PA, United States, qualizza@cmu.edu, *Egon Balas*

We discuss an enhancement of the Balas-Jeroslow procedure for strengthening disjunctive cuts for mixed 0-1 programs. When applied to a split cut derived from a source row of the simplex tableau, the enhanced procedure yields, besides the mixed integer Gomory cut, also cuts that are sometimes stronger.

3 - Models and Algorithms for Multi-Echelon Distribution Networks

Roberto Wolfler-Calvo, LIPN, Université Paris Nord, 93430, Villetaneuse, France, roberto.wolfler@lipn.univ-paris13.fr, *Aristide Mingozzi*, *Roberto Baldacci*

In Multi-Echelon Distribution Networks the deliveries from the production plants to the customers are managed through intermediate depots by means of two or more levels of delivery. Generally, two different types of decisions must be addressed in designing this type of distribution networks. The first one is of strategic type and consist in opening one or more depots, on a given set of a priori defined depot locations, and to design, for each opened depot, a number of routes in order to supply the demands of a given set of customers. This problem is called Location Routing Problem (LRP) and the objective is to minimize the sum of the route costs and the fixed costs of the opened depots. The second one is of tactical type and consist in designing the set of routes that must be operated from the different level of the networks. If the deliveries from the production plant to the customers are managed by means of two levels of delivery, the problem is known as Two Echelon Vehicle Routing Problem (2E-VRP) and the objective is to minimize the sum of the routing costs of the first and second level routes. In this paper we describe an exact method for solving both the LRP and the 2E-VRP. Computational results on benchmark instances from the literature are also presented.

4 - Reference Point based Solution Approach for the Resources Constrained 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, lidipuglia@deis.unical.it, *Francesca Guerriero*

The Resources Constrained Shortest Path Problem (RCSPP) is one of the most studied problem in combinatorial optimization. The aim is to find the shortest path under additional constraints, representing upper bounds on the consumption of resources along the path. In the scientific literature, different approaches have been defined to solve the RCSPP. In this work we propose an innovative interactive method to address the RCSPP, based on a novel search strategy in the criteria space. The performance of the proposed approach is evaluated on the basis of an extensive computational study.

■ TA-04

Tuesday, 9:00-10:20

3.2.13

Project scheduling

Stream: Metaheuristics

Invited session

Chair: *André Rossi*, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr

Chair: *José Carlos Reston Filho*, P&D, Fundação André Nunes Coelho, Rua 4 N° 65 Casa 3, Cj Pq Tropical Parque 10, 69055-743, Manaus, Amazonas, Brazil, jcreston@gmail.com

1 - Towards the minimization of project duration and cost in stochastic project management environments

José Carlos Reston Filho, P&D, Fundação André Nunes Coelho, Rua 4 N° 65 Casa 3, Cj Pq Tropical Parque 10, 69055-743, Manaus, Amazonas, Brazil, jcreston@gmail.com, *Anabela Pereira Tereso*, *Lino Costa*

There is a general consensus that the rational use of available resources is, nowadays, an important task, since project managers are interested in the maximization of profit and the minimization of risk. In this work, it is proposed a multi-objective model to optimize the use of resources in a stochastic environment. In this multi-objective formulation the aim is to minimize the project duration and the total project cost at the same time. In the future, we intend to solve this problem using multi-objective evolutionary algorithms.

2 - An electromagnetism-like algorithm for a project scheduling problem with discounted cash flows

Marisa Toste, Ciências e Tecnologia, Escola Superior de Tecnologia e Gestão de Oliveira do Hospital do Instituto Politécnico de Coimbra, Rua General Santos Costa, 3400-124, Oliveira do Hospital, Portugal, marisa.toste@estgoh.ipc.pt, *Dalila Martins Fontes*

An electromagnetism algorithm is developed to address a resource constrained project scheduling problem. The chosen problem involves discounted cash flows and therefore the objective is to find a schedule that maximizes the project net present value. The electromagnetism method (EM) is a population based meta-heuristic algorithm utilizing an attraction-repulsion mechanism to move sample points (i.e., solutions) towards the optimality. Computational results, on problem instances found in previous literature, are reported.

3 - Modeling Project Resource Scheduling Problem with Activity Compressibility

M. Karimi-Nasab, Industrial Engineering, Iran University of Science and Technology, Narmak, 1684613114, Tehran, Tehran, Iran, Islamic Republic Of, mehdikariminasab@yahoo.com, *B. Shah-Hoseini*

Resource scheduling is a major part of every real project management. The problem is here analyzed via a new mixed integer model. As the problem is known to be NP-Hard, a new population-based heuristic solution method is developed to obtain a near-optimal resource schedule in a deterministic project planning problem. The algorithm is run on a set of test data and computational experiences report about the superior performance of the algorithm than the existing methods.

■ TA-05

Tuesday, 9:00-10:20

3.2.16

EURO Excellent in Practice Award 2010

Stream: EURO Excellence in Practice Award 2010

Invited session

Chair: *M. Grazia Speranza*, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, speranza@eco.unibs.it

1 - Billerud optimizes its bleaching process using online optimization

Mikael Rönnqvist, Department of Finance and Management Science, Norwegian School of Economics and Business Administration, NO-5045, Bergen, Norway, mikael.ronnqvist@nhh.no, *Patrik Flisberg*, *Stefan Nilsson*

The company Billerud is a leading packaging company and has four integrated pulp and paper mills. Since 2004, the paper mill Skärblacka is using an on-line process control system, OptCab, for its bleaching operations. The core of OptCab is an online optimization system that dynamically updates a process description and establishes an optimized bleaching control. Between 2004 and 2008, the use of chemicals has decreased by about 10% which corresponds to a saving of 2 million Euros. Additional savings are less negative environmental impact and that the final brightness quality is more stable.

2 - Game Theory for Security: Lessons Learned from Deployed Applications

Milind Tambe, Computer Science and Industrial & Systems Engineering Departments, University of Southern California, 3737 Watt Way, PHE 410, 90089, Los Angeles, CA, United States, tambe@usc.edu, *Fernando Ordonez*, *Manish Jain*, *Christopher Kiekintveld*, *Jason Tsai*, *Shyamsunder Rathi*, *James Plta*

Intelligently allocating limited security resources to protect important terrorist targets is a key concern around the world. Game theory is ideally suited for such security allocation, as it accounts for differences in target priorities and adversary responses to security strategies. We present our research on fast game-theoretic algorithms and its deployed applications: (1) ARMOR, deployed at Los Angeles Airport (LAX) since 2007 to randomize checkpoints and canine patrols. (2) IRIS, in use since 2009 by the US Federal Air Marshals Service to generate random flight schedules for air marshals.

3 - Catch-Up Scheduling for Childhood Vaccination

Pinar Keskinocak, Georgia Tech, United States, pinar@isye.gatech.edu, *Faramroze Engineer*, *Larry Pickering*

We developed a decision support tool for constructing catch-up schedules for childhood immunization, to ensure that a child receives timely coverage against vaccine-preventable diseases. We show that the catch-up scheduling problem is NP-hard, and develop a dynamic programming algorithm that exploits the typical size and structure of the problem. Our approach is unique in methodology, information, strategy, and advice it offers to the user. The tool is being advocated by the Centers for Disease Control and Prevention and the American Academy of Pediatrics.

■ TA-06

Tuesday, 9:00-10:20

8.2.30

DEA Methodology VI

Stream: DEA and Performance Measurement

Invited session

Chair: *Giannis Karagiannis*, economics, university of macedonia, 156 egnatia str., 54006, thessaloniki, Greece, karagian@uom.gr

1 - The Malmquist Productivity Index and its Decomposition for Radial DEA Models with Single Constant Input

Giannis Karagiannis, economics, university of macedonia, 156 egnatia str., 54006, thessaloniki, Greece, karagian@uom.gr

In this paper we explore the Malmquist productivity index and its decomposition for radial DEA models with single constant input to evaluate the research achievements of each faculty member in the Department of Economics at the University of Macedonia, Greece. In this case, scale efficiency change effect and the input bias index have no contribution to productivity changes. In the proposed setting the single constant input corresponds to each faculty member and we consider two outputs (e.g., journal articles and other publications) and one attribute (quality of journal articles).

2 - A Slack-based measure for measuring the efficiency of decision-making unit with negative data, using DEA

Fuh-Hwa Liu, Industrial Engineering & Management, National Chiao Tung University, 1001 Ta Shueh Road, Dept. IE&M, 300, Hsin Chu City, Taiwan, Taiwan, fliu@mail.nctu.edu.tw, *Ling-Chuan Tsai*

In this research, we introduce a slack-based measure for Data Envelopment Analysis (DEA) problem with negative data. DEA introduced to OR/MS literatures by Charnes, Cooper, and Rhodes (1978), which measuring the efficiency of a set of decision making units such as firms or public sector agencies with technologies characterized positive data only. DEA problems with positive and negative data have been one of the main issues for performance evaluation and there have been various approaches for them. Emrouznejad, Anouze, and Thanassoulis (2010) have reviewed the literature and proposed a semi-radial measure. We employed their data set to have the comparisons between the results of those approaches and ours.

3 - Technical Economies of Scope using Data Envelopment Analysis

Ozren Despic, Aston Business School, Aston University, Aston Triangle, B4 7ET, Birmingham, West Midlands, United Kingdom, o.despic@aston.ac.uk, *Konstantinos Bakoulas*, *Emmanuel Thanassoulis*

This paper presents a DEA approach on identifying the existence of technical economies of scope. We introduce the notion of technical economies of scope, which exists when lower inputs are needed to produce an output bundle by a single diversified firm rather than to produce each individual output by separate specialized firms. The paper reviews previous DEA-based approaches and develops a new approach to identifying and measuring technical economies or diseconomies of scope.

■ TA-07

Tuesday, 9:00-10:20

8.2.47

DEA Application X

Stream: DEA and Performance Measurement

Invited session

Chair: *Luis C. Dias*, Faculdade de Economia / INESC Coimbra, University of Coimbra, Av Dias da Silva 165, 3004-512, Coimbra, Portugal, lmcaldas@fe.uc.pt

1 - Efficiency changes in Turkish airports for the period 2006-2009

Erhan Berk, Hava Duragi Lojmanlari 4.Blok Daire:1, 06790, ANKARA, Turkey, eberk@kho.edu.tr, *Diyar Akay*

The global economic crisis has been an impact on aviation sector like the other sectors in recent years. Turkey is one of the countries not adversely affected from this global crisis in terms of aviation sector. There are several factors that make this success possible, and of the important one among them are airports. In this study, efficiency of the airports in Turkey is measured for the period 2006-2009, and their changes with respect to the size and the regions are observed and discussed.

2 - Benchmarking university libraries: The influence of different environments

Gerhard Reichmann, Department of Information Science and Information Systems, University of Graz, Universitätsstr. 15/F3, 8010, Graz, Austria, gerhard.reichmann@uni-graz.at, *Margit Sommersguter-Reichmann*

In this contribution we analyse performance differences across university libraries from different countries from a cross-section and a longitudinal perspective, thus comprising libraries which act in a strongly regulated environment (Germany, Austria) and others which operate in a more competitive, market-oriented environment (US, Canada). We use the Malmquist index approach to disentangle environmental efficiency from managerial efficiency and to decompose productivity changes between 1999 and 2008 into changes in technical efficiency and changes in technology.

3 - Chance-constrained FDH model by genetic algorithm in uncertain environment

Hiroshi Morita, Department of Information and Physical Sciences, Osaka University, 2-1 Yadam-oka, 5650871, Suita, Japan, morita@ist.osaka-u.ac.jp

We consider the chance-constrained DEA under uncertainty, where the input and output may include some stochastic variations. To overcome the difficulty to solve the joint chance-constrained model, we adopt the genetic algorithm in uncertain environments. The FDH model is considered under uncertainty, since this algorithm is useful to solve the combinatorial optimization problem. The possibility of extension to the conventional DEA model is also discussed.

4 - Discriminating efficient units using L1 norm FDH

Shinn Sun, Department of Management, Fo Guang University, No. 160, Linwei Road, 26242, Jiaosi, Yilan County, Taiwan, ssun@mail.fgu.edu.tw

The purpose of this paper is two-fold: to introduce L1 norm into A&T FDH proposed by Agrell and Tind for ranking efficient decision making units (DMUs); to compare this new model with FDH by Deprin et al., A&P FDH by Puyenbroeck, 0-1 LP FDH by Jahanshahloo et al. The proposed method is able to remove the existing difficulties in the FDH. In this study, we examine two questions: which FDH model has the highest discrimination power of ranking efficient units and what results of ranking are different by these three FDH model. In developing this method, we are influenced by Jahanshahloo et al. and we exploit the leave-one-out idea and L1 norm. Three numerical examples with few DMUs and many DMUs are used for the mathematical comparison of these three FDH models.

■ TA-08

Tuesday, 9:00-10:20

6.1.36

Project Scheduling: New Results and Applications

Stream: Project Management and Scheduling

Invited session

Chair: *Jenny Nossack*, Management Information Sciences, University of Siegen, Hölderlinstraße 3, 57068, Siegen, North Rhine-Westphalia, Germany, jenny.nossack@uni-siegen.de

1 - Multi-Project Scheduling with 2-Stage Decomposition

Gündüz Ulusoy, Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, gunduz@sabanciuniv.edu, *Anil Can*

A non-preemptive, zero time lag multi-project scheduling problem with multiple modes and renewable and nonrenewable resources is considered. A 2-stage decomposition approach is adopted to formulate the problem as a hierarchy of 0-1 mathematical programming model. At stage 1, each project is reduced to an activity and the resulting project network is solved so as to maximize NPV. Using the starting times and resource profiles obtained in stage 1 each project is solved in stage 2 for minimum makespan. Lagrangian relaxation and Branch & Cut are applied.

2 - A Constraint Integer Programming Approach for Resource-Constrained Project Scheduling

Stefan Heinz, Zuse Institute Berlin, Germany, heinz@zib.de, *Timo Berthold*, *Marco Lübbecke*, *Rolf Möhring*, *Jens Schulz*

We propose a hybrid approach for solving the resource-constrained project scheduling problem which is an extremely hard to solve combinatorial optimization problem of practical relevance. Jobs have to be scheduled on resources subject to precedence constraints such that the resource capacities are never exceeded and the latest completion time of all jobs is minimized. We show that lower bounds from the linear relaxation of the integer programming formulation and conflict analysis are key ingredients for pruning the search tree. For five instances of the PSPLIB we report a new lower bound.

3 - Improving a Make-to-Order Production Process using Resource-Constrained Project Scheduling

Wolfgang Summerauer, Department of Business Administration, University of Vienna, Bruenner Strasse 72, 1210, Vienna, Vienna, Austria, wolfgang.summerauer@univie.ac.at, *Christian Almeder*, *Richard Hartl*

We present a case study of a small Austrian plastics and elastics producer which tries to optimize its make-to-order production process considering aspects of sustainability like e.g. work conditions, energy consumption and amount of waste. The large product portfolio, the need for skilled workers and the scarce resources (e.g. furnaces and work stations) make the problem interesting, but also challenging to solve. Our approach to overcome those difficulties is to tackle it as a resource-constrained project scheduling problem (RCPS).

4 - Decision support system for continuous production

Krystina Bakhrankova, Faculty of Economics, Informatics and Social Sciences, Molde University College, Specialized University in Logistics, Britvegen 2, 6411, Molde, Norway, krystina.bakhrankova@himolde.no

This paper develops a model-based decision support system (DSS) for an existing European chemical plant with a multi-stage continuous production process. The system comprises two modules: energy cost minimization and output maximization. Following the production description, a gist of the underlying formulations is presented. Then, the DSS is tested on real data instances with a focus on its configuration, practical implications, and implementation challenges. The system reflects the essence of the researched process, provides substantial cost savings, and improves capacity utilization.

■ TA-09

Tuesday, 9:00-10:20

6.2.53

Mathematical Modeling on Timetabling Problems: Models and Analytic Network Process Approach

Stream: Mathematical Programming

Invited session

Chair: *Mujgan Sagir*, IE, Eskisehir Osmangazi University, ESOGU IE Dept., Meselik, Eskisehir, Turkey, mujgan.sagir@gmail.com

1 - EXAM SCHEDULING: PARAMETER ESTIMATION WITH the ANP and MATHEMATICAL MODELING ON THE SOLUTION

Mujgan Sagir, IE, Eskisehir Osmangazi University, ESOGU IE Dept., Meselik, Eskisehir, Turkey, mujgan.sagir@gmail.com, *Zehra Kamisli Ozturk*

An invigilator is a person who supervises students during examinations. Assigning invigilators to exams is considered as a phase during the exam scheduling process. The problem has its own constraints and a multi objective structure. To prioritize the objectives of this problem, an ANP model is constructed with ten clusters. All the participants and the criteria with their interrelations are defined. Different objectives of the problem are treated as alternatives. Relative weights are obtained by using the Super Decisions software. Then we solve a previously developed mathematical model by using this new set of parameters. It is seen that with the new parameters, model gives different solution.

2 - A Genetic Algorithm for Course Scheduling Problem

Zehra Kamisli Ozturk, Open Education Faculty, Anadolu University, Anadolu University, Faculty of Open Education Yunusemre Campuse No: 318, 26470, Eskisehir, Turkey, zkamisli@anadolu.edu.tr, Mujgan Sagir

In this study, a genetic algorithm(GA) is developed to solve multi-objective university course scheduling problem. The proposed GA's based on random keys that mean the solutions are encoded by using random keys. Random key based genetic algorithm encodes the chromosomes with a length of just the number of courses and contains problem' all information. Another advantage of the algorithm is the fact that, we do not need to use problem specific genetic operators and repair mechanisms. The algorithm's tested on some problem instances and it's concluded that competitive results're obtained.

3 - Vehicle Routing Problem: An Application Study

Ediz Atmaca, Industrial Engineering, Gazi University Faculty of Engineering and Architecture, Gazi University Faculty of Engineering and Architecture, Industrial Engineering Department, 06570, Ankara, Turkey, hediz@gazi.edu.tr

The Vehicle Routing Problem(VRP)can be defined as a problem of finding the optimal routes of delivery or collection from one or several depots to a number of customers.In this study,VRP with flexible time windows are discussed for a supermarket that provides material distribution from main warehouse to its stores. The mathematical programming model is developed to improve existing routes and solved.The problem that is treated as cost reduction,can be solved by using multi-purpose decision making techniques for decision makers who want to achieve their multiple objectives in real time.

4 - A solution approach for staff scheduling in service systems

Burcin Ozsoydan, Industrial Engineering, Osmangazi University, Turkey, fbozsoydan@ogu.edu.tr, Aydin Sipahioglu

In a service system, staff should be used effectively without causing any breakdowns. However, to find an appropriate staff schedule that they desire is not easy. This kind of problem generally appears in service systems where they serve whole day or large part of the day as in post office, hospital etc. Balancing the working hours among the staff or minimizing the total cost may be chosen as objective function. In this study, a mathematical model is proposed to determine staff schedule considering their individual preferences. And, an effective solution approach is offered to solve the model.

■ TA-10

Tuesday, 9:00-10:20

6.2.56

Graphs and Networks VI

Stream: Graphs and Networks

Invited session

Chair: Marc Demange, ESSEC Business School, Bucharest, Romania, demange@essec.edu

1 - A family of Torus Grids that are G-Graphs

Cerasela Tanasescu, ESSEC Business School, Bucharest, Romania, tanasescu@essec.edu, Alain Bretto

The most famous link between abstract group theory and the theory of graphs is certainly provided by Cayley Graphs. A much more recent studied family of graphs constructed from groups are G-graphs that have also highly-regular properties. One first step in the study of G-graphs is to better understand their connection with Cayley Graphs. In this context, many well known graph families were recently identified as G-graphs. Here we show that $2n \times n$ Torus Grids, for even n (a well known family of Cayley Graphs), are G-graphs.

2 - On Inverse Matching Problems

Marc Demange, ESSEC Business School, Bucharest, Romania, demange@essec.edu, Laurent Alfordari, Jerome Monnot

Inverse combinatorial optimization aims to modify as least as possible an instance of a combinatorial problem so that a fixed solution becomes optimal. Considering the Maximum Matching Problem we mainly consider the boolean case where one has to delete the least possible number of edges (changing a weight from 1 to 0) to make the fixed matching a maximum one. We also consider the extended framework where the aim is to make the fixed matching only k -optimal for a fixed k . We propose hardness results and a polynomial case in bipartite graphs.

3 - Design of optical wdm networks

Amal Benhamiche, CORE-TPN, Orange Labs R&D, 38-40 rue du Général Leclerc, 92794, Issy-Les-Moulineaux, France, amal.benhamiche@orange-ftgroup.com, A. Ridha Mahjoub, Nancy Perrot

We consider the Grooming, Routing and Wavelength Assignment problem in optical WDM mesh networks. This is a network design problem which consists in grooming demands in lightpaths, assigning a wavelength to each lightpath and routing the traffic on these with minimum cost. We first give an Integer Linear Programming formulation for the problem, then we discuss some pre-processing procedure and propose a fast heuristic which shows to be very efficient for solving large and real instances. We finally provide an illustrative application of the proposed heuristic for a real network instance.

■ TA-12

Tuesday, 9:00-10:20

8.2.39

ANP 01

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: Birsan Karpak, Management, Youngstown State University, One University Plaza, WCBA 635, 44555, Youngstown, OH, United States, bkarpak@ysu.edu

1 - Prioritizing the Criteria in Renewable Energy Pricing

Mehmet Yalçın Altuntaş, Industrial Engineering, Istanbul Technical University Management Faculty, Tanzimat sokak. 58/20 Göztepe, 34730, İstanbul, Turkey, yalcinaltuntas@gmail.com, Gulgun Kayakutlu

Renewable energy sources are still far from being cost advantageous, despite the reduction in costs of technologies. Success in reducing the operational pricing will certainly support public acceptance. This study aims to construct a pricing model specific to renewable energies maintaining variables unique for renewable energies. Almost sixty factors are depicted in literature to be clustered as economic, technologic, social, political and environmental attributes. Analytical Network Process (ANP) is applied to determine the most important factors to be considered in the pricing structure.

2 - Access of Green Supply Chain Management for SMEs

Irem Duzdar, Industrial Engineering, Istanbul Arel University, Tepekent Campus, Kucukcekmece, Istanbul, Turkey, iremd82@gmail.com, Gulgun Kayakutlu

During recent years, supply chain managers tried more to consider environmental issues in their decision making process. Green supply chain management (GSCM) is not just about considering environment in supply chain decision making processes, but also about productivity and making more profit. Green supply chain management can be defined as associating environmental thinking into supply-chain management, beginning from the product design; material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life. Objective of this study is to identify the main criterions of GSCM for small and medium size companies (SMEs). The green criterions for those companies are defined with Causal Map. Assessment of those criterions is a multi criteria decision making problem. Analytical Network Processing (ANP) technique is used for this study. After becoming definite the most important criterions GSCM culture start to be formed. This paper will be designed behavioural strategies for utilizing the GSCM system for SMEs.

3 - Success factors of for a manufacturing SME in Ohio: Women perspective

Birsan Karpak, Management, Youngstown State University, One University Plaza, WCBA 635, 44555, Youngstown, OH, United States, bkarpak@ysu.edu, Anne M. McMahan

This study implements an Analytical Network Process (ANP) based framework developed for small /medium manufacturing enterprises to prioritize measures of success and related antecedents (collectively called success factors) to a woman owned manufacturing company in Ohio. A female expert has judged the impact of each factor on other success factors for her business. Key priorities are identified. The study results will guide the authors as they pursue distinctive issues related to women owned small businesses in Ohio.

■ TA-13

Tuesday, 9:00-10:20

2.2.21

Continuous Location I

Stream: Location Analysis

Invited session

Chair: *Emilio Carrizosa*, Estadística e Investigación Operativa, Universidad de Sevilla, Matemáticas, Reina Mercedes s/n, 41012, Sevilla, Spain, Spain, ecarrizosa@us.es

1 - Line location with restrictions on the slope of the line

Thorsten Krempasky, Numerische und Angewandte Mathematik, Georg August Universität Göttingen, Lotzestraße 16-18, 37083, Göttingen, Germany, krempask@math.uni-goettingen.de, *Anita Schoebel*

Coming from the field of robust estimators, this talk draws a connection to location theory. We start with the so-called "Regularized Least Absolute Deviation" (RLAD) regression and look at it as a line location problem. We present a solution path for the RLAD regression by solving line location problems with vertical distance and restrictions on the slope of the line. Looking at these problems with different distance functions leads to interesting results in line location as well as in regression theory.

2 - Hybrid Methods for Solving Location-Allocation Problems with Dense Demand

Alper Murat, Industrial and Manufacturing Engineering, Wayne State University, 4815 Fourth Street, q, 48202, Detroit, MI, Afghanistan, amurat@wayne.edu, *Vedat Verter*, *Gilbert Laporte*

We develop hybrid methods for solving continuous location-allocation problems using gradient-based search methods and the alternate location allocation (ALA) heuristic of Cooper (1964). We present the hybridization of ALA with two improvement approaches which prioritize location and allocation decisions. We illustrate their applications to problems with dense demand. Results show that the proposed hybridization improves the efficiency of ALA.

3 - DCM optimization in continuous location

Rafael Blanquero, Estadística e Investigación Operativa, Universidad de Sevilla, Faculty of Mathematics, Tarfia S.N. 41012-Seville (Spain), 41012, Seville, Spain, rblanquero@us.es, *Lenys Bello*, *Emilio Carrizosa*, *Eligius M.T. Hendrix*

A function is said to be DCM if it can be expressed as a difference of two convex monotonic functions. For DCM functions, it is possible to combine convexity and monotonicity properties to obtain sharp bounds, to be used in global optimization procedures such as Branch and Bound. In this talk we deal with two models for locating a competitive facility in the plane that can be successfully solved by using DCM optimization.

4 - Robust Solutions for Location Problems with Uncertainties

Kathrin Klamroth, Department of Mathematics and Informatics, University of Wuppertal, Gaussstr. 20, 42097, Wuppertal, Germany, klamroth@math.uni-wuppertal.de, *Markus Kaiser*

We consider location problems where uncertainty not only occurs in the demand and position of the existing facilities, i.e., in the location objective, but also in the constraints of the problem like, for example, the size and location of the feasible region and/or the occurrence and position of barriers to travel. Different models to cope with uncertainty like minmax regret models (to handle uncertain demands) and recent robustness concepts like recoverable robustness (to handle uncertainty in the constraints) are discussed.

■ TA-14

Tuesday, 9:00-10:20

2.2.15

Closed-Loop Supply Chains

Stream: Supply Chain Planning [C]

Contributed session

Chair: *Aysegul Demir*, Department of Industrial Engineering, Middle East Technical University, Endüstri Muhendisligi Bolumu Oda No: 325, ODTU/Cankaya, 06531, Ankara, Turkey, demir.aysegul@gmail.com

1 - Inventory Management in Closed-loop Supply Chains under Non-stationary Demand

Ratna Babu Chinnam, Industrial & Manufacturing Engineering, Wayne State University, 4815 Fourth Street, 48202, Detroit, MI, United States, r_chinnam@wayne.edu, *Ibrahim Dogan*

This study aims to analyze remanufacturer's inventory control policy under non-stationary demand. The objective is to decide on virgin product replenishment quantities under used product returns. The exact solution to this inventory control problem in our setting is complex and time demanding. We offer and analyze a number of different sub-optimal policies.

2 - Coordination and uncertainty in closed loop supply chains

Juan Pedro Sepúlveda, School of Engineering, Universidad del Desarrollo, Avenida La Plaza 0680, Las Condes, Santiago de Chile, Chile, jpssepulveda@udd.cl, *Felipe Baesler*

There is a lack of research about coordination in closed loop supply chains, Ketzenberg (2008). Principally the works in this area use approaches like game theory or contracting (Guide and Wassenhove, 2009), so we think that there is a gap in the studies about the value of coordination on operational decisions like inventory management. In this paper we will analyze quantitatively the gains of coordination, through the analysis of ad-hoc inventory models, in the reverse logistics setting and we evaluate the gains for different levels of uncertainty about customer demand and returns.

3 - Pricing and Production Decisions in Reusable Container Systems

Busra Atamer, Industrial Engineering, Middle East Technical University, ODTU Endüstri Muhendisligi Bolumu, Oda No:326, Orta Dogu Teknik Universitesi Kampusu, 06531, Ankara, Turkey, busra@ie.metu.edu.tr, *Ismail Serdar Bakal*, *Z. Pelin Bayindir*

In this study, we consider decision problems on reusable container systems. The return rate of containers depends on customer demand and deposit price; and the producer determines the return rate via modifying the latter. Production planning and pricing decisions are to be made simultaneously because the producer also has to decide on the quantity of brand new reusable containers to be purchased. In this environment, we maximize the manufacturer's profit by utilizing constrained non-linear optimization techniques. We gain significant insights with our analytical and computational observations.

4 - On the value of Radio Frequency Identification (RFID) technology for managing pools of Returnable Transport Items (RTIs)

Aysegul Demir, Department of Industrial Engineering, Middle East Technical University, Endüstri Muhendisligi Bolumu Oda No: 325, ODTU/Cankaya, 06531, Ankara, Turkey, demir.aysegul@gmail.com, *Simme Douwe Flapper*, *Sedef Meral*

Limited asset visibility is a key problem in the management of RTIs. One way of increasing asset visibility is RFID technology. However, RFID requires high investment cost and intense efforts for implementation. In this study, we investigate the value of increase in asset visibility and improvement opportunities provided by RFID technology for the management of RTI pools in a closed-loop supply chain setting both considering its costs and benefits with the help of mathematical models. We present the results obtained with the models for a case study, as well as topics for further research.

■ TA-15

Tuesday, 9:00-10:20

2.2.12

Vehicle Routing Problems with Pickups and Deliveries

Stream: Vehicle Routing

Invited session

Chair: *Gunes Erdogan*, Industrial Engineering, Ozyegin University, Özyeğin Üniversitesi Lojmanları, Reşat Bey Sok. No: 21 Apt. B6, 34000, İstanbul, Turkey, gunes.erdogan@ozyegin.edu.tr

1 - An optimization model for the Vehicle Routing Problem with Multiple Container Load

Massimo Di Francesco, Department of Land Engineering, UNIVERSITY OF CAGLIARI, Piazza d'armi, 09123, CAGLIARI, Italy, mdifrance@unica.it, Teodor Gabriel Crainic, Paola Zuddas

We study a vehicle routing problem with pickups and deliveries of full container loads from/to an intermodal terminal. Trucks can carry more than one container and are requested to wait containers emptied after deliveries to satisfy pick-up demands. To address this problem, we propose an optimization model. We will provide randomly generated experiments as well as comparisons to the decisions of real-world carriers.

2 - Optimization of Batteries Distribution and Route Planning with Pickups and Deliveries

Sónia Cardoso, Departamento de Engenharia e Gestão, Instituto Superior Técnico, Portugal, soniaraque20@hotmail.com, Ana Paula Barbósa-Póvoa

Nowadays logistics plays a key role in improving companies' efficiency and ensuring competitive advantages. One of the main focuses of logistics is the distribution and in order to optimize the resources used, vehicle routing problems have been widely studied. This paper presents the solution of a distribution problem of a Portuguese company producer and retailer of batteries. A MILP model was developed to define the optimal set of routes that minimize total costs in terms of the number of vehicles and the total travelling distance, taking into account the vehicles' capacity.

3 - The Traveling Salesman Problem with Pickups, Deliveries and Handling Costs

Daniele Vigo, DEIS, University of Bologna, Via Venezia 52, 47023, Cesena, Italy, daniele.vigo@unibo.it, Maria Battarra, Gunes Erdogan, Gilbert Laporte

This paper introduces a new variant of the One-to-Many-to-One Single Vehicle Pickup and Delivery problem that incorporates the handling cost incurred to rearrange the load at customer locations. The simultaneous optimization of routing and handling costs is difficult and the resulting loading patterns are hard to implement in practice. Branch-and-cut algorithms based on integer linear programming formulations of simplified loading policies are proposed. Extensive testing on instances involving up to 25 customers indicate that the simplified policies favorably compare with the optimal one.

4 - A Branch-and-Cut Algorithm for the Non-Preemptive Capacitated Swapping Problem

Gunes Erdogan, Industrial Engineering, Ozyegin University, Özyeğin Üniversitesi Lojmanları, Reşat Bey Sok. No: 21 Apt. B6, 34000, İstanbul, Turkey, gunes.erdogan@ozyegin.edu.tr, Jean-Francois Cordeau, Gilbert Laporte

This paper models and solves a capacitated version of the Non-Preemptive Swapping Problem. This problem is defined on a complete digraph, at every vertex of which there may be one unit of supply of an item, one unit of demand, or both. The objective is to determine a minimum cost capacitated vehicle route to transport the items in such a way that all demands are satisfied. The vehicle can carry more than one item at a time. Three mathematical programming formulations, several classes of valid inequalities are provided, as well as the results of extensive computational experiments.

■ TA-16

Tuesday, 9:00-10:20

2.2.14

OR models and algorithms

Stream: Public Transport

Invited session

Chair: Federico Perea, Matemática Aplicada 2, Universidad de Sevilla, 41092, Seville, Spain, perea@us.es

1 - Wardrop Equilibria with Risk Averse Users

Fernando Ordonez, Industrial and Systems Engineering, University of Southern California, 3715 McClintock Ave, GER

240, 90089, Los Angeles, CA, United States, fordon@usc.edu, Nicolas Stier-Moses

Traffic in a transportation network can be modeled as the outcome of users optimizing their costs in a network game. There are, however, random events that impact user's traffic costs. In this work we extend network games by adding random deviations to congestion costs. Given a model of user risk behavior, we show that an equilibrium for this game always exists. We introduce different specific equilibrium models that tradeoff accuracy with tractability and show computationally that these models are closer to an equilibrium where users optimize their desired percentile cost than the classic Wardrop equilibrium.

2 - A Customer Oriented Model for Public Transportation Timetables

Miguel Angel Pozo, Universidad de Sevilla, Alcalde Isacio Contreras, N°8, 1°A, 41003, Seville, Spain, miguelpozo@us.es, Francisco A. Ortega

The Transit Network Timetabling Problem (TNTP) aims to determine optimal timetables for each line in a transit network by establishing departure and arrival times at each station. The main objective in public transportation consists of providing an optimal service for passengers under fleet size constraints. This paper deals with the optimal timetable for a given number of vehicles when users differ between their desired travel times. According to different transport policies, the problem is formulated through two location-allocation models and is solved for real size instances.

3 - Demand based railway timetables, capacity and quality of service.

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, Gabriel Villa, Encarnación Algabe

Railway scheduling and timetabling have been widely studied in the literature. Currently, most efforts focus on the process of solving integer programming models both using meta-heuristics and exact approaches. However, in the case of medium-frequency, there are only a few approaches based on passenger demand. This paper focuses in an integrated approach to modeling the scheduling problem as well as considers new issues such as capacity analysis or quality of service provided to customers, which are inseparable from the scheduling problem.

4 - GRASP Algorithms for the Railway Network Design Problem

Federico Perea, Matemática Aplicada 2, Universidad de Sevilla, 41092, Seville, Spain, perea@us.es, Antonio J. Lozano, Juan A. Mesa

We propose a GRASP algorithm to solve the railway network design problem and the robust version of it. These problems are modeled as integer linear programming problems, and design a topological railway network maximizing the trip coverage in the presence of a competing mode, assuming that links can fail. Since this problem is computationally intractable for realistic sizes, grasp heuristics are designed for solving it. Some experiments have been carried out, and their results make us think that this kind of heuristics are suitable for railway network design problems.

■ TA-17

Tuesday, 9:00-10:20

1.3.14

Contracts and Sub-contracting for Transportation

Stream: Transportation Planning

Invited session

Chair: Melanie Bloos, Chair of Logistics, Bremen University, Wilhelm Herbst Str.5, 28359, Bremen, Germany, bloos@uni-bremen.de

1 - A web platform for effective planning of green combined transportation in EU

Vasileios Zaimpekis, Financial & Management Engineering, University of the Aegean, Kountouriotou 41, Chios, 82100, Chios Island, Greece, vzeimp@fme.aegean.gr, Dimitrios Saliaris, Konstaninos Mamasis, Ioannis Minis

This paper presents the design and implementation of an innovative web platform that supports shippers and forwarders to seek near optimal intermodal transport solutions that take into account cost, transportation time, risk and CO2 emissions. The paper analyses initially the related requirements of 35 freight companies. Subsequently, the design of the platform is presented, which takes into account these requirements in order to a) develop an attractive transportation plan using available data and related OR techniques, b) request offers from registered providers, and c) monitor delivery.

2 - Solving a milk collection and delivery problem

Nadia Lahrichi, Management et technologie, CIRRELT, ESG/UQAM, CP8888, succ centre-ville, H3C3P8, Montreal, Qc, Canada, nadia.lahrichi@cirrelt.ca, *Teodor Gabriel Crainic*, *Michel Gendreau*, *Walter Rei*, *Louis-Martin Rousseau*

The Fédération des producteurs de lait du Québec is a coalition of dairy farmers in province of Quebec. The producers have delegated to the Fédération the responsibility for negotiating all conditions of transporting milk, and especially costs, from the farm to the plant on their behalf with the transporters. The objective is to study the process of contracting with carriers for determining the fare of transportation. This process typically starts with assigning dairy farms to vehicles and delivering the volume collected to plants.

3 - Optimisation models and algorithms for waste management in South African rural areas

Elias Jakobus Willemsse, Built Environment, CSIR, PO Box 395, Pretoria, 0001, Pretoria, Gauteng, South Africa, ewillemsse@csir.co.za, *Johan Joubert*

In rural areas of South Africa, local entrepreneurs are subcontracted by municipalities to collect the household waste and transport it to bulk waste containers. In this paper optimisation models and algorithms are presented that will help municipalities to better plan and implement this strategy. The optimisation models are able to determine the location of transfer stations within the service area; to sector an area into balanced collection zones—each zone is assigned to a subcontractor; and to generate a collection route for each subcontractor.

■ TA-18

Tuesday, 9:00-10:20

1.3.15

Supply Chain Management

Stream: Stochastic Modeling and Simulation

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: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - An application of the revised weighting method in vendor selection with price breaks

Tunjo Perić, Bakeries Sunce, Komedini 1, 10090, Zagreb, Croatia, tunjo.peric1@zg.t-com.hr, *Zoran Babic*

This paper investigates the possibility of application of the revised weighting method in the problem of vendor selection and quantities supplied with price breaks. Goals and criteria are expressed in a hierarchical structure and the change of prices depends upon the size of order quantities. The proposed methodology is tested on the example flour purchase by the firm dealing with production of bread and pastry.

2 - Interaction analysis of participants in supply chains

Ivana Kovacevic, Human resource management, Faculty of organizational sciences, Jove Ilica 154, 11 000, Belgrade, Republic of Serbia, Serbia, kivana@fon.rs, *Biljana Panic*

Supply chain efficacy is dependent on fine coordination of participants, precisely on quality of their interactions. So, communication could facilitate or jeopardize the whole process. Simulation of the beergame example of supply chain process revealed some behavioral patterns that are described by transactional analysis terminology. Transactional analysis is used as a theoretical frame for diagnosing and understanding social interactions. Some suggestions for overcoming potential communication problems in supply chains are given in the conclusion.

3 - Simulation of supply chain dynamic behaviour by means of discrete event tools

Christos Papanagnou, Automation, Alexander TEI Thessaloniki, Sindos, 54100, Thessaloniki, Greece, chrobo@yahoo.com, *Panagiotis Tzionas*

The scope of this research is to study the dynamic behaviour of supply chains by examining initially the impact of different standard forecasting methods such as moving average and exponential smoothing on the bullwhip effect. Further, we investigate efficient ordering policies under different scenarios followed in cases where information feedback patterns are taken into consideration by participants. Finally, we derive the total operational cost of each participant and we examine moving average vs exponential smoothing competition schemes by minimizing the corresponding operational costs

4 - Strategic Cost Management and Supply Chain Management: lessons from a case study

Manuel Nunes, Production and Systems, University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal, lnunes@dps.uminho.pt, *Paulo Afonso*

Strategic management of costs requires analysis that goes beyond the frontiers of the firm in order to know the value supply chain as a whole, i.e., right from the origins of the technology, materials, human and financial resources that it uses, up to the final consumer. In this context, product and/or service costing systems must be complemented with methods that are capable of reflecting the full impact of costs on a firm's strategy. In this paper, a methodology based on strategic management of costs (applied to the supply chain) that supports decision-making is presented.

■ TA-19

Tuesday, 9:00-10:20

1.3.20

Economical Models

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Alberto Pinto*, Mathematics, University of Minho, Campus de Gualtar, 4710-057, Braga, aapinto@math.uminho.pt

Chair: *José Martins*, University of Minho, 4700, Braga, jmmartins@estg.ipleiria.pt

1 - Adaptive forecasting methods for time series with complex trend patterns

Vitor Mendonca, CIO - FCUL, University of Lisbon, Edifício C6, Campo Grande, 1749-016, Lisboa, Portugal, vitormendonca@gmail.com, *Antonio Rodrigues*

Growth or development processes may exhibit trend patterns more complex than usually assumed by traditional models, including pure sigmoidal growth in innovation diffusion. We propose three new modelling approaches, using recursive estimation methods, designed to better account for modulated but aperiodic changes in curvature and convexity in trends. This is confirmed from comparative experiments of their application to an heterogeneous set of time series from very different origins – marketing, energy, climate, technology, health, etc.

2 - An economic analysis of biofuels production, processing, and distribution in the US

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

Recent energy policies in the US aim to increase the share of renewables in transportation fuel. Specifically, 36 billion gallons of ethanol derived from corn and cellulosic biomass is required to be blended with gasoline by the year 2022. The impact of this on land use and equilibrium in food markets is addressed in this paper. We use a large scale spatially explicit mathematical model to determine the dynamic equilibria in commodity markets and an optimum network for production, processing, and distribution of ethanol. We present the methods used and some empirical results of the model.

3 - Mathematical modeling for sugarcane residual biomass exploitation

Helenice Florentino, Bioestatística, IB UNESP, Depto de Estatística IB UNESP, Bairro Rubião Júnior S/N, 18618-000, Botucatu, SP, Brazil, helenice@ibb.unesp.br

Brazil is the world's largest sugarcane producer. There is great concern about the crop system used, because the common practice is manual harvesting with prior straw burning. The Brazilian authorities have approved a law prohibiting the burning. However, the major difficulty in using this residue is how to economically transport this biomass from farm to processing center. The aim of this work was to develop a model to minimize the cost of the residual biomass transfer process and to maximize the residual biomass energy balance. For this 0-1 multiobjective programming techniques were used.

4 - A duopoly collusion, dumping and Cournot comparison

José Martins, University of Minho, 4700, Braga, jmmartins@estg.ipleiria.pt, *Alberto A. Pinto*

In this study, we consider an economical model where two firms of different countries can compete in collusion, Cournot and dumping followed punishment. We compare the profits of both firms in these three games in order to discover which game is more profitable for each firm.

■ TA-20

Tuesday, 9:00-10:20

1.3.33A

Cutting and Packing 6

Stream: Cutting and Packing

Invited session

Chair: *José Fernando Gonçalves*, LIAAD, Faculdade de Economia, Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-464, Porto, Portugal, jfgoncal@fep.up.pt

1 - A Parallel Multi-population Genetic Algorithm for a Constrained Two-dimensional Orthogonal Packing Problem

José Fernando Gonçalves, LIAAD, Faculdade de Economia, Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-464, Porto, Portugal, jfgoncal@fep.up.pt

This paper addresses a constrained two-dimensional, non-guillotine restricted, packing problem, where a set of small rectangles has to be placed into a larger stock rectangle to maximize the value of the rectangles packed. The algorithm proposed hybridizes a novel placement procedure with a genetic algorithm based on random keys. Computational tests are presented using available instances taken from the literature. The results validate quality of the solutions and the approach. Supported by Fundação para a Ciência e Tecnologia (FCT) project PTDC/GES/72244/200.

2 - An efficient algorithm for enumerating bottom-left stable positions and its applications

Shinji Imahori, Department of Computational Science and Engineering, Nagoya University, Furo-cho, Chikusa-ku, 464-8603, Nagoya, Japan, imahori@na.cse.nagoya-u.ac.jp, *Yuyao Chien*, *Yuma Tanaka*, *Mutsunori Yagiura*

We propose an efficient algorithm for enumerating bottom-left stable positions when we are given a set of packed rectangles and one new rectangle. Our algorithm uses no-fit polygons of rectangles and it can enumerate all the bottom-left stable positions within a short computation time even when the number of packed rectangles is more than one million. We also propose a compaction algorithm that translates the already packed rectangles closer to one another. By combining these two algorithms, we present a heuristic algorithm for the two-dimensional rectangle packing problem.

3 - A combined cutting stock and lot-sizing problem

Elsa Silva, Centro de Investigação Algoritmi, Universidade do Minho, Braga, Portugal, elsa@dps.uminho.pt, *Filipe Alvelos*, *J. M. Valério de Carvalho*

The two-dimensional cutting stock problem (2DCSP) consists in the minimization of the wastage when cutting a set of rectangular items from a (virtually infinite) set of plates. In this communication, we extend the 2DCSP by considering that the demand of the items is known for multiple time periods and there are storage costs. We propose an integer programming model which integrates the 2DCSP and lot-sizing problem.

4 - Two-Dimensional Cutting Stock Management in Fabric Industries and Optimizing the Large Object's Length

Shaghayegh Rezaei, Textile Engineering, Islamic Azad University, Science and Research Branch, Ashrafi esfehani Highway, Hesarak str., Tehran, Iran, Islamic Republic Of, shaghayegh.rezaei@gmail.com, *Mahdi Shadaloee*

Selection of cutting patterns to minimize production waste is an important issue in operations research. In this study, the two-dimensional cutting stock problem has been investigated to reduce the cutting waste, with focus on men's clothing. Regular and irregular shapes are enclosed by rectangles; and the metaheuristic algorithm of simulated annealing (SA) was used. This research showed that the amount of required stock can be reduced in fabric cutting by using the SA algorithm. Moreover, if the length of pieces is not fixed, uncontrollable stock can be changed into controllable ones.

■ TA-21

Tuesday, 9:00-10:20

6.2.47

Optimization Modeling IV

Stream: Software for OR/MS

Invited session

Chair: *Manuel Soler Arnedo*, Statistics and Operations Research, Universidad Rey Juan Carlos, C/ Tulipán s/n, 28933, Móstoles, Madrid, Spain, Manuel.soler@urjc.es

1 - Nonlinear optimization in a thermo-economic analysis of a small cogeneration system

Ana Ferreira, DPS, University of Minho, Azurém, Guimarães, 4800-058, Guimarães, Portugal, cristina_ferreira0@hotmail.com, *Celina Pinto Leão*, *Manuel Nunes*, *Senhorinha Teixeira*, *Luís B. Martins*

Combined heat and power means that both electrical and thermal energy are produced simultaneously. The main objective of this work is the use nonlinear optimization techniques in a thermo-economic analysis in the design of a small cogeneration system. The maximization of annual worth of the cogeneration plant was performed. According to the results obtained from the tested scenarios, it can be concluded that the optimal value of cogeneration systems capacity is sensitive to capital cost and mostly to the energy prices (gas buying and electricity grid-selling prices).

2 - A MINLP Model for the Hydro Scheduling of an Electricity Producer

Javier Diaz, Sistemas e Informatica, Universidad Nacional de Colombia, Cra 80 65-223, Facultad de Minas Bloque m8A oficina 212, 1, Medellín, Antioquia, Colombia, javidiaz@unal.edu.co

An MINLP model is developed to maximize the profit of a hydroelectric generation company considering the technical efficiency and shut up costs of the units. The decision variables are the water discharges. It optimizes the integrated operation of a system of cascaded hydroelectric plants. Statistical regressions are used to estimate both the technical efficiency of a Francis turbine from its 'hill diagram' and the head-volume relationship of the reservoirs. We analyze several case studies of realistic dimensions.

3 - Billiards games: an optimization approach

Jean-François Landry, Computer Science, Université Blaise Pascal/Université de Sherbrooke, France, jean-francois.landry2@usherbrooke.ca, *Jean-Pierre Dussault*, *Philippe Mahey*

This presentation will address the difficulties related to solving the discrete/continuous aspects present in various billiards games. A short description of a few known billiards games will first be provided, along with the distinct aspects that characterize them. With the problematic clearly identified, an optimization model will then be introduced, which takes advantage of the knowledge that can be extracted from this type of problem. Possible optimization approaches to solve this model will finally be discussed, along with a short demonstration.

4 - Hybrid Optimal Control for Commercial Aircraft Trajectory Shaping

Ernesto Staffetti, Department of Statistics and Operations Research, University Rey Juan Carlos, C/ Tulipan s/n. 28933, Mostoles, Madrid, ernesto.staffetti@urjc.es, *Manuel Soler Arnedo*, *Alberto Olivares*

Given the sequence of phases and flight modes conforming the flight profile of a commercial aircraft, the initial and final states and a set of path constraints, we solve the problem of finding control inputs and the corresponding trajectory of the aircraft that minimizes fuel consumption. Such optimal control problem is solved using a direct approach, a collocation method, in which the highly nonlinear dynamics of an aircraft is solved using an Interior Point Optimizer, IPOPT, an open source software package for large-scale nonlinear optimization.

■ TA-22

Tuesday, 9:00-10:20

3.1.10

Health Care Scheduling I

Stream: Health Care Management

Invited session

Chair: *Tugba Cayirli*, Management, Ozyegin University, KUSBAKISI CAD. NO: 2, ALTUNIZADE - USKUDAR, 34662, ISTANBUL, Turkey, tugba.cayirli@ozyegin.edu.tr

1 - Optimization of Daily Scheduling for Extramural Health Care Services

Andrea Trautsamwieser, Institute of Production and Logistics, University of Natural Resources and Applied Life Sciences, Feistmantelstraße 4, 1180, Vienna, Austria, andrea.trautsamwieser@boku.ac.at, *Patrick Hirsch*

The demand for extramural health care services is rising tremendously. Therefore, powerful algorithms are required to assist decision making. A model formulation and a solution approach for the daily planning are presented. The objective is to minimize the traveling- and waiting times of the nurses and to minimize the dissatisfaction level of clients and nurses. A feasible solution has to observe suitable assignments of clients to nurses considering for example qualification levels. Additionally, working time restrictions, hard time windows, and mandatory breaks have to be kept.

2 - A Universal Appointment Rule for a Single-Server System with Walk-ins & No-Shows

Tugba Cayirli, Management, Ozyegin University, KUSBAKISI CAD. NO: 2, ALTUNIZADE - USKUDAR, 34662, ISTANBUL, Turkey, tugba.cayirli@ozyegin.edu.tr, *Kum-Khiong Yang*, *Ser Aik Quek*

This study introduces a universal appointment rule presented as a mathematical function of environmental factors that include probabilities of no-shows, walk-ins, number of patients per session, coefficient of variation of service times and relative cost of doctor's time to patient's time. Nonlinear regression is conducted on simulated data to derive the association between clinic parameters and rule formulation. The performance of the rule is evaluated in terms of the total cost of system as a weighted sum of patients' wait time, doctor's idle time and overtime.

3 - Metaheuristic solutions for the or planning and scheduling problem

Paolo Landa, Department of Economics and Quantitative Methods (DIEM), University of Genova, Via Vivaldi 5, 16126, Genova, Italy, paolo.landa@yahoo.it, *Elena Tanfani*, *Angela Testi*, *Roberto Aringhieri*, *Patrick Soriano*

This paper presents a metaheuristic algorithm to determine Operating Rooms (ORs) plans using a block-scheduling system. Given a surgery department made up of different sub-specialties sharing a fixed number of ORs, the problem is that of determining the allocation of OR time blocks to sub-specialties together with the subsets of patients to be operated on over a given planning horizon. The problem is formulated as a 0-1 LP model with operative, capacity and demand constraints. Since the model is strongly NP-hard, we propose a tabu search approach to find good (suboptimal) solutions in reasonable CPU times. Computational results are reported and compared with those provided by a 0-1 LP based heuristic

■ TA-23

Tuesday, 9:00-10:20

6.2.49

MOO: Scheduling Problems

Stream: Multi-Objective Optimization

Invited session

Chair: *Jacques Teghem*, MATHRO, Faculté Polytechnique de Mons, 9, rue de Houdain, 7000, Mons, Belgium, jacques.teghem@fpms.ac.be

Chair: *Taicir Loukil*, Faculté des Sciences Economiques et de Gestion, Route l'aérodrome km 4, BP 3018 Sfax, Tunisia, 3018, Sfax, Tunisia, Taicir.Loukil@fsegs.rnu.tn

1 - A bicriteria flowshop problem with time lags

Emna Dhouib, LOGIQ, Institut Supérieur de Gestion Industrielle de Sfax, Route El Mharza km 1.5, 3018, SFAX, emna-dhouib@yahoo.fr, *Jacques Teghem*, *Daniel Tuytens*, *Taicir Loukil*

We consider the permutation flowshop problem with minimal and maximal time lags constraints. The objective is to hierarchically minimize first the number of tardy jobs and then the makespan. A mixed integer linear programming is proposed and the problem is also solved by local search metaheuristics. Both approaches are compared numerically.

2 - A bi-objective approach for rescheduling a flowshop

Jacques Teghem, MATHRO, Faculté Polytechnique de Mons, 9, rue de Houdain, 7000, Mons, Belgium, jacques.teghem@fpms.ac.be

Following the seminal paper of Hall and Potts, we consider a scheduling problem for which a set of new jobs arrives when original jobs are already scheduled -but not yet processed - to minimize a classical objective. We analyze how to schedule the total set of jobs, original and new, to minimize simultaneously the classical objective and a disruption objective of the initial schedule. The aim is to determine or to approximate the Pareto Front. In a first step we apply a multiobjective metaheuristic to approximate this set of solutions. In a second step, we analyze various particular cases, with one or two machines, for which an optimal schedule minimizing the classical objective is obtained by a priority rule. For these cases, we propose exact algorithms to obtain the Pareto Front.

3 - Benchmark generators for reactive multi-mode project scheduling problem after a mode modification

Sonda Elloumi, Quantitative Methods, Faculty of Economic and Management Sciences, 3 Rue Ibn Khaldoun, Route de Gremda Km4, 3062, Sfax, Tunisia, elloumi_sonda@yahoo.fr, *Philippe Fortemps*, *Taicir Loukil*

During its execution, a project can undergo unexpected events. Hence, reactive algorithms are crucial. Since no benchmark instances are available for reactive algorithms, we propose three complementary benchmark generators. All these generators lean on a baseline schedule. Then, they suppose that at a certain date of the project progress, the planned mode of a future activity should change. This fact is tackled with different manners according to the chosen generator, which in its turn depends on the user convenience.

4 - Bi-criteria thermal-energy production scheduling, using genetic algorithms

Dalila Fontes, Faculdade de Economia e LIAAD-INESC Porto L.A., Universidade do Porto, Rua Dr Roberto Frias, 4200-464, Portugal, fontes@fep.up.pt, *Luís Roque*, *Fernando A. C. C. Fontes*

A genetic algorithm is developed to address a unit commitment problem, involving the minimization of the operating costs and of the pollution emission costs. Since minimizing pollution may lead to an increase in operating costs and vice versa, a bi-objective problem is faced. In order to schedule the energy production, one has to determine which plants will be used, as well as, the quantities to be produced by each of these plants. The GA proposed approximates the Pareto front by finding a set of interesting solutions. Computational results are reported for a couple of standard test systems.

■ TA-24

Tuesday, 9:00-10:20

6.2.50

Applications of OR in Life Science Informatics

Stream: Computational Biology, Bioinformatics and Medicine

Invited session

Chair: *Erfan Younesi*, Department of Bioinformatics, Fraunhofer Institute for Algorithms and Scientific Computing SCAI, Schloss Birlinghoven, C3, 53754, Sankt Augustin, NRW, Germany, erfan.younesi@scai.fraunhofer.de

1 - A Temporal Logic Constraint Solving Approach to Model Coupling: Case Study on the Effects of Irinotecan Injections on the Mammalian Cell Cycle

Elisabetta De Maria, INRIA, France, 78153, Paris, France, elisabetta.demaria@dimi.uniud.it

In systems biology, the number of available models of cellular processes increases rapidly, but re-using models in different contexts or for different questions remains a challenging issue. We show how the formalization of experimental observations in temporal logic with numerical constraints can be used to automatically validate a coupled model and optimize unknown parameter values with respect to experimental data. In particular, we study the coupling of the mammalian cell cycle, the circadian clock, the p53/Mdm2 DNA-damage repair system, and the irinotecan metabolism.

2 - Gene Network Analysis: Identifying Causal Relationships

Jörg Zimmermann, Institute of Computer Science III, University of Bonn, Roemerstr. 164, 53117, Bonn, NRW, Germany, jz@iai.uni-bonn.de

Microarrays enable the fast acquisition of gene expression profiles. In order to get functional models from these profiles, gene networks have emerged as an important concept, leading to two main problems:

1. How to extract a specific network from biological data?
2. How to analyze the network structure?

Causal relationships can be modeled by directed networks. The resulting edge-orienting problem can be solved by using SNPs as "causal anchors" and a scoring algorithm, which measures the strength of evidence for a causal direction.

3 - Detecting early breast cancer with Artificial Immune Recognition Systems

Christos Katsis, Dept. of Applications of Information Technology in Administration & Economy, Technological Educational Institute of Ionian Islands, Kapodistriou 11, Neapolis, GR31100, Lefkas, Greece, ckatsis@cc.uoi.gr, *I. Gogkou*, *Christos Papadopoulos*, *Yorgos Goletsis*, *Giorgos Stylios*

We present a two stage method for a decision support system in early breast cancer detection. In hard to diagnose cases, different examinations (mammography, ultrasonography, magnetic resonance imaging) provide contradictory results and patient is guided to biopsy for definite results. Our method is based on Artificial Immune Recognition Systems and is evaluated in real data from 53 subjects with contradictory diagnoses. The obtained results are promising. Comparative results with other approaches are given. The application of such an approach can reduce the number of unnecessary biopsies.

■ TA-25

Tuesday, 9:00-10:20

6.2.48

Risk Management and Portfolio Optimization I

Stream: Financial Mathematics and OR

Invited session

Chair: *Azar Karimov*, Financial Mathematics, Institute of Applied Mathematics, Middle East Technical University, Eskishehir road, 06530, Ankara, Afghanistan, azer.kerimov@gmail.com

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Optimal portfolio with annuity purchase

Tadashi Uratani, Industrial and System Engineering, Hosei University, Nakacho 18, 162-0835, Shinjuku, Japan, uratani@hosei.ac.jp, *Takashi Kobayashi*

We study the self-annuitization and the dynamic optimal portfolio selection to minimize the probability of lifetime ruin. In order to avoid the risk of living after spending out his wealth, there are three financial instruments, a risky asset, risk free asset, and annuity which guarantee fixed income until death. As a retiree is getting older, the annuity price is becoming cheaper to purchase it. The problem is to find the optimal portfolio of three financial assets and the timing to buy annuity. The optimal solution is holding only the risky asset afterwards his wealth equals to the risky investment. We define an annuity price function and solve the purchase time as a first hitting time.

2 - Portfolio rebalancing model using the criterion of entropy

Wen Yi Lee, Information Management, National Chi Nan University, 470 University Road, Puli Nantou 545, Taiwan, 545, Puli, Taiwan, s96213502@ncnu.edu.tw, *Jing-Rung Yu*

A diversified portfolio is required to form an efficient model with lower risk for investors. The maximization of entropy can generate a diversified portfolio. In addition to the criteria of entropy, risk and return, the short selling and the transaction cost are taken into account to form a more realistic rebalancing model. In order to transfer a non-linear entropy model into a linear entropy model, the ordered weighted averaging operator (OWA) is adopted. Our model is compared with the model with return and risk. A numerical example is illustrated the proposed model in more details.

3 - Do High-Tech Stock Recommendations Have Investment Value?

Chin-Tsai Lin, Graduate Institute of Business and Management, Yuanpei University, No. 306, Yuanpei St., 30015, Hsin Chu, Taiwan, cotlin@mail.ypu.edu.tw, *Yi-Hsien Wang*, *Fu-Ju Yang*, *Tung-Cheng Hu*, *Yi-Shan Chen*

This study investigates the investment value of analysts' stock recommendations on the performance of listed high-tech companies and examines whether these explanatory variables are associated with observed cumulative abnormal returns. These analytical results demonstrate that average abnormal returns are significantly positive pre- announcement date, and negative post- announcement date. Hence, the observed phenomena can be attributed to the analysts generally adopt conservative position following disclosure of information.

4 - Extreme Value Theory: a new tendency in market risk management?

Selena Totic, Operational Management and Statistics, Faculty of Organizational Sciences, Belgrade University, Patrijarha Varnava 25, 11158, Belgrade, Serbia, selena@fon.rs, *Milica Bulajic*

The recent financial crisis brought many questions concerning the adequacy of different risk measures and especially Value-at-Risk (VaR) methodologies. Among them highly ranked was the deficiency of common VaR methodologies to capture fat-tail risks. In this paper, the Extreme Value Theory as an alternative approach of measuring VaR is explored. The most important theoretical results of univariate EVT are introduced. Special emphasis is paid to two methodologies related to the Extreme Value Theory (EVT): the Peaks over Threshold (POT) and the Blocks Maxima (BM).

■ TA-26

Tuesday, 9:00-10:20

3.1.11

Operation research games

Stream: Cooperative Game Theory

Invited session

Chair: *Gustavo Bergantinos*, Statistics and O. R., University of Vigo, Facultade de Económicas, Universidade de Vigo, 36310, Vigo, Pontevedra, Spain, gbergant@uvigo.es

1 - On Monotonic rules in minimum cost spanning tree problems

Juan Vidal-Puga, Estadística e IO, Universidade de Vigo, Facultade de Ciencias Sociais e da Comunicación, Campus A Xunqueira sn, 36005, Pontevedra, Pontevedra, Spain, vidalpuga@uvigo.es, *Gustavo Bergantinos*, *Anirban Kar*

We characterize, in minimum cost spanning tree problems, the family of rules satisfying monotonicity over cost and population.

2 - A generalization of obligation rules for minimum cost spanning tree problems

Gustavo Bergantinos, Statistics and O. R., University of Vigo, Facultade de Económicas, Universidade de Vigo, 36310, Vigo, Pontevedra, Spain, gbergant@uvigo.es, *Leticia Lorenzo*, *Silvia Lorenzo-Freire*

Tijs et al (2006) introduce the family of obligation rules for minimum cost spanning tree problems. We give a generalization of such family. We prove that our family coincides with the set of rules satisfying an additivity property and a cost monotonicity property. We also provide two new characterizations for the family of obligation rules using the previous properties. In the first one we add a property of separability; and in the second one we add core selection.

3 - An axiomatic approach in minimum cost spanning tree problems with groups

Gómez-Rúa María, Estadística e Investigación Operativa, Universidade de Vigo, Facultade de CC. Económicas e Empresariais. Lagoas-Marcosende, s/n, 36310, Vigo, mariarua@uvigo.es, *Gustavo Bergantinos*

We study minimum cost spanning tree problems with groups, where agents are located in different villages or cities. The groups are the agents of the same village. In Bergantiños and Gómez-Rúa (2009, ET) we define the rule F as the Owen value of the irreducible game with groups and we prove that F generalizes the folk rule of minimum cost spanning tree problems. Bergantiños and Vidal-Puga (2007, JET) give two characterizations of the folk rule. In this paper we extend such characterizations to our setting. Some of the properties are the same and the other need to be adapted.

4 - Linear Production Games with Externalities

Manuel Alfredo Mosquera Rodríguez, Statistics and Operations Research, University of Vigo, Edificio Jurídico-Empresarial, Campus Ourense, 32004, Ourense, Ourense, Spain, mamrguez@uvigo.es, *Natividad Llorca*, *Joaquín Sánchez-Soriano*

We deal with Linear Production situations in which there is a limited common-pool resource. In this case, if we are interested in studying these problems from a cooperative view-point, we should consider that the value of a coalition also depends on what the outsiders could do. In this sense, the use of a characteristic function in partition function form seems more suitable than the coalitional function form. We approach the definition of these functions from a non cooperative perspective and propose three different models. Finally, we analyze the core-related concepts for the three models.

■ TA-27

Tuesday, 9:00-10:20

8.2.06

FREIGHT TRANSPORT AND LOGISTICS

Stream: Transportation and Logistics [c]

Contributed session

Chair: *Katharina Grobleben*, Logistics Management, WHU, Burgplatz 2, 56179, Vallendar, Germany, katharina.grobleben@whu.edu

1 - Customer Agreement Characteristics and their Impact on Rail Freight Productivity

Lars Backåker, Department of Science and Technology, ITN, Linköping University, Bredgatan 33, SE-60174, Norrköping, Östergötland, Sweden, lars.backaker@itn.liu.se, *Johanna Törnquist Krasemann*

Modern rail freight operators are today continuously striving for increased productivity within their service networks. Since the rail freight industry is characterized by large-scale, strictly limited service networks, further improvements in the area have been proved difficult. Until now, several operation research contributions have focused on simplifying operational planning. Moving on, we find it necessary to consider how customer agreement characteristics affect planning and productivity. A literature review has been established.

2 - The impact of the equal exchanges recovery strategy in closed-loop supply chains of returnable transport item (RTI)

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, *Simme Douwe Flapper*, *Eva Ponce-Cueto*

Many companies using RTIs, like crates, pallets, containers, for the distribution of their products have problems in timely getting back these items. One strategy used in practice to deal with the above is the equal exchange policy: at the moment of delivery the customer has to return as many RTIs as the number of RTIs used for delivering the order. An MILP model is used to study the behavior of, and the economic cost for the customer and the supplier under the above strategy for a number of different situations. The results obtained are discussed and directions for further research indicated.

3 - Hybrid Optimization/Simulation Approach to Design the Reverse Logistics Network of a 3PL

A. Cetin Suyabatmaz, Faculty of Engineering and Natural Sciences, Sabanci University, MBDF 1021, Sabanci Universitesi, Orhanli, Tuzla, 34956, Istanbul, Turkey, csuyabatmaz@sabanciuniv.edu, *F. Tevhide Altekin*, *Guvenc Sahin*

As the product take-back legislations enforced by the governments are put into effect, the percentage of companies using reverse logistics services of third party logistics service providers (3PLs) have reached to 33% in US and 15% in Europe. In this study, we present a hybrid optimization/simulation approach to design the reverse logistics network of a 3PL. A mixed integer programming model and simulation are iteratively used to design the network while incorporating uncertainties associated with the returns. The proposed approach is validated by a computational analysis.

4 - Towards a modal shift in European freight transportation

Katharina Grobleben, Logistics Management, WHU, Burgplatz 2, 56179, Vallendar, Germany, katharina.grobleben@whu.edu

In light of current developments in the transport sector, a modal shift is needed. The paper investigates which service attributes have the greatest impact on freight mode choice decisions in regard to road, rail-road and barge-road freight transport services. In more detail, the paper tests the validity of the rational approach for freight mode choice models. Based on a comprehensive literature review on intermodal transport and mode choice modeling, a refined empirical research methodology is used to investigate the choice behavior of decision-makers for freight transport services.

■ TA-28

Tuesday, 9:00-10:20

8.2.10

Stochastic Programming Models 1

Stream: Stochastic Programming 1

Invited session

Chair: *Nilay Noyan*, Manufacturing Systems/Industrial Engineering, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, nnoyan@sabanciuniv.edu

1 - A scenario tree approach to Optimal Pharmaceutical Research and Development Portfolios using real option valuation method

Majid Rafiee, Industrail Engineering, sharif University, Deptment on Industrail Engineering, sharif University of Technology, Tehran, Iran, Tehran, Iran, Islamic Republic Of, ma_rafie@yahoo.com

R&D managers in a pharmaceutical company's pipeline must consider the entire portfolio in the face of market and technological uncertainty and resource constraints. This paper presents a stochastic optimization model of pharmaceutical multi-period project selection problem using a real option valuation method. Then it generates related scenario fan and, via existing algorithms, reduces scenarios to generate a new (smaller) scenario tree. Model with reduced scenarios has been solved in this paper. Numerical results indicate improved portfolios and show the effectiveness of the proposed algorithm.

2 - A Stochastic Two-Period Model in Airline Seats Inventory Control

Patricia Xufre, CIO-FCUL and ISEGI-UNL, Edificio C6, Campo Grande, 1749-016, Lisboa, Portugal, pxufre@isegi.unl.pt

We formulate and analyse a stochastic two-period inventory control model for airline seats management. This is an extension of the classical newsboy model: it incorporates the possibility of a price increase between the two periods; and, it assumes the existence of consumer diversion, which will cause dependent sales. Furthermore, the formulation allows realistic assumptions such as cancellations, no-shows and overbooking. We derive the fare allocation limit, as well as the initial capacity for this model. We discuss the results obtained and some managerial implications.

3 - A Stochastic Programming Approach for Stochastic Assembly Line Balancing with Line Stoppages

F. Tevhide Altekin, Faculty of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, altekin@sabanciuniv.edu, *Nilay Noyan*, *Selin Soner Kara*

The stochastic assembly line balancing problem (ALBP) seeks a feasible assignment of tasks with stochastic task times to a series of stations such that precedence relations are satisfied and some performance measure is optimized. This paper studies the stochastic ALBP under the assumption that whenever the work content required by at least one workstation exceeds the cycle time, the assembly line is stopped. A stochastic programming formulation that minimizes the total operating cost is proposed. To demonstrate the cost savings, the results of a computational study are also presented.

4 - Managing Production in Supply Chain under uncertainty

Yi-Shu Yang, Industrial Engineering and Technology Management, Da-Yeh University, 168, University Rd., Da-Tusen., Chang-Hua, Taiwan, joanna@mail.dyu.edu.tw

According to globalization, the competition of business is drastic. It is necessary for enterprises integrated into a supply chain to share information. The challenge for supply chain management is demand uncertainty. The purpose of this research is, satisfying the uncertain demands based on scenarios, to propose a two-stage stochastic programming model for supply chain in order to allocate production plans, inventory levels and logistics in a supply chain. Finally, a numerical example verifies the feasibility of stochastic programming for supply chain.

■ TA-29

Tuesday, 9:00-10:20

8.2.11

Satisfiability: Structures and Complexities

Stream: Boolean Programming

Invited session

Chair: *Stefan Porschen*, Institut für Informatik, Universität zu Köln, Universität zu Köln, Pohligstrasse 1, 50969, Cologne, NRW, Germany, porschen@informatik.uni-koeln.de

1 - The Strength of Parameterized Resolution

Olaf Beyersdorff, Institut for Theoretical Computer Science, Leibniz University Hanover, Appelstr. 4, 30167, Hannover, Germany, beyersdorff@thi.uni-hannover.de

Parameterized complexity offers a fine view on classically intractable problems yielding efficient solutions for many hard optimization problems. We examine the proof-theoretic strength of parameterized resolution introduced by Dantchev, Martin and Szeider (FOCS'07). Using a game we obtain lower bounds to the proof size in parameterized tree-like resolution for the pigeon-hole and the order principle. Conversely, we demonstrate the strength of the proof system by constructing short refutations of a number of principles hard for general resolution.

Joint work with N. Galesi and M. Lauria.

2 - On Random Ordering Constraints

Andreas Goerdt, Fakultät für Informatik, Technische Universität Chemnitz, 09107, Chemnitz, Germany, goerdt@informatik.tu-chemnitz.de

Ordering constraints are formally analogous to instances of the satisfiability problem in CNF, but instead of a boolean assignment we consider a linear ordering of the variables. For many types of constraints the satisfiability problems are NP-complete. We look at random ordering constraints. There is a sharp unsatisfiability threshold for certain types of constraints, of undetermined value. We pursue the problem of approximating the value of the threshold. We show that random instances of the betweenness constraint under certain conditions are satisfiable with high probability.

3 - A Constructive Proof of the Lovász Local Lemma

Robin Moser, Computer Science, ETH Zurich, Universitaetsstrasse 6, 8092, Zurich, ZH, Switzerland, moserro@gmail.com

The Lovász Local Lemma is a powerful tool to non-constructively prove the existence of combinatorial objects meeting certain criteria. Beck demonstrated that a constructive variant can be given under certain more restrictive conditions. Simplifications of his procedure and relaxations of its restrictions were subsequently exhibited. We devised an poly-time algorithm to find the object guaranteed to exist by the Local Lemma. Here, I apply the algorithm to the sample application of bounded dependency k-SAT and use a simple information theoretic argument to bound the its running time.

4 - Towards genetic theory of non-Hamiltonicity: A study of mutants and their descendents.

Michael Haythorpe, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Boulevard, Mawson Lakes, 5095, Adelaide, SA, Australia, michael.haythorpe@unisa.edu.au, *Pouya Baniasadi*, *Vladimir Ejov*, *Jerzy Filar*

The Hamiltonian cycle problem is a famously difficult graph theory problem that can be stated simply - given a graph with N nodes, can a simple cycle of length N be found in the graph, or not? We look at the set of non-Hamiltonian cubic graphs and investigate why they contain no Hamiltonian cycles. We show that these graphs fall into three categories: bridge graphs, mutants, and descendents. Mutants are a new characterisation that is a superset to the set of all nontrivial snarks. Descendents are graphs which have a smaller graph as an ancestor, that can be identified in polynomial time.

■ TA-30

Tuesday, 9:00-10:20

8.2.13

MCDA II: Theoretical contributions

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

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 - An empirical study of rank reversals in the PROMETHEE methods

Céline Verly, CoDE-SMG, Université Libre de Bruxelles, Bd du Triomphe CP 210-01, 1050, Bruxelles, Belgium, celine.verly@ulb.ac.be, *Yves De Smet*

The methods based on pair wise comparisons suffer from possible rank reversals when the set of alternatives is modified. Different authors have reported such "problems" in AHP, ELECTRE, PROMETHEE, ... In this talk, we empirically study this phenomenon in the scope of the PROMETHEE methods. At first, we present different types of rank reversal. Then, we quantify the likelihood of rank reversal occurrences in artificial data sets. Finally, we compare these results with an ELECTRE-like procedure.

2 - On the bipolar-valued logical foundation of the classic outranking relation

Raymond Bisdorff, CSC/ILIAS, University of Luxembourg, 6, rue Richard Coudenhove-Kalergi, L-1359, Luxembourg, Luxembourg, raymond.bisdorff@uni.lu

Recently, Pirlot and Bouyssou have reported that a strict (asymmetric) outranking relation defined similarly to the classic outranking relation is in general not identical to its codual relation. This hiatus is problematic as the asymmetric part of an outranking relation is commonly identified with the codual relation. In this presentation we explore this hiatus in the context of our bipolar-valued epistemic logic. By considering an extended bipolar veto principle we are indeed able to preserve the identity between the asymmetric part and the codual of the outranking relation.

3 - Subjective expected utility on the basis of ordered categories

Denis Bouyssou, Université Paris Dauphine, CNRS-LAMSADE, Place du maréchal de Lattre de Tassigny, 75775, Paris Cedex 16, France, bouyssou@lamsade.dauphine.fr, *Thierry Marchant*

This paper shows that subjective expected utility can be obtained using primitives that are much poorer than a preference relation on the set of acts. Our primitives only involve the fact that an act can be judged either "attractive", "neutral" or "unattractive". These categories may be interpreted as denoting the position of an act vis-à-vis a status quo. We give conditions implying that there are a utility function on the set of consequences and a probability distribution on the set of states such that attractive (resp. unattractive) acts have a subjective expected utility that is above (resp. below) some threshold. The numerical representation that is obtained has strong uniqueness properties.

4 - Evaluations of Infinite Utility Streams: Pareto-Efficient and Egalitarian Axiomatics

María D. García-Sanz, Economía e Historia Económica, University of Salamanca, Edificio FES, Campus Miguel de Unamuno, Salamanca, Spain, dgarcia@usal.es

Two factors influence the resolution of the conflict among infinite generations: the consistency/ethical postulates requested; and the utilities that each generation can possess. We follow the Basu-Mitra approach to this problem. Firstly we examine efficiency and strengthened forms of Hammond Equity for the Future both when the utilities are in the unit interval and natural numbers. Secondly, we analyze the possibility of combining Pareto-efficiency and the spirit of the Hammond Equity principle for both specifications of utilities. We conclude that the Anonymity, Hammond Equity for the Future, and Hammond Equity ethics can be combined with weak specifications of the Pareto postulate.

■ TA-31

Tuesday, 9:00-10:20

8.2.15

OR and Ethics I

Stream: OR and Ethics

Invited session

Chair: *Fred Wenstøp*, Strategy and Logistics, BI Norwegian School of Management, Nydalsveien 37, 0483, Oslo, Norway, fred.wenstøp@bi.no

1 - From Policy Narratives to Policy Models

Giorgio Gallo, Informatica, University of Pisa, Largo B. Pontecovo, 2, 56127, Pisa, Italy, gallo@di.unipi.it, *Roberto Burlando*

A policy narrative is a "story", having a beginning, middle and end, outlining a specific course of events which has gained the status of conventional wisdom within a certain community. The "Tragedy of the Commons" is an example. A policy model, instead, describes a situation which, depending on the values of its parameters, can give origins to more than one story. Thus it is much more powerful in describing the knowledge we have about a particular situation. We will discuss positive and negative aspects of the use of policy stories/models, together with some of their ethical implications.

2 - A Decision Framework for Ethics

Cathal Brugha, Management Information Systems, University College Dublin, Quinn School of Business, Belfield, 4, Dublin 4, Ireland, Cathal.Brugha@ucd.ie

We use meta-theory to introduce eight meta-adjusting questions: what, where, who, which way, whether, whither, when and why, and four meta-adjusting dimensions: our commitments and convictions, how we adjust the world and how we adjust ourselves. Ethical decision-making uses reverse processes. It uses meta-adapting within the questions, first asking why, then when, and so on. It also uses meta-adapting within the four dimensions. For each dimension, it prioritises adapting ourselves, within adapting the world, within evincing what makes most sense, within aducing what is best for all.

3 - Janus faced moral mathematics, self-interest and emotions

Haavard Koppang, Gimle Terrasse 3., 0264, Oslo, Norway, haavard.koppang@bi.no, *Fred Wenstøp*

We address the question 'Why do we behave the way we do?' with 'moral mathematics' which we define as reasoning about moral and rationality with the help of pure logic and mathematics. The expression has two contrasting aspects to it: "moral" and "mathematics", a duality we will explore. By additionally looking at self-interest and emotions we will elucidate duality anon. We visit game theory, Parfit's concept of self-interest, and the famous trolley problems where simple mathematics does not seem to count, as we approach an understanding of how moral works and the role of emotions.

4 - Application of Chinese Doctrine of the Mean into Enterprise Leadership

Tzu-Yin Liang, Department of Chinese, National Kaohsiung Normal University, No.116, Heping 1st Rd., Lingya District, 802, Kaohsiung City, Taiwan, g9343706@yuntech.edu.tw, *Shan-Yu Su*, *Shih-Chou Kao*

The aim of the study was to investigate the application of Chinese Doctrine of the Mean on the leadership in the enterprise. The content analysis (documentary analysis or informational analysis) was used to analyze the leadership concept in Chinese Doctrine of the Mean. Two points were addressed in this study from depicting the central thinking of Chinese Doctrine of the Mean, and having an insight into Western thinking of the leadership. Furthermore, to achieve the harmonization and to raise the competitive ability, how to implement Chinese Doctrine of the Mean into the Western leadership was described into this study. Based on the content analysis in Chinese Doctrine of the Mean, the object of the enterprise strategy is to reach the Neutralization Realm of Pre-Qin Confucianism. This strategy of the leadership involves the perfect ethics and most sincere. The tactic of the leadership is that a leader has to own the ability of the self-cultivation and respect the person with virtue. Moreover, the leader also has to sympathize with painstaking employees and to tolerate their unwitting mistakes.

■ TA-32

Tuesday, 9:00-10:20

8.2.17

OR in Animal Science

Stream: OR in Agriculture and Forest Management

Invited session

Chair: *Lluís Miquel Pla*, Mathematics, University of Lleida, Fac. Dret i Economia, Jaume II, 73, 25001, Lleida, lmpa@matematica.udl.cat

1 - Dynamic model of red deer population size

Dominika Cywicka, Department of Cattle Breeding, University of Agriculture in Krakow, al. Mickiewicza 24/28, 30-059, Kraków, Poland, cywicka@tlen.pl, *Magdalena Hędrzak*

The level of the game harvest in Poland is based on: population number estimated by an inventory, expected birth rate and mortality rate. In binding documentation additional information about harvest realised in last season is included. It seems quite interesting, that estimated number of red deer remains similar in the following years, even though the implemented harvest is lower than the planned one. The model of red deer population dynamics, based on the official data, allows to verify the estimated number of red deer, as well as the assumptions regarded in the harvest planning.

2 - Dynamic model of processes of hatching of chicken

Magdalena Hędrzak, Department of Cattle Breeding, University of Agriculture in Krakow, al. Mickiewicza 24/28, 30-059, Kraków, Poland, magdziuch@tlen.pl, *Marcin W. Lis*, *Barbara Tombarkiewicz*, *Krzysztof Pawlak*, *Jerzy W. Niedziółka*

The brood of wild precocial birds demonstrate the trend to leave of eggs (hatch) in the same time. The chicks in the commercial incubators also synchronize the stages of hatching (internal and external pipping, hatching). Dynamic of these processes depend on many factors e.g. race, age of hens, parameters of incubation, period of storage eggs. The aim of the study was to create the dynamic model of hatching processes. The decision variables are: layer and broiler type, age of the flock, hour of external pipped and hatched of following chicks. The Euler's algorithm was used to computation.

3 - Dynamic modelling of economic costs of foot and mouth disease (FMD) epidemics

Jarkko Niemi, Economic Research, MTT Agrifood Research Finland, Luutnantintie 13, FI-00410, Helsinki, Finland, jarkko.niemi@mtt.fi, *Heikki Lehtonen*, *Tapani Lytykäinen*, *Leena Sahlström*, *Terhi Virtanen*

FMD is a highly contagious animal disease, which has the potential to cause catastrophic economic losses. This study estimates how costs to producers, consumers and taxpayers are accumulated. Disease spread among farms is simulated with an epidemiological Monte Carlo simulation model that uses spatial and temporal data. Market effects are estimated with a stochastic dynamic partial equilibrium model. Societal mean costs are EUR 24.2 mill. per epidemic (95% EUR 34.3 mill.). Measures to reduce infected farms, outbreak duration or loss of exports for fatty dairy product are central to reduce losses.

4 - Simulating the shift from marine netcages to inland recirculating aquaculture systems

Ilan Halachmi, Inst of Agricultural Engineering, Agricultural Research Organization, 50250, Bet Dagan, Israel, halachmi@volcani.agri.gov.il

Recirculating Aquaculture System (RAS) is an intensive production-line implementing reused water, continuously produce around the year in its full capacity. The 'warmed-up' (so called transient) period, until it runs to its full production capacity might take from few months up to two years. Shorten the transient period is curtail for the economic success of a new enterprise. The aim of the study was to develop a simulation model aiming at shortening the transient period. Gilthead Sea-bream (*Sparus aurata*) growth data was collected from 2003 to 2005 from 22 marine net-cages located at the Red Sea. The model combines discrete-event as well as continuous-time stochastic variables; it is dynamic, i.e., the passage of time plays a crucial role. Model inputs: fish weight, number of fish in each batch and the fish batch arrival timing. Potential input combinations was 5,314,560,000. Simulation responses: monthly sales, fish stocking density (kg biomass/m³) and utilization of each culture tank at any given time, standing stock biomass (tons in each tank and in the entire system) and feed-load effects on the biofilters. A meta-model was developed, the optimal resource configuration maximized the annual profit subjected to constraints. The results from the meta-model fed back to the simulation for fine tuning and further scenario analysis. The aquaculture farm implemented the results.

■ TA-33

Tuesday, 9:00-10:20

8.2.19

Energy Pricing Models

Stream: Energy, Environment and Climate [c]

Contributed session

Chair: *Mette Bjørndal*, Department of Finance and Management Science, Norwegian School of Economics and Business Administration, NHH, Helleveien 30, N-5045, Bergen, Norway, mette.bjorndal@nhh.no

1 - Renewable Technologies, Optimal Generation Mix and Price Volatility in Competitive Electricity Markets

Irena Milstein, Faculty of Management of Technology, Holon Institute of Technology, 52 Golomb St., 58102, Holon, Israel, irenam@hit.ac.il, *Asher Tishler*

We develop a two-stage decision model (game) with fossil-using and with weather-dependent renewable generating technologies. In the first stage of the game, when only the distribution function of demand is known firms choose capacities (by maximizing their expected profits). In the second stage, each firm selects its daily production of each technology subject to its available capacities (the availability of renewable technology depends on the random weather conditions). We show that total generation capacity is higher and price spikes are substantially higher in the presence of renewable technologies than in their absence. We demonstrate these results by applying the model to real world data.

2 - Strategic Bidding of GENCOs in Competitive Power Market Through Q-Learning Algorithm

Hasan Rastegar, Electrical Eng., Amirkabir University of Technology, AUT, 424 Hafez Ave., Tehran, Iran, 424, Tehran, Iran, Islamic Republic Of, rastegar@aut.ac.ir, *Masoud Rahmani*

Electrical energy market is a multi-agent system that operates in uncertain and changing environment with very limited feedback. In this paper is shown by using Q-Learning method with applying minimum available information to model a supplier in the market, it is possible to distinguish the market participants behavior and bid an appropriate price to achieve maximum benefit. First it is tried to modify the convergence speed of algorithm concerning the same level benefit gradient power plants. Second a novel algorithm based on signing the price selection space of each generator is proposed to increase the sensitivity of Q-Learning algorithm and stability of proficiency in unexpected load changing.

3 - Aggregation Choices in Zonal Pricing Algorithms for Managing Transmission Congestion in Electricity Markets

Mette Bjørndal, Department of Finance and Management Science, Norwegian School of Economics and Business Administration, NHH, Helleveien 30, N-5045, Bergen, Norway, mette.bjorndal@nhh.no

Locational marginal prices constitute a well known benchmark for managing transmission capacity constraints in electricity markets. We study aggregation choices when simplifying nodal prices into zonal or area prices. We discuss two different aggregation concepts, which we call economic and physical aggregation, and their relation to optimal nodal prices. In addition to balancing supply and demand, the prices derived in a zonal pricing scheme should be consistent with the physical constraints of the transmission network. As an illustration we consider the present Nord Pool spotprice algorithm.

■ TA-34

Tuesday, 9:00-10:20

8.2.23

Model Formulations and Real World Applications of Lot Sizing and Scheduling III

Stream: Lot-sizing and Scheduling, Economic Order Quantity

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 - A single-stage ATSP-type model for lot sizing and sequencing in a beverage production process

Deisemara Ferreira, Production Engineering, Universidade Federal de São Carlos, São Carlos, São Paulo, Brazil, deise@dep.ufscar.br, *Alistair Clark*, *Bernardo Almada-Lobo*, *Reinaldo Morabito*

Soft-drink production often involves sequence-dependent changeover times and costs and requires synchronisation between production stages. The research literature proposes models with constraints for syrup preparation and bottling stages. However, this presentation proposes a one-stage formulation with ATSP-type lot-sequencing constraints. Different sets of constraints to eliminate sub-tours are tested and compared using instances from a soft-drink bottling plant. Moreover, a solution strategy that iteratively patches any sub-tours and provides upper bounds for the model is developed and tested

2 - The block planning approach for lot-sizing and scheduling in make-and-pack production systems

Hans-Otto Guenther, Production Management, TU Berlin, Strasse des 17. Juni 135, 10623, Berlin, Germany, hans-otto.guenther@tu-berlin.de

In the consumer goods, industry make-and-pack production systems can be found which consist of a single bottleneck stage after which final products are packed and shipped to distribution centres or individual customers. To support lot sizing and scheduling in this type of industry the block planning concept is proposed. A novel MIP optimization model is presented that determines the size and the time phasing of the production lots. Numerical results demonstrate the practicability of this approach under experimental conditions which reflect typical settings from an industrial case study.

3 - Flow Shop Production Scheduling Problem with Compressible Processing Times

M.b. Aryanezhad, IE, IUST, Narmak, 1684613114, Tehran, Tehran, Iran, Islamic Republic Of, talebi.sahar@gmail.com, *S. Talebi*, *M. Karimi-Nasab*

A new mathematical formulation for a production scheduling problem with compressible processing times is proposed. The model determines both lot sizing and lot streaming of multiple products in a flow shop and takes the undesirability of idle times into account. Compressibility of process times in an arbitrary time interval leads to nonlinearity. A genetic algorithm (GA) is developed to solve the model. Experiments with both real case parameters and random test problems shows that the model can consider a variety of real cases. The GA gives better solutions than analytical prediction.

■ TA-35

Tuesday, 9:00-10:20

6.2.46

Facilitated Decision Analysis II

Stream: Facilitated Modelling in OR

Invited session

Chair: *Gilberto Montibeller*, Dept. of Management (OR Group), London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.montibeller@lse.ac.uk

1 - Evaluating the use of Scenarios and Multi-Criteria Decision Analysis (MCDA) as a Framework for Decision-making under Strategic Uncertainty

Camelia Ram, Management, London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, camelia.ram@gmail.com, *Gilberto Montibeller*

Scenarios provide alternative frames through which the implications of a strategic decision can be viewed, so can be very useful when evaluating strategic options. Developing scenarios may be too time-consuming to incorporate into an evaluation exercise. This paper seeks to explore the effects of applying a method of options evaluation based on combining scenario generation rooted in Morphological Analysis with Multi-Criteria Decision Analysis. This paper will examine how it performs with respect to time; development of new options; and consideration of strategic priorities. Three cases relating to the strategic vision in agriculture, port services and land use Trinidad & Tobago are used.

2 - Proposal of use the Multicriteria Decision Aid for improve the use of assessment tools with focus on performance indicators

Edilson Giffhorn, Production Engineering, Santa Catarina Federal University, Rod. Amaro Antônio Vieira, 655, apt. 106-E, Bairro Itacorubi, 88034-101, Florianópolis, Santa Catarina, Brazil, edilson.giffhorn@gmail.com, *Leonardo Ensslin*, *Sandra Ensslin*, *William Vianna*

The aim of this paper is to present a proposal for structuring indicators to improve the use of different approaches of performance evaluation and its applications. For this will be used a constructivist Multicriteria Decision Aid approach in order to identify, organize and measure ordinally the performance indicators. The result is a guide that helps in the identification and construction of performance indicators that allow better accuracy to the use of different assessment methodologies.

3 - Stimulating creative thinking with MCDA: modelling the market space and exploring alternative perspectives

Santiago Castro, Research, Cogentus, Soane Point., 6-8 Market Place, RG1 2EG, Reading, Berkshire, United Kingdom, santiagocastro@yahoo.com

This paper shows that, when combining with advanced software technologies, Multi-Criteria Decision Analysis (MCDA) becomes a very powerful methodology to represent strategic situations, comparing various competitors' performances in all key market factors. Furthermore, modern software functionalities currently enable to capture different points of views of stakeholders and even go beyond, exploring scenarios, simulating alternative perspectives to re-define the company's offering. Based on practical cases taken from consulting work implemented in various industries, this paper illustrates how combining facilitation skills and enhanced scenario simulation capabilities can stimulate imagination and creativity to finally produce strategic innovation. In that sense this article suggests a new scenario approach, which is more about creative thinking rather than purely normative assessment of options, or future oriented forecasting of scenario planning.

■ TA-36

Tuesday, 9:00-10:20

3.1.05

Fuzzy Optimization and Decision Analysis 2

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence

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: *Josef Vicha*, Mathematical Institute in Opava, Silesian University in Opava, Na rybníčku 1, 74601, Opava, Czech Republic, Josef.Vicha@math.slu.cz

1 - Fuzzy Bi-matrix Games — Optimistic and Pessimistic Approach

Josef Vicha, Mathematical Institute in Opava, Silesian University in Opava, Na rybníčku 1, 74601, Opava, Czech Republic, Josef.Vicha@math.slu.cz, *Jaroslav Ramik*

It has been shown that a bi-matrix game with fuzzy goal is equivalent to a crisp non-linear programming problem in which the objective as well as all constraint functions are linear except two constraint functions, which are quadratic. This equivalence is further extended to bi-matrix games with fuzzy pay-offs. In this paper we introduce an optimistic and pessimistic approach to this problem. An illustrative example is presented and discussed.

2 - Duality in Fuzzy Linear Optimization

Milan Vlach, Theoretical Computer Science and Mathematical Logic, Charles University, Malostranske namesti 25, 118 00 Prague 1, 118 00, Prague, Czech Republic, milan.vlach@mff.cuni.cz, *Jaroslav Ramik*

In the classical linear optimization, the notion of a dual problem to a given problem is well understood. To devise a dual problem to a linear optimization problem that contains fuzzy data, one has to specify in advance a number of fuzzy objects. There are several concepts of duality for fuzzy linear optimization leading to results which resemble some of the results established in the classical case. We show that a number of duality models and results on fuzzy linear optimization from the literature can be obtained as special cases of a natural general model.

3 - A Fuzzy TOPSIS Methodology for the Supplier Selection Problem

Shabnam Mojtahedzadeh Sarjami, Mathematics and Statistics, Curtin University of Technology, Kent St, Bentley WA, 6102, Perth, Western Australia, Australia, Shabnam.mojtahed@postgrad.curtin.edu.au, *Louis Caccetta*

The supplier selection problem is to determine a portfolio of suppliers from a set of candidates that best meets the requirement of an organisation. In this paper, we propose a fuzzy TOPSIS method to select the suppliers. Fuzzy logic is applied to cope with uncertainties of criteria weights and supplier's performance ratings while TOPSIS ensures that the ranking order of all suppliers has the shortest distances to the positive-ideal solution and farthest distance to the negative-ideal solution simultaneously. The proposed method will be illustrated through a numerical example.

■ TA-37

Tuesday, 9:00-10:20

3.1.09

Mathematical models for energy and environment

Stream: Long Term Planning in Energy, Environment and Climate

Invited session

Chair: *Edi Assoumou*, Centre de Mathematiques Appliquees, Mines ParisTech, Sophia Antipolis, France, edi.assoumou@cma.ensmp.fr

1 - ETSAP modeling tools: a bottom-up framework for energy issues

Edi Assoumou, Centre de Mathematiques Appliquees, Mines ParisTech, Sophia Antipolis, France, edi.assoumou@cma.ensmp.fr, *Gilles Guerassimoff*, *Sandrine Seloisse*, *Nadia Maïzi*

The Energy Technology System Analysis Program has been building and promoting the use of bottom-up energy models for several decades. Today MARKAL/TIMES approaches are used in several countries worldwide. This paper is dedicated to the presentation of the optimal approach on which the TIMES-FR and TIAM-FR models are relying. Some specific points related to its implementation at country level in the French framework and for multi-regional assessment are presented.

2 - Mescalito : A simplified approach for global long term energy scenarios

Francois Cattier, R&D, EDF, Site des Renardières, 77818, Moret sur Loing Cedex, France, francois.cattier@edf.fr, *Jerome Wirth*

Mescalito is a tool to analyse: -World energy prospects to 2100 : trends in demand, supply availability and constraints -Effects of policy actions or technological changes -CO₂ emissions The Mescalito approach is characterised by: -Supply functions taking into account fossil fuel resources but also the rate of after-peak production decline -An adjustment of supply and demand made directly through quantities, though most of other models use prices -The estimation of unsatisfied demand This paper describes Mescalito and highlights its outcomes through different scenarios.

3 - Decision-helping tools for long term investment in energy storage systems

Nicolas Omont, Artelys, 12 rue du 4 septembre, 75002, Paris, France, nicolas.omont@artelys.com, *Florent Cadoux*, *Nicolas Bonnard*, *Arnaud Renaud*

The energy sector is characterized by very long asset life spans. Consequently, investment decisions are taken with a time horizon ranging up to several decades. Associated quantitative decision helping methods therefore face uncertainties as their major difficulty: models and optimization methods are designed to deal with them. We propose a survey of such methods in order to draw their strength and weaknesses from technical and decision maker point of views. We will focus on structural versus cyclical uncertainties and on their impact on risk and benefit functions on energy storage systems.

4 - Comparison of statistical and engineering models to simulate long-term behavioural changes

Jean-Michel Cayla, EDF/Mines ParisTech, Paris, France, jeanmichel.cayla@gmail.com, *Benoit Allibe*

Conservation behaviour in residential space heating have shown a significant reduction potential of energy consumption but rarely appear in long term models. Several methods allow the simulation of long term behavioural changes, leading to various potential estimates. To investigate divergences we used engineering and statistical models using a survey on 2012 French households. Our results confirm the importance of behaviour in the current energy consumption as well as in long term planning. We also highlight sources of uncertainty in models and their impact on behavioural foresight results.

■ TA-38

Tuesday, 9:00-10:20

6.2.44

Rating and Valuation of Credits

Stream: Stochastic Valuation for Financial Markets

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Ömür Ugur*, Institute of Applied Mathematics, Middle East Technical University, 06531, Ankara, Çankaya, Turkey, ougur@metu.edu.tr

1 - LOTUS-based segmentation in credit scoring

Katarzyna Bijak, School of Management, University of Southampton, Highfield, SO17 1BJ, Southampton, United Kingdom, k.bijak@soton.ac.uk

Credit scoring is used to assess risk of bank customers. A one-scorecard model can be built for the customer population. Dividing the population into groups (segmentation) and developing separate scorecards for them is believed to improve performance of the whole model. In this research, a segmentation method is suggested which is based on the Logistic Tree with Unbiased Selection (LOTUS) algorithm that is derived from data mining. It is applied to data provided by two of the major UK banks and one of European credit bureaus. As reference, logistic regression and classification trees are used.

2 - Quantitative Analysis on Japanese Corporate Ratings with Artificial Neural Network?

Katsuaki Tanaka, Faculty of Business Administration, Setsunan university, 17-8 Ikedanakamachi, 572-8508, Neyagawa, Osaka, Japan, k-tanaka@kjo.setsunan.ac.jp, *Hideki Katsuda*, *Motohiro Hagiwara*, *Susumu Saito*

In Japan investors have begun to use corporate ratings given by 4 major rating agencies as an index to measure the credit risk of each company. Corporate ratings are based on quantitative data and qualitative information that investors do not obtain it completely. We propose the artificial neural networks method to evaluate the determinant structure of corporate ratings given by rating agencies in the USA and Japan with the quantitative data of Japanese manufacturing companies only. We also provide the sensitivity analysis about the number of explanatory variables.

3 - Predictive abilities of credit spread curves to the industrial production in the United States

Petr Jablonsky, Faculty of finance and accounting, University of Economics, Prague, nam. W. Churchilla 4, 130 67 Praha 3, Praha 3, Czech Republic, Petr.Jablonsky@seznam.cz

The study examines predictive abilities of term structure of credit spread curves to changes in industrial production in the United States. Usually, the term structure is represented in models by arbitrary selected tenors. We suggest to parameterize the spread curves by a Nelson-Siegel model and utilize the whole term structure captured by three parameters — level, slope and curvature. Our following empirical analysis is based on US industrial spread curves of different credit quality in April 2002 to July 2009.

4 - Predictive value of different levels of information in credit scoring: cross-country comparison

Galina Andreeva, Business School, University of Edinburgh, 50 George Sq, EH8 9JY, Edinburgh, United Kingdom, Galina.Andreeva@ed.ac.uk

Credit scoring is a collection of decision support techniques used in consumer credit risk management. Models predicting consumer delinquency use different types of information: personal characteristics of borrowers, characteristics about the product(s) purchased, credit bureau data and, recently, macroeconomic variables. The paper analyses the value of different levels of information for predicting delinquency and purchase propensity using store card data from Belgium, the Netherlands and Germany. Comparisons are made across these three countries and with a generic cross-country model.

■ TA-39

Tuesday, 9:00-10:20
6.2.45

Limit Behaviour and Approximations II

Stream: Optimal Control

Invited session

Chair: *Vladimir Veliov*, Institute of Mathematical Methods in Economics, Vienna University of technology, ORCOS, Argentinierstr. 8/119, 1040, Vienna, Austria, veliov@tuwien.ac.at

1 - Infinite horizon optimal control problems - existence and applications

Sabine Pickenhain, Mathematics, BTU Cottbus, Konrad-Wachsmann-Allee 1, 03046, Cottbus, Germany, sabine.pickenhain@tu-cottbus.de

Control problems with infinite horizon have been investigated since the 1970s in the context of models from economics, as well as from natural sciences. The need to make a systematic distinction between the different interpretations of an objective as either Lebesgue integral or improper Riemann integral has been pointed out by the author and her co-workers. The simplest way to solve optimal control problems with infinite horizon is to find a solution on a finite interval and try to extend the solution onto the whole half-axis. But there is no guarantee for the extended solution to be admissible or optimal on an infinite interval. For that reason the proof of existence of optimal solutions is very important.

Considering a weight function in the integrand of the objective we propose to choose Weighted Sobolev and Weighted Lebesgue-Spaces as state and control spaces, respectively and prove existence results for infinite horizon optimal control problem. Applications from economics and biology are given.

2 - On HJB equations associated to the Optimal Control of DDE's: Regularity and Optimal Feedbacks

Salvatore Federico, Luiss, Rome, via Sant'Andrea, 13, 56125, Pisa, Italy, s.federico@sns.it, *Fausto Gozzi*

I present a couple of papers dealing with the optimal control problem of delay differential equations and state constraint. The main contributions are the proof of a regularity result for the viscosity solutions of the associated HJB equation and a verification theorem yielding the construction and the characterization of optimal controls in some special cases. The class of problems includes some problems arising in economics, in particular the so-called models with time to build.

■ TA-40

Tuesday, 9:00-10:20
6.2.52

Network design 3

Stream: Network Optimization [c]

Contributed session

Chair: *Bessaih Fawzi*, Operational research, Université d'Avignon, 44, chemin des roseaux, 84310, Morieres, France, France, fawzi@hotmail.fr

1 - Algorithm for designing survivable TDM networks with general failure scenarios

Pavel Skums, Mechanics and Mathematics, Belarus State University, Nezavisimosti av., 4, 220030, Minsk, Belarus, skumsp@gmail.com, *Yury Orlovich*, *Yufei Wang*

We consider a problem of designing survivable TDM network in which traffic demands of different protection types are routed over the SDH facilities subject to given capacity restrictions and prescribed set of failure scenarios. A common optimization objective of the problem is to minimize the total cost of the network. For this problem we developed an algorithm based on a combination of Lagrangian and surrogate Lagrangian relaxations approaches. The computational results show that our approach allows obtaining good near optimal solutions.

2 - Lower bounds for the Weight-constrained Minimum Spanning Tree problem

Eulália Santos, University of Aveiro, 3810-448, Aveiro, eulalia.santos@sapo.pt, *Agostinho Agra*, *Adelaide Cerveira*, *Cristina Requejo*

We consider the Weight-constrained Minimum Spanning Tree problem (WMST). In order to obtain good lower bounds for the WMST we discuss families of valid inequalities for the corresponding set of feasible solutions and discuss the separation algorithms associated to each family of inequalities. Based on these separation algorithms we propose a cutting plane algorithm. Finally a computational study based on random generated data is presented.

3 - Switch Matrix Validation Design on the Telecommunication Satellites

Bessaih Fawzi, Operational research, Université d'Avignon, 44, chemin des roseaux, 84310, Morieres, France, France, fawzi@hotmail.fr, *Philippe Michelon*, *Dominique Feillet*

The main mission of a telecommunications satellite is to receive a set of signals, amplify them, and retransmit them. The tube amplifiers used are complex and costly. To overcome possible failures, and to ensure the long term success of the mission (15 to 20 years), these amplifiers must be duplicated. Several billion cases are analysed to confirm that the satellite is robust in all failure scenarios. This paper presents a method of resolution based on enumeration and systematic research, and stresses the need to reduce the combinatorics.

4 - Packing edge-disjoint cycles in graphs

Peter Recht, TU Dortmund, Germany, peter.recht@tu-dortmund.de

Let $G = (V, E)$ be a graph. A cycle packing $Z = C_1, \dots, C_l$ of G is a collection of pairwise edge-disjoint cycles C_i of G ($i = 1, \dots, l$). This talk deals with $\nu(G)$, the maximum cardinality of a cycle packing Z . Bounds on $\nu(G)$ are given. *M*

■ TA-41

Tuesday, 9:00-10:20
3.1.06

Methodological Aspects of System Dynamics Modeling

Stream: System Dynamics Modeling

Invited session

Chair: *Jim Duggan*, Information Technology, NUI, Galway, University Road, Galway, Galway, Ireland, jim.duggan@nuigalway.ie

1 - Risk cost modeling for transportation infrastructure project investment

Steve Jang, Logistics Management, National Defense University, 3, Ming-you 11th Street, Lane 112, Tao-yuan, 330, Taipei, Taiwan, jang_steve@yahoo.com

A transportation infrastructure project is generally very complex that has highly dynamic and interdependent risks. It is principally the cause of cost overrun in almost 9 out of 10 transportation infrastructure projects around the world. Many studies have revealed that the current risk cost estimating methods do not address dynamic and non-linear risk interactions. This paper introduced an approach which applied System Dynamics modeling and the statistical techniques to sort out this issue. The model validation testing concludes that the proposed approach is robust on risk cost estimating.

2 - The interpretation of system dynamics models

Martin Rafferty, Accounting and Finance, London South Bank University, Room L340c, London South Bank University, London Road, SE1 6LN, London, United Kingdom, rafferm@lsbu.ac.uk

It is the object of this paper to re-examine some of the less well trodden paths within system dynamics. The initial vehicle for the analysis is an examination of mass balance, unit consistency, dimensional consistency and determination of initial states. The applicability of these concepts to the social sciences is analysed. Several cases are examined as system dynamics simulations; two from the domain of the physical sciences and two from the social sciences. The conclusions of this research are that all models are approximate and therefore can only be understood from an interpretive perspective. This is not to say that all simulation models are wrong or right; the judgement depends on the observer's frame of reference.

3 - Modelling Healthcare Processes with System Dynamics and Discrete Event Simulation: a Critical Realist Perspective

Kristian Rotaru, Accounting and Finance, Monash University, Australia, 900 Dandenong Rd, 3145, Caulfield East, Victoria, Australia, kristian.rotaru@buseco.monash.edu.au, Leonid Churilov, Andrew Flitman

Both System Dynamics (SD) and Discrete Event Simulation (DES) are actively used for modelling healthcare processes. Most of the previously published comparative SD and DES studies have been a priori adopting either DES or SD worldview as a starting point for their comparison, depending on the expertise of the authors. The objective of this paper is to investigate how Critical Realist philosophy of science can help better modelling in healthcare by facilitating explicit articulation of the fundamental assumptions underlying SD and DES modelling philosophies.

4 - An Integrated Methodology for System Dynamics and Agent Based Simulation

Jim Duggan, Information Technology, NUI, Galway, University Road, Galway, Galway, Ireland, jim.duggan@nuigalway.ie

Simulation provides a means to gain insight into the past behaviour and future trajectories of complex systems. There are two recognised approaches to social simulation: system dynamics (SD), centred on the feedback perspective, and agent based simulation (ABS), which uses the individual and their interactions as unit of modelling. This paper presents an approach where the two methods can be viewed as complimentary rather than conflicting. It focuses on the strengths of each method and proposes an iterative cycle — using an epidemic model - where SD is used to capture the relationships between the target system and other systems, and ABS concentrates on the individual, or disaggregate, perspective.

■ TA-42

Tuesday, 9:00-10:20

3.1.07

Optimization and Data Mining II

Stream: Optimization and Data Mining

Invited session

Chair: Roberto Santana, Universidad Politecnica de Madrid, 0000, Madrid, Spain, roberto.santana@upm.es

Chair: Concha Bielza, Inteligencia Artificial, Universidad Politécnic de Madrid, Campus de Montegancedo, 28660, Madrid, Spain, mcbielza@fi.upm.es

1 - A kernel-based model for spectral clustering with pairwise constraints

Carlos Alzate, ESAT-SCD-SISTA, K. U. Leuven, Kasteelpark Arenberg 10, 3001, Leuven, Belgium, carlos.alzate@esat.kuleuven.be, Johan Suykens

A spectral clustering method for incorporating prior knowledge on the cluster assignment is presented. This method fits in an optimization framework with primal and dual model representations. The primal problem is expressed in terms of high dimensional feature maps and it is extended by adding equality constraints which represent the prior knowledge. The dual problem is an eigenvalue decomposition of a modified kernel matrix. The formulation allows out-of-sample extensions and model selection in a learning setting. Simulations with toy examples and image processing problems are presented.

2 - Combining discrete SVM and fixed cardinality warping distances for multivariate time series classification

Carlotta Orsenigo, Management, Economics and Industrial Engineering, Politecnico di Milano, p.zza leonardo da vinci 32, 20133, milan, italy, Italy, carlotta.orsenigo@polimi.it, Carlo Vercellis

Time series classification is a supervised learning problem aimed at labeling temporal multivariate sequences of variable length. We propose a new classification method, based on an extension of discrete support vector machines, that benefits from the notions of warping distance and softened variable margin. Furthermore, to transform a dataset into a rectangular shape, we also develop a new method based on fixed cardinality warping distances. Computational tests on benchmark and real marketing datasets indicate the effectiveness of the proposed method in comparison to other techniques.

3 - Graphical reports for distribution problems

Jörn Grahl, Information Systems & Business Administration, University of Mainz, Jakob Welder-Weg 9, 55099, Mainz, grahl@uni-mainz.de

Empirical studies show that decision makers more likely accept results from Decision Support Systems (DSS), when their mental model is aligned with the DSS model. A mental model summarizes experiences about the structure of solutions as well as the impact of decision variables on the solutions. DSS models are hard to understand and might not be directly accessible. Simple graphical aggregation schemes are proposed that visualize the impact of decisions and the structure of solutions. The current state of research for distribution problems and example visualizations are presented.

4 - Data and graph mining algorithms in estimation of distribution algorithms applied to feature subset selection problems

Roberto Santana, Universidad Politecnica de Madrid, 0000, Madrid, Spain, roberto.santana@upm.es, Concha Bielza, Pedro Larrañaga

We investigate different facets of the relationship between the data generated by estimation of distribution algorithms (EDAs) in feature subset selection (FSS) problems, the improvement of these solutions and their interpretation. Different examples show the importance of taking into account the relationship between the probabilistic models used by EDAs, the choice of the classifier and the representation of the selected features. This type of analysis can help to achieve a better understanding of the obtained solutions and in some cases improve the classification results obtained by FSS.

■ TA-43

Tuesday, 9:00-10:20

8.2.02

Revenue Management II

Stream: Demand, Pricing and Revenue Management

Invited session

Chair: Jochen Goensch, Department of Analytics & Optimization, University of Augsburg, Universitätsstraße 16, D-86159, Augsburg, Germany, jochen.goensch@wiwi.uni-augsburg.de

1 - Performance measures in nested capacity allocation mechanisms

Behzad Samii, Operations and Technology Management Center, Vlerick Leuven Gent Management School, Reep 1, 9000, Gent, Belgium, behzad.samii@vlerick.be

In an uncertain demand environment, one approach to provide differentiated service levels is to reserve some portion of the available capacity exclusively for specific high priority customer classes. In this research, we provide closed form solutions for service level measures in a two-class single-period resource reservation problem using both Standard and Theft Nesting allocation mechanisms. We show that under certain capacity and demand rate conditions one mechanism dominates the other and consequently the optimal reserved quantity should be decided according to the preferred mechanism.

2 - Managing Consumer Price Sensitivity

Sri Devi Duvvuri, Marketing, SUNY at Buffalo, 215 F Jacobs, 14260, Buffalo, New York, United States, sduvvuri@buffalo.edu

Effective customer relationship management requires robust measurement of consumers' responses to various marketing stimuli. To test the existence of consumer-specific price sensitivity, we estimate two competing models – Thurstone and Hierarchical model. The former assumes the existence of only group-specific factors (e.g., factors for related products) for explaining the variation in the price sensitivities; the latter posits an additional general or intrinsic price sensitivity factor. We use scanner panel data from several categories to test these models.

3 - Optimal Pricing Policy for the Recyclable Short Life-Cycle Products in a Duopoly Market

Hsiao-Fan Wang, IEEM, Natl Tsing Hua University, 101 Sec.2, Kuang-Fu Rd., 30043, Hsinchu, Taiwan, hsiaofanwang@gmail.com

In recent years, the cycle of releasing products is shortened, and many countries have set up the barriers of the strict regulation to ensure the green products being imported. Since green products are market driven, proposing a method for pricing on a green product for its short life cycle in the market is our primal intention. This study particularly concerns about the optimal pricing policy where there are two kinds of products having different degrees of greenness from different manufacturers sold by one retailer. The objective is to maximize the retailers' profit.

4 - On Retail Assortment, Pricing, and Return Policies

Alex Grasas, Economics and Business, Universitat Pompeu Fabra, Ramon Trias Fargas 25-27, 08005, Barcelona, Spain, alex.grasas@upf.edu, *Aydin Alptekinoglu*

Using a nested-MNL-based consumer choice model, we study a retailer's assortment, pricing and return policy (fraction of price refunded upon return) decisions. Practical circumstances that render prices and refunds exogenous to the problem have structural consequences for optimal assortment. When all variables are endogenous, the retailer carries some number of most popular products; whereas, when prices and refunds are exogenous, it is optimal for the retailer to carry a mix of most popular and most eccentric products if the return policy is sufficiently strict.

■ TA-44

Tuesday, 9:00-10:20
8.2.03

Modelling energy systems

Stream: SD Modeling in Sustainable Development
Invited session

Chair: *Steven De Schepper*, VRIJE UNIVERSITEIT BRUSSEL, BE-1050, BRUSSELS, Belgium, Steven.De.Schepper@vub.ac.be

Chair: *Jean-Pierre Brans*, MOSI (CSOO), V.U.B., Pleinlaan,2, 1050, Brussels, Belgium, jpbrans@vub.ac.be

1 - Using Biodiesel in Belgium

Steven De Schepper, VRIJE UNIVERSITEIT BRUSSEL, BE-1050, BRUSSELS, Belgium, Steven.De.Schepper@vub.ac.be

The paper investigates the use of biodiesel as a substitute for petroleum diesel in Belgium by means of system dynamics modelling and statistical techniques. The potential advantages and drawbacks with respect to the Belgian economy are analysed. Important aspects such as safety of supply, balance of payment, prices, impacts on local employment and incomes, environmental and food issues, etc. are discussed. Promotion policies implemented by the national and regional authorities are also investigated.

2 - Using EV batteries for grid regulation — A system dynamics approach

Robert Hein, Logistics Management, WHU, Burgplatz 2, 56179, Vallendar, Germany, robert.hein@whu.edu, *Stefan Spinler*

There are two ways of providing grid regulation by electric vehicle (EV) batteries: either by EVs being parked and connected to the grid (vehicle-to-grid) or by stationary grid regulation units with discarded battery packs formerly used in EVs (battery-to-grid). We evaluate both potential alternatives simultaneously using system dynamics to determine how prices for grid regulation and resulting salvage values for discarded battery packs evolve over time. Since salvage values affect the total costs of ownership, they are likely to have a strong impact on EV purchase decisions.

3 - Improving the performance of a photovoltaic solar panel production line

Ana Raquel Xambre, DEGEI, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal, raquelx@ua.pt, *João Nicolau*, *Ana Luísa Ramos*, *Helena Alvelos*

The work refers to a study carried out in order to solve a problem of manufacturing process reengineering, in a manufacturer of photovoltaic solar panels that wanted to increase its production output by introducing some changes in the manufacturing line. The decision maker wanted to analyse the performance of the current production system and the impact of the proposed modifications so simulation was used in order to assist the decision making process. The use of simulation proved to be the correct approach since it allowed the modelling of the system dynamics as close to reality as possible.

4 - Characterisation and classification of Energy Systems Models

Christos Ioakimidis, MECHANICAL ENGINEERING, INSTITUTO SUPERIOR TECNICO (IST) - UNIVERSIDAD DE LISBOA (UTL), Av. Rovisco Pais, 1049-001, LISBON, Portugal, christos.ioakimidis@dem.ist.utl.pt, *Paulo Ferrao*

The use of energy models nowadays is one of the basic tools to approach successfully a problem related with the climate change and even more for the energy-environment-economy of a place. A literature review of the use of these modelling tools with the characterisation and classification of these energy systems models through the creation of a mapping scheme that provides information - via indicative clusters - of the most appropriate energy model tool(s) that have to be used according to the case study are presented in this work.

■ TA-45

Tuesday, 9:00-10:20
8.2.12

Nonconvex Programming approaches for Machine Learning and Data Mining

Stream: Nonconvex Programming: Local and Global Approaches

Invited session

Chair: *Tao Pham Dinh*, INSA Rouen, 76131, Rouen, France, pham@insa-rouen.fr

1 - Sparse Fisher Discriminant Analysis by exact penalty techniques in DC Programming

Mamadou Thiao, LMI INSA of ROUEN, National Institute for Applied Sciences of Rouen (INSA), LMI - Avenue de l'Université, 76801 Saint-Etienne-du-Rouvray Cedex, Saint-Etienne du Rouvray, France, mamadou.thiao@insa-rouen.fr, *Tao Pham Dinh*, *Hoai An Le Thi*

We investigate the sparse Fisher discriminant analysis which arises in various fields such as machine learning and statistics. We propose a new solution for the sparse Fisher discriminant analysis by directly adding to the Fisher discriminant problem a constraint for sparsity requirements. We formulate equivalently the problem as a DC program (minimization of a DC function over a closed convex set) by exact penalty techniques in DC programming and then use the local DCA algorithm for the computations. The method is demonstrated with some numerical simulations on some real-world data sets.

2 - Rare event simulations applied to learn an optimal Intelligence policy in a hierarchical context

Frédéric Dambreville, DGA, 16bis Av. Prieur de la Cote d'Or, 94110, Arcueil, France, submit@fredericdambreville.com,
Francis Celeste, Fabienne Ealet

Resource optimization for information collection in the context of Intelligence process is a challenging application of military operation research. The main issue is to satisfy the prior constraints of many sensors at different operational and hierarchical levels, while maximizing the planned information requests. Our approach is constraint oriented, and is based on Rare Event simulation. This technique (Cross Entropy) is supported by the definition of a family of sampling laws, which models the structures (e.g. hierarchical context of the decision process) and constraints of the problem.

■ TA-46

Tuesday, 9:00-10:20

8.2.14

OR in Fisheries, Maritime Sciences and Related Aspects

Stream: OR in Fisheries, Maritime Sciences and Related Aspects

Invited session

Chair: *Pall Jansson*, Engineering Faculty, University of Iceland, Hjarðarhagi 4, 107, Reykjavik, Iceland, pall@hi.is

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - A stochastic optimization model for obtaining a total allowable catch quota in a multispecies Chilean fishery

Victor Albornoz, Departamento de Industrias, Universidad Tecnica Federico Santa Maria, Av. Santa Maria 6400, 6671219, Santiago, Chile, victor.albornoz@usm.cl, *Cristian Canales*

In this contribution the authors present a two-stage stochastic nonlinear optimization model proposed as a planning tool in the common sardine and anchovy multispecies fishery. The stochastic program is an extension of a nonlinear programming one and allows a better representation of the problem, by including the uncertainty in the recruitment of new individuals through a finite set of possible scenarios, that according to the sensitivity analysis done seems an interesting aspect to be considered. Moreover, we are proposing a joint annual quota for the multispecies fishery, incorporated as a decision variable in the proposed model.

2 - A Nonlinear Mixed-Integer Stochastic Programming Formulation for Fish Processed Production Planning

Herman Mawengkang, Mathematics, The University of Sumatera Utara, FMIPA USU, KAMPUS USU, 20155, Medan, Indonesia, hmawengkang@yahoo.com

Fish and its processed products are the most affordable source of animal protein in the diet of most people in Indonesia. The goal in production planning is to meet customer demand over a fixed time horizon divided into planning periods by optimizing the trade-off between economic objectives such as production cost and customer satisfaction level. We use scenario generation based approach and feasible neighborhood search for solving the model. The results which show the amount of each fish processed product and the number of workforce needed in each horizon planning are presented.

3 - Optimal Control Path of Bangladesh Trawl Shrimp Fishery - A continuous Time Analysis

Mohammed Khan, Finance and Banking, University of Chittagong, Professor, Department of Finance and Banking,

University of Chittagong, Bangladesh, Chittagong, Bangladesh, shamimukhan@gmail.com

The optimum allocation of dynamic system of the renewable resource can only provide optimal schedule or time-path indicating optimal amount to be harvested in each time period. This time schedule along with optimal rate of harvest is the optimal control path, which can manage the resource perpetually. The paper attempts to formulate a non-linear dynamic model of Bangladesh trawl shrimp fishery for optimal control with continuous-time horizon. An optimal control path of Bangladesh marine shrimp fishery is determined using the model, which is observed as not managed and utilized optimally.

4 - A Spatial Resource Allocation Model for Marine Protected Area (MPA) Planning

Yang-Chi Chang, Marine Environment & Engineering, National Sun Yat-sen University, 70 Lain-Hae Road, 804, Kaohsiung, Taiwan, changyc@mail.nsysu.edu.tw

MPA is an important measure for maintaining biodiversity and rescuing endangered species through effective inhibition of human interferences. Thus how to design an effective MPA is an important issue to be explored. The current study developed a spatial resource allocation model based on integer linear programming for no-take reserve planning. The MPA partitions suggested by the model are able to preserve the maximum ecological resources under the limited spatial area. Besides, decision makers have the options of choosing from various trade-off solutions to fit their decision preferences.

■ TA-47

Tuesday, 9:00-10:20

8.2.16

Advances in Discrete-Continuous Optimal Control 2

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: *Dmitrii Lozovanu*, Institute of Mathematics and Computer Science, Academy of Sciences of Moldova, Academiei 5, IMI, MD-2020, Chisinau, Moldova, Moldova, Republic Of, lozovanu@math.md

1 - Collective Taxis in Cities: A Simulation Tool for Optimal Real Time Operation and Design

Jennie Lioris, CERMICS IMARA, ENPC-INRIA, Domaine de Voluceau Rocquencourt, 78150, Le Chesnay, France, jennie.lioris@inria.fr, *Guy Cohen, Arnaud de La Fortelle*

A discrete event simulation is coupled with real time control algorithms in order to study collective taxi systems operating in large cities with or without a dispatching center. Repeated simulations and a methodology of analysis of the results allow to tune those algorithms but also to dimension resources (number of taxis in service, their capacity, etc.) and evaluate the influence of demand (level, geometry) on performances. This is an invaluable tool to assess the potentials of such a system and choose the best adapted operation mode prior to any experiment in the field.

2 - Trade discounts and pass-through as control tools in a vertical distribution channel

Igor Bykadorov, Sobolev Institute of Mathematics, Siberian Branch Russian Academy of Sciences, Acad. Koptuyug Av. 4, 630090, Novosibirsk, Russian Federation, bykad@math.nsc.ru, *Andrea Ellero, Elena Moretti*

We consider a distribution channel where a manufacturer sells a product to a single retailer. Retailer's motivation and skills are explicitly considered in an optimal control framework where the manufacturer controls wholesale price and maximizes profit. Channel pricing policies are then considered in a differential game framework allowing the retailer to control the mark-up amount. For piecewise constant controls we compare manufacturer's and retailer's profits at Nash and Stackelberg equilibria, considering both the manufacturer and the retailer as possible leaders of the channel.

3 - Combined Dynamic Traffic Assignment and Optimal Traffic Control models

Evangelos Mitsakis, Department of Civil Engineering, Aristotle University of Thessaloniki, Ploutonos 14, 54655, Thessaloniki, Thessaloniki, Greece, emit@civil.auth.gr

The paper aims to present the major findings of an extensive critical review of existing research and literature in the fields of modelling dynamic traffic assignment and optimal traffic control. Issues related to the combined use of such models are being discussed, while demand uncertainty is also considered. The models are presented and analysed both in terms of the underlying mathematical formulations, as well as in terms of algorithmic solutions, in order to better evaluate quantitative and qualitative results for their practical applicability in large scale networks.

València, Camí de Vera, s/n, Edifici 7A, 46022, VALENCIA, Spain, vigibos@eio.upv.es, *Susana San Matías*

Heuristics have been successfully applied in the last decades to solving complex decision and design problems in an industrial context. Particularly, optimization is being used in process control design, and evolutionary techniques such as Genetic Algorithms have proven to be effective in fine tuning quality tools such as control charts. Here we propose a heuristic approach for designing quality control tools based on exploiting the particular features of the functions being involved in each case and we present a concrete application to the optimal determination of the Pre-control parameters.

■ TA-48

Tuesday, 9:00-10:20

8.2.04

Heuristics 1

Stream: Nonlinear Programming

Invited session

Chair: *Ana Maria A.C. Rocha*, Production and Systems, University of Minho, Campus de Gualtar, 4710-057, Braga, Portugal, arocha@dps.uminho.pt

1 - Packing rectangular items in convex regions: an heuristic MINLP approach

Andrea Cassioli, Dipartimento di sistemi e informatica, Università di Firenze, Via di S.Marta 3, 50139, Firenze, Italy, cassioli@dsi.unifi.it, *Marco Locatelli*

The packing of rectangular items in arbitrary convex regions, allowing only orthogonal rotations, can be cast as a MINLP unconstrained feasibility problem. A bi-level heuristic approach, based on a variable neighbourhood search framework, is devised: global exploration is performed perturbing both continuous and integer variables, and then, fixed the latter, standard continuous local searches are used to find optimal configurations. Numerical results confirm that the proposed strategy is effective and robust.

2 - Heuristics for QFT loop shaping by evolutionary optimization

Joaquín Cervera, Informática y Sistemas, Universidad de Murcia, Facultad de Informática., Campus de Espinardo., 30100, Murcia, Murcia, Spain, jcervera@um.es, *Alfonso Baños*

This work presents ad-hoc heuristics for Quantitative Feedback Theory (QFT) loop shaping, a non convex and nonlinear optimization problem. The authors already proposed a suboptimal solution using a fractional structure in the compensator and evolutionary optimization. Fractional compensators reduce the set of to-be-optimized parameters, which is crucial for evolutionary search success, but adequate heuristics are still needed to avoid local optima. This work shows considered heuristics for that purpose together with a comparison of the results obtained by different heuristics for a case study.

3 - New concave penalty functions for improving the feasibility pump

Marianna De Santis, DIS, Sapienza, University of Rome, Via Ariosto, 25, 00185, Roma, Italy, mdesantis@dis.uniroma1.it, *Stefano Lucidi*, *Francesco Rinaldi*

Mixed-Integer optimization represents a powerful tool for modeling many optimization problems arising from real-world applications. The Feasibility pump is a heuristic for finding feasible solutions to mixed integer linear problems. In this work, we propose a new feasibility pump approach using concave non-differentiable penalty functions for measuring solution integrality. We present extensive computational results on binary MILP problems from the MIPLIB library showing the effectiveness of our approach.

4 - Heuristic strategies for optimal design of quality control tools

Vicent Giner-Bosch, Departament d'Estadística i Investigació Operativa Aplicades i Qualitat, Universitat Politècnica de

Tuesday, 10:40-12h00

■ TB-01

Tuesday, 10:40-12h00

Aula Magna

Keynote Talk 6

Stream: Keynote Speakers

Invited session

Chair: *Valerie Belton*, Dept. Management Science, University of Strathclyde, 40 George Street, G1 1QE, Glasgow, United Kingdom, val.belton@strath.ac.uk

1 - Problem Structuring Methods 'in the Dock' : Arguing the case for Soft OR

Fran Ackermann, Management Science, Strathclyde University, 40 George Street, G1 1QE, Glasgow, United Kingdom, fran.ackermann@strath.ac.uk

Problem Structuring Methods (or Soft OR) have been around for nearly 40 years and yet these methods are still very much overlooked in the OR world. Whilst there is almost certainly a number of explanations for this, two key stumbling blocks are 1) the subjective nature of the modelling yielding insights rather than testable results, and 2) the demand on users to both manage content (through modelling) and manage processes (work WITH rather than on behalf of groups). This keynote presentation aims to put a case forward to support an increase in the use of these methods, either on their own to support clients with messy complex problems or in combination with more mathematical methods thus facilitating models that address a shared well understood objective, provide testable results, and are negotiated and thus owned by key stakeholders.

■ TB-02

Tuesday, 10:40-12h00

3.2.14

Advanced Combinatorial Optimization 3

Stream: Combinatorial Optimization

Invited session

Chair: *J. M. Valério de Carvalho*, Departamento de Produção e Sistemas, Universidade do Minho, 4710 053, Braga, Portugal, vc@dps.uminho.pt

1 - Exact Integer Programming in SCIP

Kati Wolter, Optimization, Zuse Institute Berlin, Takustrasse 7, 14195, Berlin, Berlin, Germany, wolter@zib.de

Most MIP solvers focus on quickly finding solutions that are accurate with respect to numerical tolerances. There are, however, applications, e.g., chip verification, for which this slight inaccuracy is not acceptable. We introduce an approach for the exact solution of MIPs in SCIP. It combines inefficient but always applicable rational computations with a safe floating-point approach, which is efficient but of limited applicability. Preliminary computational results will be presented

2 - The Inverse 1-Median Problem in the d-dimensional space with the Chebyshev-Norm

Johannes Hatzl, Department of Optimization and Discrete Mathematics, Graz University of Technology, Steyrergasse 30, 8010, Graz, Austria, hatzl@opt.math.tugraz.at

In this talk, we consider the 1-median problem in the d-dimensional space with the Chebyshev-norm. We give an optimality criterion for this problem which enables us to solve the following inverse location problem in polynomial time: Given n points P_1, \dots, P_n with non-negative weights and a point P_0 the task is to change the weights at minimum cost such that P_0 is a 1-median with respect to the modified weights. In fact, this problem reduces to a balancing flow problem for which an optimal solution can be obtained in polynomial time.

3 - Stabilization procedures based on dual feasible functions

Cláudio Alves, Produção e Sistemas, Escola de Engenharia, Universidade do Minho, Campus de Gualtar, 4710-057 Braga,

Braga, Portugal, claudio@dps.uminho.pt, *François Clautiaux*, *J. M. Valério de Carvalho*, *Jürgen Rietz*

Convergence of column generation for the cutting stock problem is addressed. We introduce a general framework for deriving dual cuts, and describe a new type of cuts, which exclude solutions that are linear combinations of some other known solutions. New lower and upper bounds for the dual variables are discussed. We also show how the prior knowledge of a good dual solution helps improving the results. It tightens the bounds around the dual values, and makes the search converge faster if a solution is sought in its neighborhood first. Computational experiments on hard instances are reported.

4 - Improving a lagrangean decomposition for the unconstrained binary quadratic programming problem

Luiz A. N. Lorena, LAC - Lab. Assoc. Computação e Mat. Aplicada, INPE - Brazilian Space Research Institute, Av. dos Astronautas - 1758, Caixa Postal 515, 12243-970, São José dos Campos, São Paulo, Brazil, lorena@lac.inpe.br, *Geraldo Mauri*

We present a lagrangean decomposition based on column generation techniques to solve the unconstrained binary quadratic programming problem. We use a mixed binary linear version of the original quadratic problem with constraints represented by a graph. This graph is partitioned in clusters of vertices forming sub-problems whose solutions use the dual variables obtained by a coordinator problem. Computational experiments consider a set of difficult instances and the results show the efficiency of the proposed method over traditional lagrangean relaxations and other methods found in the literature.

■ TB-03

Tuesday, 10:40-12h00

3.2.15

Routing problems

Stream: Metaheuristics

Invited session

Chair: *Jose Brandao*, Management, University of Minho, Largo do Paço, 4704 -553 , Braga, Portugal, sbrandao@eeg.uminho.pt

Chair: *Elisabeth Gussmagg-Pfieggl*, Faculty of Business, Economics and Statistics, University of Vienna, Chair for Production and Operations Management, Bruennerstrasse 72, 1210, Vienna, Austria, elisabeth.gussmagg-pfieggl@univie.ac.at

1 - A hybrid approach for real world postman problems

Elisabeth Gussmagg-Pfieggl, Faculty of Business, Economics and Statistics, University of Vienna, Chair for Production and Operations Management, Bruennerstrasse 72, 1210, Vienna, Austria, elisabeth.gussmagg-pfieggl@univie.ac.at, *Karl Doerner*, *Richard Hartl*, *Stefan Irnich*, *Fabien Tricoire*

We are solving a rich postman problem using a hybrid approach. Due to the complexity of the problem, and the size of the (real world) instances, we tackle the problem in two steps: first, we generate routes heuristically, secondly, a set covering problem is solved using an exact method. After each step, a local search is performed to improve the solution.

2 - Iterated tabu search algorithm for the open vehicle routing problem with time windows

Jose Brandao, Management, University of Minho, Largo do Paço, 4704 -553 , Braga, Portugal, sbrandao@eeg.uminho.pt

The problem studied here, the open vehicle routing problem with time windows (OVRPTW), is different from the vehicle routing problem with time windows in that the vehicles do not return to the distribution depot after delivering the goods to the customers. We have solved the OVRPTW using iterated tabu search. The performance of the algorithm is tested using a large set of benchmark problems.

3 - A heuristic approach for the CVRP with open routes

R. Aykut Arapoglu, Industrial Engineering Department, Eskisehir Osmangazi University, Meselik Campus, 26480, Eskisehir, Turkey, arapoglu@ogu.edu.tr, *Abdurrahman Yildiz*

We present a variant of the classical capacitated VRP that allows "closed" routes ending at the depot as well as "open" routes that end at customer node(s). The problem arises when the company has the option of outsourcing extra vehicles in addition to its own fleet of vehicles. The objective is to find a route for each vehicle used, minimizing the total distance traveled. Only small sized instances of the problem can be solved to optimality using integer programming techniques and therefore, a simulated annealing based heuristic procedure is proposed for larger problems.

4 - Multi-Vehicle One-to-One Pickup and Delivery Problem with Split Loads

Mustafa Sahin, Faculty of Engineering and Natural Sciences, Sabanci University, 34956, Istanbul, mustafasahin@sabanciuniv.edu, *Gizem Cavuslar*, *Temel Öncan*, *Güvenc Sahin*, *Dilek Tuzun Aksu*

The multi-vehicle one-to-one pickup and delivery problem determines a set of least cost vehicle routes to satisfy a set of pickup and delivery requests between location pairs. With split loads, a delivery request may be satisfied with more than a single vehicle service. We develop a tabu-search algorithm. The improvements are obtained through insert, split and swap moves in addition to an optimal-split neighborhood considering the optimality conditions that prohibit some moves. The algorithm is tested on data sets from the literature; it provides good-quality solutions in reasonable time.

■ TB-04

Tuesday, 10:40-12h00

3.2.13

Multi-objective scheduling with metaheuristics

Stream: Metaheuristics

Invited session

Chair: *Juan Carlos Rivera Agudelo*, Ciencias Básicas, Universidad Eafit, Cr 49 No. 7 Sur - 50. Bloque 38. Oficina 424., 057, Medellín, Antioquia, Colombia, jkrivera@gmail.com

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

1 - L-ant to solve a multiobjective complex scheduling problem

Frédéric Dugardin, LOSI, University of Technology of Troyes, 12, rue Marie Curie, 10010, Troyes, France, frederic.dugardin@utt.fr, *Farouk Yalaoui*, *Lionel Amodeo*

This work deals with multiobjective scheduling of a reentrant hybrid flow shop problem. The objectives are the minimization of the makespan and the minimization of the sum of total tardiness. The method employed here is a new meta-heuristic called L-ant. This method involves a multi-objective ant colony system algorithm which uses the Lorenz dominance relationship. The latter provides a different selection from the Pareto one. Then the Lorenz dominance increases the convergence speed of the algorithm. This algorithm has been compared with other metaheuristics on multiple instances.

2 - A Genetic Algorithm to Solve the Bi-Objective Resource-Constrained Project Scheduling Problem

Juan Carlos Rivera, Mathematical Engineering, Eafit University, Medellín, Antioquia, Colombia, jriversa6@eafit.edu.co

Resource-Constrained Project Scheduling Problem (RCPSP), is a NP-Hard combinatorial optimization problem, which consists of assigning start times to a series of activities with fixed duration. Activities have precedence and resource constraints for their execution. To solve the bi-objective RCPSP, in which minimization of the makespan and maximization of the robustness are considered, a Genetic Algorithm based method is proposed. An alternative random key representation is used, which allow reducing feasible space. Comparisons are made using benchmark instances from the PSPLIB library.

3 - Genetic Algorithm with Parameter Design and Variable Weighting to Bicriteria Open Shop Scheduling Problems

Hong Tau Lee, Industrial Engineering and Management, National Chin-Yi University of Technology, Taipin, Taichung,

Taiwan, ROC, 411, Taichung County, Taiwan, leeht@ncut.edu.tw, *Sheu-hua Chen*

An experimental design is employed to determine the best combination of parameter levels that can then be adopted in the genetic algorithm for an open-shop scheduling problem. The fitness function comprises both the modified makespan and total tardiness, thus avoiding the effect of a dominating criterion. A variable weighting approach for the two criteria is utilized to alter the search directions of each generation and accelerate convergence of the algorithm. The proposed genetic algorithm is implemented using the data of a case company. The results show that the schedule generated by the proposed genetic algorithm outperforms the company's current FCFS with SPT scheduling approach in terms of makespan and total tardiness as well as number of tardy jobs.

4 - Multiobjective Simulation Optimization for Operating Room Scheduling

Felipe Baesler, Industrial Engineering, Universidad del Desarrollo, Aynavillo 456, Concepcion, Chile, fbaesler@udd.cl, *Juan Pedro Sepúlveda*

This paper presents an approach for operating room scheduling considering two main conflicting objectives. The approach uses discrete event simulation to capture the resources randomness involved in the patient flow process. The model interacts with a metaheuristic that searches for better schedules. Pareto frontiers for different experiments were constructed using the e-constraint technique and showed that the scheduling approach improves the hospital performance in comparison to the current method.

■ TB-05

Tuesday, 10:40-12h00

3.2.16

EURO Excellent in Practice Award 2010

Stream: EURO Excellence in Practice Award 2010

Invited session

Chair: *M. Grazia Speranza*, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, speranza@eco.unibs.it

1 - Inventory management of multiple items with irregular demand: A case study

George Nenes, Mechanical Engineering, University of Western Macedonia, Bakola & Sialvera, 50100, Kozani, Greece, gnenes@uowm.gr, *Sofia Panagiotidou*, *George Tagaras*

We present the case of a Greek enterprise managing inventories of thousands of different items with intermittent and lumpy demand. We describe the solutions given to several practical problems in the course of devising an easy-to-use yet effective and all-encompassing procurement and inventory control system. Using simple quantitative tools we develop an efficient procedure for the determination of the base stock levels that achieve the target fill rates in the proposed periodic review regime. We outline the computerized implementation of the new system and the very encouraging results.

2 - Modelling Performance Appraisal and Career Development in the European Commission

Michael Pidd, The Management School, Lancaster University, Dept. Of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, m.pidd@lancaster.ac.uk, *Dave Worthington*, *Stephan Onggo*, *Didier Soopramanien*

The European Commission employs over 22,000 officials, with a performance appraisal and promotion system based on points that officials earn each year. A Lancaster University team worked closely with EC officials to develop a new system. At the core of the work was a new manpower planning problem in which the appraisal system was a major focus. We combined multivariate analysis and simulation techniques in a novel way to produce a transparent and easy-to-use model. Much of the model use was as a 'tool for thinking', and it was a crucial part of negotiating a new system implemented in 2009.

3 - Quantitative Methods for a New Configuration of Territorial Units in a Chilean Government Agency Tender Process

Guillermo Duran, Ingenieria Industrial, University of Chile, Republica 701, 1000, Santiago, Chile, gduran@dii.uchile.cl, *Rafael Epstein*, *Cristian Martinez*, *Gonzalo Zamorano*

JUNAEB is a Chilean agency responsible for the retention of children in the school system. The agency manages a school meals program under which firms bid on supply contracts for different Territorial Units (TU). Before 2007 TUs attractiveness to suppliers was highly variable. This led a series of problems for the agency in the tender process. This work uses OR methodologies to determine a new TU configuration which ensures a similar attractiveness. The new configuration added challenges to the combinatorial tender process. In 2007 the agency increased the service by 40%, using our proposal.

■ TB-06

Tuesday, 10:40-12h00
8.2.30

DEA Application I - Banking

Stream: DEA and Performance Measurement

Invited session

Chair: *Joseph Paradi*, Chemical Engineering and Applied Chemistry, University of Toronto, 200 College Street, M5S3E5, Toronto, Ontario, Canada, paradi@mie.utoronto.ca

1 - Efficiency analysis of the banks and insurance companies operating in Poland using the DEA method

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 article was to present the results of a study to determine the relative effectiveness of selected groups of commercial banks and insurance companies. The period of study covered years 2004 - 2008. The models were input-oriented. This enabled authors to obtain results, with which the strategy has been determined for the selected input factors, in order the analysed entities could become more efficient, as well as it helped to develop benchmarks for them.

2 - A DEA Incentive Plan for Branch Managers

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, *Baruch Keren*, *Lea Fridman*

We propose a DEA incentive plan for branch managers. Each branch has pre-determined values of regional variables that may affect its performance. The method utilizes two DEA models: the CCR model and the super-efficiency model. The regional variables are considered here as inputs (resources). The measured efficiencies are then translated into a wage incentive plan. The proposed plan has more fairness and it can increase the flexibility of the top management to swap between branch managers. The method also enables to evaluate the performance of each branch over periods of time.

3 - A study on profitability and marketability of Taiwanese bank firms before and after the Financial Holding Company Act

Yi-Kang Chen, Department of Business Administration, National Dong Hwa University, 1, Sec. 2, Da Hsueh Rd., ShouFeng, Hualien, 97401, Taiwan, R.O.C., Taiwan, d9532006@ems.ndhu.edu.tw, *Dauw-Song Zhu*, *Yuang-sung Chen*

The purpose of this paper is to determine whether subordinate subsidiaries to financial institutions can improve their operating performance by establishing financial holding companies (FHCs) in Taiwan. Specifically, this paper uses data envelopment analysis (DEA) to measure profitability and marketability changes among 14 banks with subsidiary FHCs. Results show that the efficiency scores of 2003—2007 were lower than those of 1997—2001; a bilateral model shows that prior to the implementation of the FHC Act, banks demonstrated higher levels of efficiency than banks subsidiaries to FHCs.

4 - Bank Branch Human Resource Allocation Efficiency Using DEA — Validated Against Real Management

Joseph Paradi, Chemical Engineering and Applied Chemistry, University of Toronto, 200 College Street, M5S3E5, Toronto, Ontario, Canada, paradi@mie.utoronto.ca

The objective of this study is to develop an intelligent staffing allocation model in DEA context to evaluate the bank branch's efficiency and identify the best and worst branches in terms of staffing levels. This proposed model is applied in a big Canadian bank with 977 branches. The results obtained from the proposed DEA model are further compared with that obtained from the Bank's current internal resource optimization system. These comparison results help the Bank's managers and analysts monitor and enhance their branch staff allocation strategy.

■ TB-07

Tuesday, 10:40-12h00
8.2.47

DEA - General topics I

Stream: DEA and Performance Measurement

Invited session

Chair: *Vania Sena*, Aston University, B4 7ET, Birmingham, United Kingdom, v.sena@aston.ac.uk

1 - An Assessment of International Chain-owned Hotels in Taiwan Using DEA

Hsiu-Feng Yong, Department of Management, Fo Guang University, 26247, Yilan, shachita.lu@gmail.com, *Shinn Sun*

The purpose of this study is to assess of operating performance of international chain-owned tourist hotels in Taiwan over the years of 1997- 2007. Data Envelopment Analysis and Balanced Scorecard are used to assess hotel performance from four perspectives in terms of financial, customer, internal processes, grow and learn. The important remarks are concluded.

2 - A Productivity Study on Taiwanese Pharmaceutical Industry

Yan Chen Li, Department of Management, Fo Guang University, 26247, Yilan, 974428@mail.fgu.edu.tw, *Shinn Sun*

The purpose of this study is to assess the productivity, productivity change of 18 pharmaceutical firms in Taiwan over 2001-2009 and examine the effects of environmental factors on productivity. The important findings are presented.

3 - A Performance Study on Energy Use of International Tourism Hotels in Taiwan

Tz-Chiang Li, Department of Management, Fo Guang University, 26247, Yilan, 974417@gmail.com, *Shinn Sun*

The purpose of this paper is to assess the performance of energy use, productivity growth of 58 international tourist hotels in Taiwan from 1997 to 2007; and to examine effects of environmental variables on the performance of energy use. The important conclusions are presented.

4 - A Performance Study on The Public Junior High Schools in Taipei County

Chin Fang Chien, Department of Management, Fo Guang University, 26247, Yilan, rtes02@gmail.com, *Shinn Sun*

The purpose of this study is to assess educational performance of elementary schools in Taipei County over the years of 2005-2008. This study examined school performance in terms of overall performance, individual performance, and productivity growth over time. The important remarks regarding school performance are concluded.

■ TB-08

Tuesday, 10:40-12h00
6.1.36

Airport operations scheduling

Stream: Project Management and Scheduling

Invited session

Chair: *Florian Jaehn*, Business Administration, Management Information Science, Hoelderlinstrasse 3, 57068, Siegen, Germany, florian.jaehn@uni-siegen.de

Chair: *Erwin Pesch*, FB 5, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, erwin.pesch@uni-siegen.de

1 - Integer solutions of ground holding models for air traffic

Kevin White, Mathematics and Statistics, University of South Australia, U of SA, Mawson Lakes, 5095, SA, Australia, kevin.white@unisa.edu.au, *Jerzy Filar*

When the capacity of an airport is limited due to bad weather or other emergencies, there are various coping strategies available to air traffic authorities, and various mathematical models for optimising these strategies. We consider the properties of the system of inequalities that arises from a popular ground holding binary integer linear programming model, and present some results from studies of air traffic in Australia.

2 - Optimization of Runway Utilization and Communication Complexity

Andrea Peter, Department of Mathematics, Research Group Optimization, Technische Universität Darmstadt, Schlossgartenstrasse 7, 64289, Darmstadt, Germany, apeter@mathematik.tu-darmstadt.de, *Alexander Martin*, *Sebastian Pokutta*

Runways are a bottleneck in aviation. We compute an optimal schedule for arrivals and departures with the help of sophisticated MIP techniques in one single step. Up to now, a schedule for the arrivals is computed and afterwards the departures are filled into the gaps. Besides, we analyze an elaborated way of combining the independent computations of the schedules of the arrivals and the departures. Is it possible to link these scheduling procedures to obtain an optimal utilization of the runway with the help of a communication tool? We are investigating the communication complexity.

3 - A Scheduling Approach to Allocate Capacity Efficiently at Congested Airports

Yiannis Salouras, Department of Management Science and Technology, Athens University of Economics and Business, Evelpidon 47A and Lefkados 33, 11362, Athens, Greece, yiannis_salouras@yahoo.com, *Konstantinos Zografos*, *Michael Madas*

A mathematical programming methodology is proposed for initial slot allocation at schedule coordinated airports. Two models are developed and assessed: i) one directly implementing the EU / IATA rules with the aim to model the decision making process of a rational schedule coordinator, and ii) another model taking also into account specific airside elements affecting capacity, rather than the abstract declared capacity notion. A comparison between the two models shows that the latter allows better schedules to be constructed from both the airlines' and the airports' perspective.

4 - Aircrafts scheduling on ground: a case study

Ludovica Adacher, DIA, Roma Tre University, via della Vasca Navale 79, 00146, Roma, Italy, Italy, adacher@dia.uniroma3.it, *Marta Flamini*

In this paper we deal with the problem of scheduling aircrafts moving on ground, subject to safety constraints and minimizing the following three objective functions in lexicographical order: (i) the number of late airplanes; (ii) the mean waiting time at the stop bars, regulating the crossing of a runway; (iii) pollution and noise, in terms of the total time the aeromotors are kept on. We model the problem with the alternative graph, we develop several heuristic algorithms and we compare the preliminary results obtained by considering real data related to a specific case study.

■ TB-09

Tuesday, 10:40-12h00
6.2.53

Recent Advances in the Theory of Mathematical Programming

Stream: Mathematical Programming

Invited session

Chair: *Sorin-Mihai Grad*, Faculty of Mathematics, Chemnitz University of Technology, 09107, Chemnitz, Sachsen, Germany, grad@mathematik.tu-chemnitz.de

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - On Solving a Problem of Non-Smooth Function Minimization over a Convex Set

Elena Morozova, Applied Mathematics Department, Herzen State Pedagogical University of Russia, 48, Moika Emb., 191186, St.-Petersburg, Russian Federation, melena65@mail.ru

A new multidimensional bisection method for minimizing non-smooth function over simplex is proposed for solving nonlinear constrained global quasiconcave minimization problem. The method does not require a differentiability of function, and is guaranteed to converge to the global minimum. The computational results are presented for a set of test problems.

2 - Nonlinear Constrained Optimization Methods Newly Compared and Penalty/Barrier Methods Applied

Teófilo Melo, Mathematics, ESTGF-IPP, Rua da Cachada - Margaride, 4610-250, Felgueiras, Porto, Portugal, tmm@estgf.ipp.pt

In this work, nonlinear constrained optimization methods, with and without derivatives, are compared. Some penalty/barrier and merit functions are implemented to evaluate the progress of the objective function and constraints violation values. To promote global convergence, linesearch techniques are used and compared, testing Armijo, Wolfe-Powell and Goldstein criteria.

3 - A Cross Entropy Method for Mixed Integer Programming

Ali Eshragh Jahromi, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, 5095, Adelaide, South Australia, Australia, Ali.EshraghJahromi@unisa.edu.au, *Asef Nazari*, *Jerzy Filar*

We propose a version of the Cross Entropy (CE) method to solve a transmission expansion problem arising in management of national and provincial electricity grids. The aim is to find an expansion policy that is economical and operational. Often, this problem is formulated as a mixed integer nonlinear program that is challenging because of the presence of possibly many local optima. CE method shows promise in solving global optimization problems. We sample the integer variables using CE and solve LPs to obtain matching continuous variables. Numerical results demonstrate the potential.

■ TB-10

Tuesday, 10:40-12h00
6.2.56

Graphs and Networks VII

Stream: Graphs and Networks

Invited session

Chair: *A. Ridha Mahjoub*, Mathematics and Computer Science, LAMSADE, Université Paris Dauphine, Place du Maréchal de Lattre de Tassigny, 75775, Paris Cedex 16, mahjoub@lamsade.dauphine.fr

1 - Optimizing the edge-weight over vertex-induced bipartite subgraphs

Denis Cornaz, LAMSADE, Université Paris-Dauphine, Pce Mal Lattre de Tassigny, 75016, Paris, France, cornaz@lamsade.dauphine.fr, *A. Ridha Mahjoub*

Naturally, 0-1 vertex-variables allow to modelizing vertex-induced subgraphs. However, with these variables, a linear edge-weight objective function becomes quadratic. We propose a sophisticated modelization using only edge-variables for finding a vertex-induced bipartite subgraph with maximum edge-weight, and we show that this approach is competitive.

2 - Structural Analysis for Differential-Algebraic Systems : Formulation and Facets.

Sébastien Martin, LAMSADE, Université Paris-Dauphine, Université Paris-Dauphine, Place du Maréchal de Lattre de Tassigny, 75775, PARIS Cedex 16, France, martin@lamsade.dauphine.fr, *Mathieu Lacroix*, *A. Ridha Mahjoub*

We consider the structural analysis problem for differential-algebraic systems with conditional equations. This consists, given a conditional differential algebraic system, in verifying if the system is well-constrained for every state and if not in finding a state for which the system is bad-constrained. We first show that the problem reduces to the perfect matching free subgraph problem in a bipartite graph. We give a formulation as an integer linear program of this problem. We also discuss the polytope of the solutions of this problem and propose a Branch-and-Cut algorithm.

3 - Design of Multilayer Survivable Optical Networks

Raouia Taktak, Lamsade, Université Paris Dauphine, 94 rue de Charonne, 75011, Paris, France, taktak@lamsade.dauphine.fr, *Virginie Gabrel*, A. *Ridha Mahjoub*

We consider the following survivable IP-over-optical network design problem. Given a set of demands and two node-disjoint paths routing each demand in the IP layer, the problem is to find for each demand two node-disjoint paths in the optical layer going through the optical switches corresponding to the routers visited in the IP layer paths and respecting the same order. We give two integer programming formulations: a cut formulation and a path formulation. We discuss the polyhedron associated with the first one and the pricing problem of the latter and present some computational results.

4 - Integer Programming Formulations for the k-Edge-Connected 3-Hop-Constrained Network Design Problem

A. *Ridha Mahjoub*, Mathematics and Computer Science, LAMSADE, Université, Place du Mar, 75775, Paris Cedex 16, mahjoub@lamsade.dauphine.fr, *Ibrahima Diarrassouba*, *Virginie Gabrel*

In this paper, we study the k-edge-connected network design problem with bounded paths. We introduce new integer programming formulations for this problem. Then we study the polytopes associated with these formulations and introduce some classes of valid inequalities as well as conditions for these inequalities to define facets. Using these results, we devise Branch-and-Cut and Branch-and-Cut-and-Price algorithms for the problem and give some computational results.

■ TB-11

Tuesday, 10:40-12h00
8.2.38

Advances in the Use of Information Technology I

Stream: Emerging Applications of OR

Invited session

Chair: *Sevgi Ozkan*, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, İsmet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Innovation Projects Realization Using Elements of Information Systems Support

Biljana Stosic, Operations Management, Faculty of Organizational Sciences, Jove Ilica 154, 11000 Beograd, Serbia, Europe, 11000, Belgrade, Republic of Serbia, Serbia, biljst@fon.bg.ac.rs, *Sonja Isljamović*

The paper is about innovation management supported by information system for continuous monitoring the realization. Starting from a concept, technical inventiveness and commercial exploitation of innovation can be considered as process/output of the process. Information and Communication Technology provides the possibility to gain competitive advantage. An example is given for project realization monitoring to enable the up-to-date insight. Developing the system, also the opportunity arises to have information about other phases and attributes of the whole project.

2 - The Impact of Information Sharing on System Dynamics in a Hybrid System with a Pull-based Remanufacturing Process

Li Zhou, SMS, Greenwich Business School, Park Row, Greenwich, SE10 9LS, London, United Kingdom, zl14@gre.ac.uk

This paper studies a hybrid system with joint manufacturing and remanufacturing process. It investigates how information sharing influences on the system dynamics performance. Especially, it focuses on the system capability of coping with uncertainties occurring in the remanufacturing/reverse process. A well known APIOBPCS is adopted as our inventory control strategy. The research methodology includes system dynamics and control theory. It concludes that in a pull-based remanufacturing process, information sharing does not always contribute to improve dynamics performance.

■ TB-12

Tuesday, 10:40-12h00
8.2.39

ANP 02

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Monica Garcia-Melon*, Engineering Projects, Universidad Politecnica de Valencia, Camino de Vera s/n, 46022, Valencia, Spain, mgarciam@dpi.upv.es

1 - Manufacturing Systems Performance Evaluation Using Holonic Architecture and the Analytic Network Process (ANP)

M Reza Abdi, School of Management, Bradford University, Emm Lane, BD9 4JL, Bradford, West Yorkshire, United Kingdom, r.abdi@bradford.ac.uk, *Ashraf Labib*

The paper develops holonic architecture for reconfigurable manufacturing systems (RMSs), which are capable of adapting to predictable and unpredictable changes in demands. The holonic architecture is then linked to an Analytical Network Process (ANP) model as a multi-criteria approach in order to evaluate RMSs performance. Accordingly, the complex holonic architecture is transformed into the fundamental components, and then grouped into a few clusters in accordance with their similarities or self-similarities. The model is generic in structure and was examined through an industrial case study in UK by using the SuperDecision software.

2 - An ANP-based framework for revenue management

Petr Fiala, Dept. of Econometrics, University of Economics Prague, W.Churchill Sq. 4, 13067, Prague 3, Czech Republic, pfiala@vse.cz

Revenue management (RM) is the process of understanding, anticipating, and influencing consumer behavior in order to maximize revenue from resources. The challenge is to sell the right resources to the right customer at the right time for the right price through the right channel. RM addresses three categories of demand-management decisions: structural, price, and quantity decisions. In the paper an Analytic Network Process (ANP) framework for revenue management is presented. The Dynamic Network Process (DNP) is a dynamic extension of ANP that can deal with time dependent priorities in RM.

3 - Selection of a Vineyard to Produce a High Quality Wine Using Analytic Network Process

Monica Garcia-Melon, Engineering Projects, Universidad Politecnica de Valencia, Camino de Vera s/n, 46022, Valencia, Spain, mgarciam@dpi.upv.es, *Pablo Aragonés-Beltrán*, *Alberto Escardino-Malva*, *Alfonso Porcar-Ramos*, *Santiago Leon-Rubio*

In this paper an application of the multicriteria decision making technique ANP (Analytic Network Process) is presented to select a vineyard to produce a high quality wine. The work has been done with the help of a wine expert, who acted as decision maker, and an ANP decision making specialist team. The whole process includes: the vineyards selection, the decision making criteria selection and analysis and its weighting process, the valuation of the alternatives and the aggregating priorities. A sensitivity analysis of the results is also carried out.

4 - Prioritizing Actions for Local Sustainable Development with Analytic Network Process

Monica Garcia-Melon, Engineering Projects, Universidad Politecnica de Valencia, Camino de Vera s/n, 46022, Valencia,

Spain, mgarciam@dpi.upv.es, *Jordi Peris-Blanes, Carola Calabuig-Tormo, Tomas Gomez-Navarro*

Local Agenda 21 aims to institutionalize in a progressive and cross-cutting way the sustainable development principles and bring about change in the ways in which people think and value urban issues and the ways in which people, organizations and institutions behave. Thus, programs and actions proposed within LA21 have to be considered as outcomes whose goals are not only to directly impact local sustainable development issues but to support institutional changes at different levels ranging from values and behaviors of people, to organizational and structural change (UN-HABITAT, 2004c). In the last years many Spanish municipalities have started developing their own LA21 programs. Due to budget restrictions they have to devote time and effort to prioritize the proposed programs. In this paper a new tool to prioritize programs within LA21 processes is presented. It will contribute to provide greater consistency and transparency when it comes to select and publicly justify the actions to be undertaken. The approach is based on a multiexpert multicriteria Decision Aid Technique, such as Analytic Network Process (ANP). Development planning involves several criteria, since it includes a broad range of social, economic and environmental goals and incorporates the complex and diverse interactions amongst all the elements of the problem. On the other hand, sustainable development planning depends upon how policymakers and other stakeholders involved understand and interpret the process. Gathering and considering their different opinions and judgments is a difficult task intrinsic to these processes. ANP provides a more truthful approach for modelling complex situations such as making decisions about sustainability actions because it allows the general study of the quantitative and qualitative explanatory variables and the incorporation of feedback and interdependence relationships among variables.

To demonstrate the goodness of the proposed methodology it has been applied to the LA21 municipality of Benetússer (Valencia, Spain). The participating experts coincided in appreciating the procedure proposed in this paper is useful and an improvement from traditional techniques

■ TB-13

Tuesday, 10:40-12h00

2.2.21

Continuous Location II

Stream: Location Analysis

Invited session

Chair: *Emilio Carrizosa*, Estadística e Investigación Operativa, Universidad de Sevilla, Matemáticas, Reina Mercedes s/n, 41012, Sevilla, Spain, Spain, ecarrizosa@us.es

1 - Lower Bounding Approaches for the Multi-commodity Capacitated Multi-facility Weber Problem

Temel Öncan, Industrial Engineering, Galatasaray University, Ciragan Cad., Ortaköy, 34357, ISTANBUL, Turkey, ytoncan@gsu.edu.tr, *Mehmet Hakan Akyüz, I. Kuban Altinel*

The Multi-Commodity Capacitated Multi-facility Weber Problem (MCMWP) is concerned with locating I capacitated facilities in the plane satisfying the demands of J customers for K types of commodities subject to capacity constraints on commodity flows between facilities and customers. We propose a Lagrangean relaxation scheme where the subproblem is solved by the column generation approach on an equivalent Set Covering problem. Efficient strategies are developed to accelerate the subgradient optimization algorithm. Discretization strategies based on block norm approximations are also devised.

2 - Upper Bounding Methods for the Multi-commodity Capacitated Multi-facility Weber Problem

Mehmet Hakan Akyüz, Industrial Engineering, Galatasaray University, Ciragan Caddesi No:36 Ortakoy, 34357, Istanbul, Turkey, mhakyuz@gsu.edu.tr, *Temel Öncan, I. Kuban Altinel*

The Multi-commodity Capacitated Multi-facility Weber Problem is concerned with locating I capacitated facilities on the plane and satisfying the demand of J customers for multiple commodities subject to facility capacity, demand requirement and bundle constraints while minimizing the total transportation costs which are assumed to be directly proportional to the distance between facilities and customers. We propose upper bounding methods based on alternate location allocation and discrete approximation strategies. Computational experiments are reported on randomly generated test instances.

3 - On the ordered anti-Weber problem for any norm in R^2

Carlos Guerrero, Applied Mathematics, University of Malaga, ETSI Informatica y Telecomunicaciones, Campus de Teatinos,

29071, Malaga, Spain, cguerrerog@uma.es, *Juan José Saameño, Jose Muñoz*

A family of single obnoxious facility location problems is modelled here by considering the same objective function that is used in the ordered median location problem. They involve distances defined by any arbitrary norm and hence it can be used in a general framework. We prove that the solutions to these obnoxious location problems, restricted to a polygonal region with m vertices and considering n existing population centers, can be found in a set defined in terms of the weighted equidistant points. For many usual norms, this dominating set is finite and can be constructed in $O(mn^2+n^4)$

4 - A continuous competitive facility location (and design) problem with variable demand

Pilar M. Ortigosa, Computer Architecture and Electronics, University of Almería, Ctra. Sacramento s/n, La Cañada de San Urbano, 04120, Almería, Spain, ortigosa@ual.es, *Juana López-Redondo, Aranzazu Gila-Arrondo, Jose Fernandez, I. García*

In most competitive location models available in literature, it is assumed that the demand is fixed independently of the conditions of the market. However, demand may vary depending on prices, distances to the facilities, etc. In this work, a new planar competitive location and design problem with variable demand is presented. Using it, it is shown numerically for the first time in literature that the assumption of fixed demand influences the location decision very much. Two methods are presented to cope with the new model, an exact interval Branch-and-Bound method and an evolutionary algorithm

■ TB-14

Tuesday, 10:40-12h00

2.2.15

Supply Chain Coordination

Stream: Supply Chain Planning [c]

Contributed session

Chair: *Wenyih Lee*, Department of Business Administration, Chang Gung University, 259 Wenhua 1st Rd., Kweishan, 333, Taoyuan, Taiwan, leewe@mail.cgu.edu.tw

1 - The application of co-opetition in the creation of supply contracts between haulage companies and 3pl companies

Panagiotis Kyriazis, operations management and ERP center, Athens University of Economics and Business, aiginis 28 kifisia, 14564, Athens, Greece, kyriazisp@aueb.gr, *George Ioannou*

In supply chain co-opetition, firms simultaneously compete and co-operate. We consider the nature of co-opetition between two firms: the haulage company is the supplier and invests to buy new trucks, and the buyer is the 3PL company who invests to develop the market before uncertainty in demand is resolved. We consider four different decision making structures for each company and discuss the optimal decision. We will show that the level of investment by the firms depends on the nature of co-opetition between them and the level of uncertainty demand.

2 - A collaborative decentralized distribution system with demand updates

Ulas Ozen, Bell Labs, Alcatel-Lucent, Alcatel-Lucent,, Blanchardstown Industrial Park, 15, Dublin, Ireland, ulas.ozen@alcatel-lucent.com, *Greys Sosic, Marco Slikker*

This paper studies inventory pooling coalitions within a decentralized distribution system consisting of a manufacturer, a warehouse, and n retailers. Two types of cooperation are considered: with forecast sharing and with joint forecasting. We show that the associated cooperative games have non-emptiness cores. However, in two examples, we illustrate that collaboration with forecast sharing might lead to bad performance, and higher forecasting accuracy might harm the cooperation. Finally, we focus on coordination of the entire supply chain.

3 - Buyback Contracts in a Dual Channel Environment

Murat Kaya, Sabanci Universitesi, Sabanci University, MDBF Orhanli Tuzla, 94305, Istanbul, Turkey, mkaya@sabanciuniv.edu

We compare the coordination performances of the wholesale price and buyback contracts in a dual-channel environment. We consider a manufacturer selling through both its direct channel and also through an independent retail channel. The consumers consider the delivery lead time in the direct channel and the product availability level in the retail channel in their channel choice. We determine the optimal contract parameters and the optimal channel mix for the manufacturer under different market and product characteristics.

4 - Coordinating the consignment policy of deteriorating inventory with buyer's space restrictions

Wenyih Lee, Department of Business Administration, Chang Gung University, 259 Wenhua 1st Rd., Kweishan, 333, Taoyuan, Taiwan, leewe@mail.cgu.edu.tw, Sheng-Pen Wang

We consider a single-manufacturer, single-buyer supply chain problem in which the manufacturer produces a single deteriorating product and delivers it to the buyer on the basis of a consignment policy. An integrated inventory control model, jointly determining the manufacturer's production batch and the replenishment lot size, subject to the buyer's warehouse capacity constraint, is proposed to minimize the system total cost. The characteristics of the model and the impact of warehouse capacity on the total costs, production batch, and replenishment lot sizes are also discussed.

■ TB-15

Tuesday, 10:40-12h00

2.2.12

Polyhedral Approaches to Routing Problems

Stream: Vehicle Routing

Invited session

Chair: *Angel Corberan*, Estadística e Investigacion Operativa, Universitat de Valencia, Facultat de Matemàtiques, Avda. Dr. Moliner, 50, 46100, Burjassot, Valencia, Spain, angel.corberan@uv.es

1 - A polyhedral model for the windy clustered prize-collecting arc routing problem

Carles Franquesa, Estadística Investigació Operativa, Universitat Politècnica de Catalunya, Barcelona, Catalunya, Spain, carlesfranquesa@gmail.com, *Angel Corberan*, *Elena Fernandez*, *Jose Maria Sanchis*

Among Arc Routing Problems (ARPs), the Prize-collecting ones (PARPs) are those in which input data graphs have profits in some edges, beside their costs, that are collected only once at most, if the demand edge is serviced. In the Clustered Prize-collecting Arc Routing Problem (CPARP), furthermore, the whole connected components, clusters, of the demand subset must be completely serviced to get the profit. In its windy version, as usual, costs associated with the edges are not symmetrical. In this work a polyhedral model for the WCPARP is presented, including new facet defining inequalities.

2 - Hop-indexed Circuit-based formulations for the Travelling Salesman Problem

Maria Teresa Godinho, Mathematics, ESTIG-IPBEJA, Campus do IPBeja, Rua Pedro Soares, 7800-295, Beja, Portugal, mtgodinho@ipbeja.pt, *Luis Gouveia*, *Pierre Pesneau*

We introduce a new Hop-indexed Circuit-based formulation for the TSP in which we consider the non necessarily simple circuit associated to each node as a subproblem. We discuss model enhancements and contextualize the linear programming (LP) relaxation of the new enhanced model with the LP relaxation of some of the strongest formulations know from the literature. We will show that among known compact formulations from the literature, the proposed formulation is the one with the tightest LP bound. Finally, we will show that the proposed formulation is quite interesting for the related and so-called cumulative travelling salesman problem. Computational results taken from instances with up to 40 nodes show that the proposed formulation provides LP gaps that are within 1% of the optimum.

3 - On the Maximum Benefit Chinese Postman Problem

Angel Corberan, Estadística e Investigacion Operativa, Universitat de Valencia, Facultat de Matemàtiques, Avda. Dr. Moliner, 50, 46100, Burjassot, Valencia, Spain,

angel.corberan@uv.es, *Isaac Plana*, *Antonio Manuel Rodríguez-Chía*, *Jose Maria Sanchis*

Here we study the Maximum Benefit Chinese Postman Problem (MBCPP). It is a generalization of the CPP in which, associated with each edge, a cost for its traversal with service, a deadhead cost for its traversal with no service and a set of benefits are considered. A benefit is derived from every traversal with service of an edge. The objective is to find a closed walk starting and ending at the depot with maximum net benefit. We have studied the polyhedron associated with the MBCPP and present a branch-and-cut algorithm for its exact resolution.

■ TB-16

Tuesday, 10:40-12h00

2.2.14

Public Bus Transportation

Stream: Public Transport

Invited session

Chair: *Marjan van den Akker*, Information and Computing Sciences, Utrecht University, POBox 80089, 3508TB, Utrecht, marjan@cs.uu.nl

1 - Resource scheduling in public transport - scheduling with similarity aspects

Boris Amberg, Decision Support & Operations Research Lab, University of Paderborn, Warburger Str. 100, 33098, Paderborn, Germany, boris.amberg@dsor.de, *Natalia Kliewer*

In public bus transport timetables usually consist of many trips that are serviced every day. But there are also some trips that do not repeat daily. Solving the corresponding resource scheduling problems day after day at minimum costs may then produce schedules that are completely different. As most companies prefer similar schedules, scheduling approaches should also consider similarity aspects: E.g. the similarity can be improved by using reference schedules or by tackling the scheduling problems of various days simultaneously. We present different approaches and compare their results.

2 - Optimizing depot locations based on a public transportation timetable

Marjan van den Akker, Information and Computing Sciences, Utrecht University, POBox 80089, 3508TB, Utrecht, marjan@cs.uu.nl, *Han Hoogeveen*, *Marcel van Kooten Niekirk*

When a bus company is going to start a new area, a totally new timetable, or wants to reorganize, a decision may have to be made on the depot locations. In this talk, we consider different approaches to determine depot locations for a given timetable. We used a clustering heuristic as well as integer linear programming models and a combination of these two. We present computational results to compare our approaches.

3 - Modifying Timetables for integrated schedules

Neele Hansen, Mathematics, TU Kaiserslautern, Paul-Ehrlich-Str. 14, 67653, Kaiserslautern, Germany, neele.hansen@itwm.fraunhofer.de, *Sven Krumke*

Timetabling and scheduling are two classical aspects of planning in public transport. While historically these problems have been considered separately, recently there have been a number of integrated models. We study this integrated situation in the following context. We are given a timetable and a feasible schedule. One is allowed to modify (within certain bounds) the timetable in order to improve upon the routing of the vehicles and the transfer quality. We provide hardness and algorithmic results to various versions of the problem (discrete, continuous modifications).

4 - Multicriteria Optimization in Public Transportation

Steffen Weider, Optimization, Zuse Institute Berlin, Takustr. 7, 14195, Berlin, weider@zib.de

Costs, operational stability, and employee satisfaction are typical objectives in optimization problems in public transportation. These criteria are traditionally simply merged into a single objective. In order to study the tradeoffs between competing goals, however, one needs to compute the entire Pareto curve. The talk discusses extensions of Lagrangean relaxation and column generation approaches to compute such Pareto curves for vehicle and crew scheduling problems in public transit.

■ TB-17

Tuesday, 10:40-12h00

1.3.14

Container Terminal Planning I

Stream: Transportation Planning

Invited session

Chair: *Christian Bierwirth*, Martin-Luther-University Halle-Wittenberg, 06108, Halle, Germany, christian.bierwirth@wiwi.uni-halle.de

Chair: *Frank Meisel*, Martin-Luther-University Halle-Wittenberg, Gr. Steinstr. 73, 06108, Halle, Germany, frank.meisel@wiwi.uni-halle.de

1 - Models for the Discrete Berth Allocation Problem: A Computational Comparison

Jesper Larsen, Department of Management Engineering, Technical University of Denmark, Produktionstorvet, Building 426, 2800, Kgs. Lyngby, Denmark, jesla@man.dtu.dk, *Katja Buhrkal*, *Sara Zuglian*, *Stefan Ropke*, *Richard Lusby*

We will consider the problem of allocating arriving ships to discrete berth locations at container terminals. This problem is recognized as one of the most important processes for any container terminal. We review and describe the three main models of the discrete dynamic berth allocation problem, improve the performance of one model, and, through extensive numerical tests, compare all models from a computational perspective. The results indicate that a generalized set-partitioning model outperforms all other existing models.

2 - How distant berth allocation models are from practice? In praise of human planners

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 berth allocation models recently proposed in the literature are considerably richer than earlier ones. However, modeling some additional features of the berth planning process is very important in order to succeed in supporting human planners by optimization algorithms. In this talk the following features will be discussed: more extensive integration toward other terminal resources; realistic cost functions, usually non-linear, reflecting the yard-side effects of the berth-side choices; specific transshipment related issues; multiple objectives induced by the integration, etc.

3 - Storage arrangement on the yard for transshipment containers by meta-heuristics

Etsuko Nishimura, Graduate School of Maritime Sciences, Kobe University, Fukae, Higashinada, 658-0022, Kobe, Japan, e-nisi@maritime.kobe-u.ac.jp, *Akio Imai*

This study is concerned with the container storage arrangement on the container yard for the transshipment containers, in order to carry out the ship handling operations efficiently. Objective function is assumed that the total service time from the mega-containership to feeders and the waiting time for feeder ships. To facilitate the solution procedure we employ the heuristics based by Genetic Algorithm(GA) and Lagrangian relaxation(LR). As our computational results, at the mega-containership early arrival, the total service times obtained by LR are smaller than those done by GA.

4 - Determining the quay crane capacity for a seaport container terminal

Frank Meisel, Martin-Luther-University Halle-Wittenberg, Gr. Steinstr. 73, 06108, Halle, Germany, frank.meisel@wiwi.uni-halle.de, *Christian Bierwirth*

The number of quay cranes to deploy at a container terminal is a crucial decision regarding the achievable vessel handling times. Terminals in operation must take into account the liner services contracted with vessel operators when adjusting their crane capacity. In this talk, we present a model for identifying a deployment of cranes that fits best to the requirements of a given set of liner services. A computational study is conducted to investigate the tradeoffs between service quality and cost that result from alternative crane deployment policies.

■ TB-18

Tuesday, 10:40-12h00

1.3.15

Simulation and Optimization of Networks under Uncertainty

Stream: Stochastic Modeling and Simulation

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: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - N-Dimensional Volume Estimation of Convex Bodies: Algorithms and Applications

Mamta Sharma, International Institute of Information Technology, 26/C, Hosur Road, Opposite Infosys., Electronics City, Bangalore, 560100, Bangalore, Karnataka, mamta.sharma@iiitb.ac.in, *G. N. Srinivasa Prasanna*, *Abhilasha Aswal*

Current polynomial time algorithms (e.g. Markov Sampling - Lovasz-Vempala 2004, Laplace Transform - Lassere 2001) for estimating volume of convex bodies are complex and difficult to implement. We present practical approaches towards volume computation, for problems with moderate number of dimensions (10-20). Our methods use polyhedral decomposition, as well as fast sampling. Our methods can be used to quantify information content and uncertainty, in constraint regions, in a robust optimization framework. We show applications in supply chain management, under conditions of future uncertainty.

2 - Extinction probabilities of decomposable branching processes

Sophie Hautphenne, Computer science, Université Libre de Bruxelles, Boulevard du Triomphe, CP 212, 1050, Brussels, Belgium, shautphe@ulb.ac.be

Many systems in biology and telecommunication may be modeled by multitype branching processes. When some types of individuals are unable to generate other types, we talk about decomposable branching processes. Types are then partitioned into irreducible equivalence classes, and partial extinction of some classes is possible without the whole process becoming extinct. We establish criteria for partial and total extinctions, and we show that the partial extinction probability is the minimal nonnegative solution of a fixed point equation with constraints or equals the total extinction probability of a modified branching process.

3 - Quantitative release planning in Extreme Programming

Tommi Tervonen, Faculty of Economics and Business, University of Groningen, PO Box 800, 9700AV, Groningen, Netherlands, t.p.tervonen@rug.nl, *Gert van Valkenhoef*, *Bert de Brock*, *Douwe Postmus*

Extreme Programming is an agile software development methodology defined through a set of practices and values. Its value is established through many real-life case studies, but it lacks practices for project planning. Therefore we provide a multiple knapsack model to assist in release planning. Our model gives a plan that maximizes expected business value. The plan consists of several sets of stories that can be implemented with decreasing probability given the predicted velocity distribution. We evaluate parameterization of the model with simulation and its application in a real-life case.

4 - Search of the best alliance composition in a interdomain network

Daniel Villa Monteiro, Labo. PRiSM, Université de Versailles - Saint Quentin, 45, Av des Etats Unies, 78000, Versailles, Yvelines, France, dvm@prism.uvsq.fr, *Thierry Mautor*, *Dominique Barth*, *Thierry Mautor*

In an interdomain network where the domains have to satisfy service requests with QoS guarantees, an alliance is a subset of domains where members share their knowledge and provide to the other members a routing (stopover) service. The optimization problem we focus on consists in finding the best alliance that gives to the members the highest increase in their service satisfaction rate and benefit.

Several solutions are proposed based on heuristics or exact solution methods. These solutions have been tested and analyzed by simulations on realistic generated topologies.

■ TB-19

Tuesday, 10:40-12h00

1.3.20

Networks and Industrial Organization

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Telmo Parreira*, Universidade do Porto, 4169-007, Porto, Portugal, c0570091@alunos.fc.up.pt

Chair: *Fernanda A. Ferreira*, Mathematics, ESEIG - Instituto Politécnico do Porto, R. D. Sancho I, 981, 4480-876, Vila do Conde, Portugal, fernandaamelia@eu.ipp.pt

1 - Checking capacity of gas transmission network

Dan Gugenheim, Departement of Research and Innovation, GDFSUEZ, 361, avenue du Président Wilson, 93211, Saint-Denis La Plaine, France, dan-externe.gugenheim@gdfsuez.com, *Fabrice Chauvet*

Given a gas transmission network owned by GRTgaz, it is necessary to check its capability to deliver gas within a set of supply and demand constraints. The pressure drop resulting from the gas flow through underground pipelines has a non linear, non convex mathematical formulation. Furthermore, the French network is difficult to handle: it is a meshed network with several supply and demand locations and interconnection stations. We discuss different models of this problem. We experiment them on small instances. Eventually, we use the most reliable model to solve our realistic problem.

2 - Single-Commodity Network Design with random edge capacities

Biju K. Thapalia, Department of Economics, Informatics and Social Science, MOLDE UNIVERSITY COLLEGE, Britvegen 2, MOLDE, P.O. Box 2110,, N-6402, MOLDE,, Norway, biju.k.thapalia@himolde.no, *Teodor Gabriel Crainic*, *Michal Kaut*, *Stein W. Wallace*

A good network for stochastic environment requires anticipation of the uncertainty while designing it. This paper examines the single-commodity network design problem with stochastic edge capacities. The paper characterizes the structures of the optimal designs and compare with the deterministic counterparts. The paper presents new approaches to compare between the deterministic and stochastic design. Also suggest an alternate to achieve good design which works well in stochastic settings without solving a full stochastic problem.

3 - A Hotelling Network

Telmo Parreira, Universidade do Porto, 4169-007, Porto, Portugal, c0570091@alunos.fc.up.pt, *Alberto A. Pinto*

This paper develops a theoretical framework to study spatial price competition in a Hotelling-type network game. Each firm i is represented by a node of degree k_i , where k_i is the number of firm i 's direct competitors (neighbors). We investigate price competition à la Hotelling with complete and incomplete information about the network structure. The goal is to investigate the effects of the network structure and of the uncertainty on firms' prices and profits. We first analyse the benchmark case where each firm knows its own degree as well as the rivals' degree. Then, in order to understand the role of information in the price competition network, we also analyse the incomplete information case where each firm knows its type (i.e. number of connections) but not the competitors' type.

4 - The licensing of patents

Fernanda A. Ferreira, Mathematics, ESEIG - Instituto Politécnico do Porto, R. D. Sancho I, 981, 4480-876, Vila do Conde, Portugal, fernandaamelia@eu.ipp.pt

We study the optimal patent licensing under Cournot duopoly where the technology transfer takes place from an innovative firm, which is relatively cost-inefficient in the pre-innovation stage compared to the recipient firm. We determine the output levels at the Nash equilibrium and the corresponding profits of the firms. We found that the optimal licensing arrangement often involves a two part tariff, fixed fee plus a linear per unit output royalty

■ TB-20

Tuesday, 10:40-12h00

1.3.33A

Cutting and Packing 7

Stream: Cutting and Packing

Invited session

Chair: *Gleb Belov*, Numerical Mathematics, TU Dresden, 01062, Dresden, Germany, bg37@gmx.net

1 - A hybrid algorithm for Constraint Order Packing

Nikolaus Furian, Engineering- and Business Informatics, Graz University of Technology, Kopernikusgasse 24/III, 8010, Graz, Austria, Austria, nikolaus.furian@tugraz.at, *Siegfried Voessner*

Constraint Order Packing extends known Bin Packing problems by new additional placement and order constraints. While metaheuristics produce good results for common Bin Packing, they are not able to take advantage of the special structures resulting from these constraints. We introduce a hybrid algorithm that is based on greedy search and nested within a network search algorithm with dynamic node expansion and meta logic, inspired by human intuition, to overrule decisions. Further we discuss bounds and show on representative test cases that our algorithm outperforms common approaches.

2 - A biobjective bin packing problem with conflicts

Ali Khanafer, INRIA Lille, France, khanafer.aly@gmail.com, *François Clautiaux*, *El-Ghazali Talbi*

We consider the bin packing problem with conflicts from a multiobjective point of view. This problem consists in minimizing the number of conflicts violated and the number of bins used. The Pareto set is generated and approximated using an epsilon-constraint strategy by means of lower and upper bounds. The upper bounds are based on methods dedicated to the graph coloring problem and to the classical bin packing problem. The lower bounding procedure is based on linear programming and column generation. Our methods are validated experimentally on a large amount of instances.

3 - An Efficient Algorithm for a Real-Life Case of the Variable Size Bin Packing Problem

Rune Larsen, Department of Mathematics and Computer Science, University of Southern Denmark, Lathyrusvej 87 4. th, 5000, Odense C, Denmark, enuren@gmail.com, *Joergen Bang-Jensen*

Real-life problems often differ from academic problems by details that make the standard solution methods infeasible. In our case these details include: a real-time environment, the possibility of ignoring waste over a threshold on a single bin; and the presence of an unusually high number of possible assignments of items to bins. The proposed solution method is a local search algorithm based on a destruction-reconstruction neighborhood that recomputes to optimality assignments of multiple bins by a dynamic programming approach.

4 - An algorithm for orthogonal packing using consecutive-ones matrices

Gleb Belov, Numerical Mathematics, TU Dresden, 01062, Dresden, Germany, bg37@gmx.net

Given a feasible layout of orthogonal packing, it automatically represents a non-preemptive cumulative-resource schedule along each coordinate axis. Such a schedule can be modeled by a 1D cutting matrix with the additional consecutive-ones property (the 1's in each row are consecutive). We discuss pure-combinatorial and LP-based enumeration strategies to obtain such matrices.

■ TB-21

Tuesday, 10:40-12h00

6.2.47

Optimization Modeling V

Stream: Software for OR/MS

Invited session

Chair: *Alexandra Newman*, Economics and Business, Colorado School of Mines, 80401, Golden, Colorado, United States, anewman@mines.edu

1 - A Hub Location Model for Network Design of Wagonload Traffic

Julia Sender, Faculty of Mechanical Engineering, TU Dortmund, Leonhard-Euler-Str. 2, 44227, Dortmund, NRW, Germany, julia.sender@tu-dortmund.de, *Uwe Clausen*

In railway logistics a special network for producing wagonload traffic is needed. Here a hub location model for wagonload traffic is presented. The aim is to determine the location, size and function of marshalling yards and links. This network design has special characteristics: two hub types, cost and capacity are considered. A stepwise cost-structure reflects the specific characteristics. The presented problem is formulated as a multi commodity flow problem. The resulting Mixed Integer Program is solved with the software CPLEX. Several test scenarios are developed and results are presented.

2 - A collaborative optimization approach to plant-wide scheduling problems

Sleman Saliba, Corporate Research Germany, ABB AG, Wallstadter Str. 59, 68526, Ladenburg, Germany, sleman.saliba@de.abb.com, *Guido Sand*, *Xu Chaojun*

We discuss the requirements of industrial solutions to plant-wide planning and scheduling problems. Subsystems of plants are often optimized locally without an overall coordination on plant level. We present a new optimization method that utilizes local scheduling algorithms and optimizes the overall schedule by coordinating coupling parameters. The performance is evaluated on a real steel plant coupling melt shops and hot rolling mills showing the coordination scheme's advantage to fully decentralized or centralized scheduling algorithms in terms of solution quality and computational effort

3 - Efficient Mixed Integer Programming Formulations in Energy and Mining

Alexandra Newman, Economics and Business, Colorado School of Mines, 80401, Golden, Colorado, United States, anewman@mines.edu

Instances of mixed integer programming models can be (nearly) intractable and/or can exhibit wildly different performance depending on the model instance. We discuss types of formulations that have proven to be relatively efficient, in particular, by using preprocessing, alternate variable definitions, and cuts, inter alia. We draw on models from the mining sector (both open pit and underground production scheduling) as well as from energy applications (the unit commitment model, building design). Our models are implemented in AMPL and solved with CPLEX.

■ TB-22

Tuesday, 10:40-12h00

3.1.10

Health Care Scheduling II

Stream: Health Care Management

Invited session

Chair: *Jens Brunner*, TUM School of Management, Technische Universität München, Arcisstr. 21, 80333, München, Germany, jens.brunner@wi.tum.de

1 - Fair optimization of the fortnightly physician schedules with flexible shifts

Jens Brunner, TUM School of Management, Technische Universität München, Arcisstr. 21, 80333, München, Germany, jens.brunner@wi.tum.de, *Raik Stolletz*

This research addresses a shift scheduling problem for physicians. We test a reduced set covering approach that requires shift templates to be generated for a single day and compare it to an implicit modeling technique. The objective is to minimize the paid out hours under the restrictions given by the labor agreement. Furthermore, we extend the basic flexible shift scheduling model by introducing preference and fairness aspects. Computational results show the efficiency of the reduced set covering formulation in comparison to the implicit modeling.

2 - Blood ordering quantities: A model to calculate ideal order quantities in hospital blood banks to minimize wastage

Sebastian Stanger, Chair of Business Administration and Logistics, University of Erlangen-Nuremberg, Lange Gasse 20, 90403, Nuremberg, BY, Germany, sebastian.stanger@wiso.uni-erlangen.de, *Marina Gebhard*, *Gernot Kaiser*

Human blood is a scarce and perishable resource. Outdated units of blood impose significant costs on the health system. Efficient management of blood inventories is a difficult task and order quantities in hospitals are a significant driver for good inventory performance and hence low wastage levels. This paper develops a new mathematical programming model to determine ideal order quantities for hospitals. The model takes account of varying remaining shelf lives in the hospitals' inventories and for units delivered from suppliers as well as the opportunity to substitute blood groups.

3 - Materials Handling in Hospitals: A Case Study

Christiane Reichart, Universidade Nova de Lisboa, Rua Fernando Cabral N12/3esq, 1750-329, Lisbon, Portugal, christiane.reichart@gmx.at, *Amílcar Arantes*

Warehousing costs and especially order picking costs account for a considerable amount of total logistics costs, what leads to the purpose of this paper which is to elaborate means by which the materials handling process in hospitals can be improved. A detailed analysis of the material storage and picking process at Hospital Santa Maria, in Portugal, is carried out in order to demonstrate best practices as well as main limitations for which solutions are developed. The findings are that introduction of within-aisle storage, electric foldable picking vehicles and pick-by-voice system in combination with the Japanese concept Kaizen can improve warehouse operations drastically.

■ TB-23

Tuesday, 10:40-12h00

6.2.49

MOO: Network Optimization and Transportation

Stream: Multi-Objective Optimization

Invited session

Chair: *Marta Pascoal*, Departamento de Matemática, Universidade de Coimbra, INESC-Coimbra, Largo D. Dinis - Apartado 3008, 3001-454, Coimbra, Portugal, marta@mat.uc.pt

1 - A reference point approach for multicriteria dial-a-ride problems

Julie Paquette, Operations Management and Logistics, HEC Montréal, 3000, chemin de la côte-sainte-catherine, H3T 2A7, Montreal, Quebec, Canada, julie.2.paquette@hec.ca, *Jean-François Cordeau*, *Gilbert Laporte*

Three service quality criteria are incorporated as objective, in addition to the cost, within a tabu search algorithm for the dial-a-ride problem. This reference point multicriteria solution approach is used to propose a set of non-dominated solutions to the manager of the service. Computational results on real-life and randomly generated data will be presented.

2 - A hybrid algorithm for a service technician routing and scheduling problem

Sophie Parragh, Department of Business Administration, University of Vienna, 1210, Vienna, Austria, Austria, sophie.parragh@univie.ac.at

The real-world service technician routing and scheduling problem we consider consists in routing a given number of technicians in order to complete a given set of tasks within a given planning horizon. Each task demands a technician that disposes of the appropriate skills of at least the demanded level. Time windows, validity periods, and maximum shift lengths have to be respected and breaks have to be scheduled. In addition, two technicians' tours may have to be synchronized to complete those tasks that demand two technicians. We present a hybrid solution algorithm for this problem.

3 - The pipeline and valve location problem

Marta Pascoal, Departamento de Matemática, Universidade de Coimbra, INESC-Coimbra, Largo D. Dinis - Apartado 3008, 3001-454, Coimbra, Portugal, *marta@mat.uc.pt*, *Gilbert Laporte*

We deal with finding a location for a pipeline between 2 points of a network and for a set of security valves, which control the damage provoked by possible spills, in order to minimize the environmental impact. A labeling approach is proposed to determine the pipeline and valve locations simultaneously, optimizing an impact measure that depends on the average number of accidents, damages and the flow in each pipe, and restricting the number of valves. Computational experiments on random instances are presented to evaluate the method's performance and to compare it to sequential approaches.

4 - A new hybrid evolutionary heuristic for the bi-objective bus driver rostering problem

Ana Respicio, DI - CIO, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, Bloco C5, Piso 1, 1749-016, Lisboa, Portugal, *respicio@di.fc.ul.pt*, *Margarida Moz*, *Margarida Pato*

The bus driver rostering problem consists of assigning to each bus driver a sequence of duties and days-off for a given horizon, satisfying rules imposed by contracts and company's norms. Two objectives are considered: minimizing the maximum overtime and minimizing the roster cost. For solving this highly complex problem we propose a bi-objective evolutionary algorithm integrating a constructive random heuristic at each iteration. Computational results show that this algorithm outperforms previously developed evolutionary heuristics, producing a spreader approximation of the Pareto frontier.

■ TB-24

Tuesday, 10:40-12h00
6.2.50

Algorithms in Computational Biology

Stream: Computational Biology, Bioinformatics and Medicine

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*

1 - Cliques and related cliques: models and applications

Pedro Martins, ISCAC, IPC and CIO, Quinta Agrícola - Bencanta, 3040-316, Coimbra, Portugal, *pmartins@iscac.pt*

A recently proposed discretized formulation for the maximum clique problem revealed to be more efficient on sparse graphs than known models in the literature. Furthermore, the new discretized information can also be used to characterize other clique related problems, answering and discovering important properties on Sociological and Biological networks. This communication presents modeling aspects for those clique related problems and presents applied results addressing Sociological networks, Molecular Biology networks and Networks of Interacting Pathways.

2 - Modeling of epidemic transmission and predicting the spread of pathogen

Tertita Delia Nova, Envir managementonment, University of Sumatera Utara, Jl. Ampera, Jl. Dr. Mansur, 20155, Medan, Indonesia, *nt.delia@yahoo.com*, *Herman Mawengkang*

Bird flu, or sometimes called avian flu, is an epidemic caused by H5N1 virus that primarily affects birds such as chickens, wild water birds, etc. These influenza viruses occur naturally among birds. The transmission mode of avian flu can occur due to the spread from one farm to another farm of chickens or birds. This paper addresses a transmission model of avian flu taking into account the factors that affect the epidemic transmission such as source of infection, social and natural factors and various control measures. From the model we estimate key parameters determining the spread of highly transmissible animal diseases between farms. We implement the model aimed at controlling such transmission between chicken farms at Padang city, the capital of West Sumatra Province, Indonesia.

3 - Microarray data reduction and classification

Silvia Pedro, School of Management, Hotel and Tourism, University of Algarve & CEAUL, Portugal, *smdp@ceaul.com*, *Lisete Sousa*, *Ana Pires*

One of the central features of microarray data is their high-dimensionality, being the number of variables greater than the number of observations. This naturally calls for the use of a dimension reduction method together with the classification one. In this presentation we compare the classification accuracy obtained applying classical principal components analysis (PCA) and robust PCA followed by three supervised classification methods: classification trees, neural networks and nearest neighbours. We applied these methods to leukemia and colon cancer data sets available in literature.

■ TB-25

Tuesday, 10:40-12h00
6.2.48

Risk Management and Portfolio Optimization II

Stream: Financial Mathematics and OR

Invited session

Chair: *Michael Markov*, Markov Processes International, 25 Maple Str, Suite 200, 07901, Summit, NJ, United States, *michael.markov@markovprocesses.com*

1 - Portfolio Calibration Approach for Asset Allocation and Financial Optimizations

Michael Markov, Markov Processes International, 25 Maple Str, Suite 200, 07901, Summit, NJ, United States, *michael.markov@markovprocesses.com*, *Evgeny Bauman*

We introduce the Portfolio Calibration method in Financial Optimizations that results in optimal portfolios preserving their efficiency in different market scenarios. For each scenario the portfolio is projected onto the efficient portfolio set and then aggregated. Different types of projections are introduced. A robust efficient set Calibrated Efficient Frontier is defined. A measure of stability of portfolio efficiency is suggested. Using Markowitz MVO as an example, we show that the Calibration method produces more stable results than both the original MVO and other approaches.

2 - Minimum Risk Methodology for Portfolio Selection

Konstantinos Kiriakopoulos, DEPARTMENT OF REGIONAL ECONOMICS, UNIVERSITY OF CENTRAL GREECE, Greece, *k_kiriak@otenet.gr*, *George Kaimakamis*, *Theodoros Mavralexis*

This paper aims to propose a new methodology for selecting ex-ante minimum risk portfolios. We consider different selection criteria such as the risk measure, rebalancing frequency, historical window and the inclusion or not of short sales. The methodology finds optimal portfolios for each selection criterion in separate and in total. The testing period is the recent financial crisis period. The portfolio comparison and the analysis performed gave as some interesting results regarding the optimal measures and we found that the portfolio constructed using these measures outperforms in all our data sets the indexing and equal weight strategy.

3 - Multiperiod Portfolio Optimization: Comparing Approximate Dynamic Programming with Stochastic Programming Methods

Dimitrios Karamanis, Operational Research, London School of Economics and Political Science, 50 Crispin Street, Lilian Knowles House, Room D2B3, E1 6HQ, London, United Kingdom, *d.karamanis@lse.ac.uk*, *Katerina Papadaki*

In this paper we present a multiperiod portfolio optimization model that includes both risk and transaction costs. The objective is to find how much the investor should buy and sell from each security in order to maximize expected terminal wealth. Scenario generation and scenario reduction techniques are being used to represent the stochastic process of the returns with a scenario tree. We use approximate dynamic programming and stochastic programming methods to solve the model. A comparison between the two approaches is presented.

4 - Multi-Criteria Decision Making Techniques: A Stock Selection Application

M.Fatih Bayramoglu, Bahcesehir University, Turkey,
 mfbayram@gmail.com, *Coskun Hamzaçebi*

Stock selection is a crucial decision for investors. Investors aim to maximize their return while minimizing the risk. In order to make more accurate decisions, multi-criteria decision making (MCDM) techniques may be used. In this study, the usage of MCDM techniques as a stock selection tool is examined.

■ TB-26

Tuesday, 10:40-12h00

3.1.11

Games solutions

Stream: Cooperative Game Theory

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 - A Non-cooperative and an Axiomatic Characterizations of the AL-values

Yukihiko Funaki, Economics, Waseda University, 1-6-1 Nishi-waseda, Shinjuku-ku, 1698050, Tokyo, Japan,
 funaki@waseda.jp, *Takumi Kongo*, *Mariana Rodica Branzei*,
Stef Tijs

We give a non-cooperative and an axiomatic characterizations of the AL-value on the class of balanced games. Here the AL-value is the weighted average of some vertices of the core. In both characterizations, average consistency property plays an essential role, and the property is obtained by the Davis-Maschler consistency property of the leximals.

2 - The restricted prenucleolus

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, *Elena Yanovskaya*

In this talk we deal with a generalization of the prenucleolus for games with restricted cooperation. The restricted prenucleolus for the class of games with restricted cooperation is defined by an analogous way as the prenucleolus for classical TU games. The restricted prenucleolus may be neither single-valued, nor symmetric. Necessary and sufficient conditions for the collection of feasible coalitions providing single-valuedness of the restricted prenucleolus and its symmetry are given. For some particular collections axiomatic characterizations of the restricted prenucleolus are proposed.

3 - Cooperative solutions on ranking situations

Manuel A. Pulido Cayuela, Estadística e Investigación Operativa, University of Murcia, Campus de Espinardo. Facultad de Matemáticas, 30100, Murcia, Murcia, Spain, mpulido@um.es,
Joaquín Sánchez-Soriano, *Natividad Llorca*, *Juan Aparicio*, *Julia Sancho*

In this paper, we deal with cooperative situations arising from markets where an Internet search service provider offers a service listing firms in decreasing order according to what they bid. We introduce the corresponding TU-game. The core, as well as the two friendly solutions for the corners of the market, are described using a related assignment game. We study also the Alexia value and the Shapley value of this type of games.

4 - Properties of The Myerson value in communication structures

Encarnación Algaba, Applied Mathematics II, Seville University, C/Camino de los Descubrimientos s/n, Isla de la Cartuja., 41092, Sevilla, Spain, ealgaba@us.es, *Jesus-Mario Bilbao*, *Rene van den Brink*, *Jorge López*

This paper deals with cooperative games in which partial cooperation is based on union stable systems. These systems have the communication situations, permission structures and augmenting systems as particular cases. We analyze the relation between the restricted game and the conference game to establish later which effects a union stable system has on certain desirable properties of these games. Basing on the properties of the position value two new characterizations are given for the Myerson value in this context.

■ TB-27

Tuesday, 10:40-12h00

8.2.06

AIR TRANSPORTATION AND LOGISTICS

Stream: Transportation and Logistics [c]

Contributed session

Chair: *Kerem Akartunali*, Management Science, University of Strathclyde, University of Strathclyde, Dept. of Management Science, G1 1QE, Glasgow, United Kingdom,
 kerem.akartunali@strath.ac.uk

1 - Efficient Delay Distribution in Air Transportation Networks

Claus Gwiggner, ATM Modeling, Electronic Navigation Research Institute, 7-42-23 Jindaiji Higashi-machi, Chofu-shi, 182-0012, Chofu, Tokyo, Japan, claus@enri.go.jp, *Sakae Nagaoka*

A new problem in air traffic flow optimization is queue management, where delays have to be distributed efficiently among the network. Minimizing fuel depends on error propagation due to trajectory prediction uncertainties. The optimal distribution strategy is known in a few simple cases.

This talk extends our results on single-server queues to small networks, where we analyze delay propagation as a function of control policies. We identify experimentally the feasibility of the problem and show our first analytical results.

2 - Optimally Allocating Boat Resources at the United States Coast Guard

Michael Wagner, Saint Mary's College of California, United States, mrw2@stmarys-ca.edu, *Zinovy Radovilsky*

We detail the results of an applied research project where we optimally allocate a fleet of boats for the United States Coast Guard. The fleet consists of hundreds of boats of different types, which needs to be allocated to approximately 200 stations on both coasts of the United States, as well as Hawaii and Alaska. The basic model is a mixed integer program with novel constraints; for example, the model determines the best way to "share" certain limited boat resources under geographical distance restrictions. Probabilistic enhancements result in an integer second order cone program.

3 - Flow Variation with Savings in Average Cost

Sonia, Decision Sciences Group, Indian Institute of Management, Prabandh Nagar, Off Sitapur Road, 226013, Lucknow, India, sonia@iitdalumni.com, *Ankit Khandelwal*

The paper discusses the cases of flow enhancement and curtailment in a capacitated minimum cost network flow problem (MCFP) along with a saving in average shipment cost. These cases are termed as pseudo paradox and reverse pseudo paradox respectively. Conditions governing the existence of both types of paradoxes are identified and illustrated with the help of numerical examples. An equivalent standard MCFP is also formulated whose optimal solution provides the best paradoxical solution pertaining to each case.

4 - Airline Schedule Design: Network Design Optimization and Heuristics Ideas

Kerem Akartunali, Management Science, University of Strathclyde, University of Strathclyde, Dept. of Management Science, G1 1QE, Glasgow, United Kingdom,
 kerem.akartunali@strath.ac.uk, *Natashia Boland*, *Ian Evans*,
Mark Wallace, *Hamish Waterer*, *Olivia Smith*

Airlines plan and schedule their activities by solving a sequence of separate problems, where generating a timetable of flights is the first step in the process. Therefore, schedule design is very crucial for any airline with significant savings potential. We study an integrated model of the schedule design and fleet assignment problems for creating efficient timetables. We propose a multi-commodity network formulation, as well as a variety of exact and heuristics methods to solve it. We conclude with computational results and a discussion of future directions.

■ TB-28

Tuesday, 10:40-12h00

8.2.10

Stochastic Programming Models 2

Stream: Stochastic Programming 1

Invited session

Chair: *David Wozabal*, Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, david.wozabal@univie.ac.at

Chair: *John Tomlin*, Yahoo! Research, 2821 Mission College Blvd, 95054, Santa Clara, CA, United States, tomlin@yahoo-inc.com

1 - Stochastic project scheduling: a financial viewpoint for the gate setting problem

Bernardo Pagnoncelli, Escuela de Negocios, Universidad Adolfo Ibañez, DIAGONAL LAS TORRES 2640 PEÑALOLÉN Oficina 533 C Santiago, Chile, 75000000, Santiago, Chile, bernardo.pagnoncelli@uai.cl, *Nicole Suella Fernandez*, *Alexandre Street*

We study the problem of setting gates for activities in stochastic project scheduling, where each activity has random duration. We propose a two-stage risk-averse stochastic mixed-integer programming model where gates play the role of first stage decisions. The formulation goes beyond the standard risk-neutral maximization, using the Conditional Value-at-Risk as a risk-adjusted objective function. A discussion over the applicability of such model as a strategic bidding tool for sealed-bid auctions will be provided based on the financial interpretations of the proposed objective function.

2 - Medium-term Planning of a Multi-product Batch Plant under Evolving Multi-period Multi-uncertainty by Means of a Moving Horizon Strategy

Jian Cui, Biochemical and Chemical Engineering, TU Dortmund, Emil-Figge-Str. 70, 44227, Dortmund, Germany, rossicui@hotmail.com, *Sebastian Engell*

In this contribution, two-stage stochastic mixed integer programming with recourse (2S-MILP) is employed for medium-term planning of a multi-product batch plant under evolving multi-period multi-uncertainty (MPMU) with discrete probability distributions. A dynamic 2S-MILP formulation is developed for these evolving MPMU and the corresponding method, a moving horizon strategy is proposed. In order to reduce the computation effort, the near future is modeled by a tree of scenarios of future uncertainties whereas the remote future is represented by the expected values (EVs).

3 - A Probabilistic Provider Selection and Task Allocation Model in Telecommunication Networks with Stochastic QoS Guaranties

Hasan H. Turan, Industrial Engineering, University of Yalova, 77100, Yalova, Turkey, hasanturan@sabanciuniv.edu, *Nihat Kasap*

In this study, two important parameters of Quality of Service, delay and jitter are considered as random variables to capture the nature of stochastic network environment. We model provider selection and task allocation problem as an expected cost minimization problem with stochastic chance constraints. Since the model is nonlinear mixed integer problem, first stochastic model is converted into its deterministic equivalent and then a heuristic algorithm is proposed to solve. Moreover, we present a simulation study to check performance of solution procedure.

4 - Sensitivity of an Inventory Allocation Model for Online Advertising with Stochastic Supply

John Tomlin, Yahoo! Research, 2821 Mission College Blvd, 95054, Santa Clara, CA, United States, tomlin@yahoo-inc.com, *Vijay Bharadwaj*

We describe a stochastic programming variant of an inventory allocation model for online advertising and investigate the sensitivity of the solutions to the variance of the underlying supply distributions, when these are (realistically) assumed to be log-normal. We also describe a medium to large scale implementation and give computational results.

■ TB-29

Tuesday, 10:40-12h00

8.2.11

Applications of Boolean Functions

Stream: Boolean Programming

Invited session

Chair: *Utz-Uwe Haus*, FMA-IMO and MaCS, Otto-von-Guericke Universitaet Magdeburg, Universitaetsplatz 2, 39106, Magdeburg, Germany, haus@imo.math.uni-magdeburg.de

1 - Minimal Conflicting Sets in ancestral genome reconstruction

Tamon Stephen, Department of Mathematics, Simon Fraser University, 14th Floor Central City Tower, 250-13450 102nd Ave., V3T 0A3, Surrey, British Columbia, Canada, tamon@sfu.ca

We consider problems of generating minimal obstacles (Conflicting Sets) to the consecutive-ones property for binary matrices used in ancestral genome reconstruction. We show that this problem can be reduced to a joint generation problem for boolean functions, and that this strategy can be helpful in discriminating between true and false positive ancestral synteny in simulated and real data sets.

This is joint work with Cedric Chauve, Utz-Uwe Haus and Vivija You.

2 - MDD-Based Propagation of Among Constraints

Willem-Jan van Hoeve, Tepper School of Business, Carnegie Mellon University, 5000 Forbes Avenue, 15213, Pittsburgh, PA, United States, vanhoeve@andrew.cmu.edu, *Samid Hoda*, *John N. Hooker*

Fixed-width MDDs were introduced recently by Hooker et al. as a more refined alternative for the domain store to represent partial solutions to CSPs. In this work, we study MDD-based propagation algorithms for 'among' constraints. We show that MDD-based filtering for 'among' can be done in polynomial time, and we present an efficient heuristic propagation algorithm that can be applied to any ordering of the MDD. Our experimental results demonstrate that MDD-based propagation can dramatically reduce the search tree size and computation time when compared to the traditional domain store.

3 - Discovering All Associations in Discrete Data using Frequent Minimally Infrequent Attribute Sets

Utz-Uwe Haus, FMA-IMO and MaCS, Otto-von-Guericke Universitaet Magdeburg, Universitaetsplatz 2, 39106, Magdeburg, Germany, haus@imo.math.uni-magdeburg.de, *Elke Eisenschmidt*

Associating biological categories with measured or observed attributes is a central challenge for discrete mathematics in life sciences. We propose a new concept to formalize this question: Given a binary matrix of objects and attributes, determine all attribute sets characterizing object sets of cardinality t that do not characterize any object set of size $s > t$. We determine how many such attribute sets exist, give an output-sensitive quasi-polynomial time algorithm to determine them, and show that k -sum matrix decompositions known from matroid theory are compatible with the characterization.

4 - Computing exact solutions for row layout problems

Miguel Anjos, Management Sciences, University of Waterloo, 200 University Avenue West, N2L 3G1, Waterloo, Ontario, Canada, manjos@uwaterloo.ca, *Frauke Liers*

Row layout problems occur in several engineering applications such as flexible manufacturing and circuit design. These problems can be formulated using Boolean variables within either a linear or a semidefinite programming framework. Recently there has been significant progress in both directions with respect to the special case of single row layout. We will survey these developments and present new results in computing exact solutions for row layout problems.

■ TB-30

Tuesday, 10:40-12h00

8.2.13

MCDA II: Group Decision

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

Invited session

Chair: *Juan Carlos Leyva-Lopez*, Departamento de Investigación y Posgrado, Universidad de Occidente, Carr. a Culiacancito Km. 1.5, 80020, Culiacan, Sinaloa, Mexico, jleyva@culiacan.udo.mx

1 - A Model of Consensus in Group Multicriteria Decision Aiding

Juan Carlos Leyva-Lopez, Departamento de Investigación y Posgrado, Universidad de Occidente, Carr. a Culiacancito Km. 1.5, 80020, Culiacan, Sinaloa, Mexico, jleyva@culiacan.udo.mx

This paper presents an order-based consensus model in group multicriteria decision aiding that proceeds from consistency to consensus. It is based on the use of valued outranking relations to model individual and group preferences. A consensus measure and proximity measure are defined, the first one, guides the consensus process and the second one supports the group discussion phase of consensus process. The consensus degrees indicate how far a group of individuals is from the maximum consensus, and the proximity measure indicates how far each individual is from current consensus.

2 - An approach for group decision with incomplete information

Paula Sarabando, ESTGV and INESC Coimbra, Rua Antero de Quental, N°199, 3000 - 033, Coimbra, Portugal, psarabando@mat.estv.ipv.pt, *Luis C. Dias*

We address the problem in which a group of decision makers is not able to provide complete information about their individual preferences. In the context of additive multi-criterion aggregation, we consider problems with ordinal information, namely considering a ranking of the criterion weights. The approach we presented has as objective to inform decision-making by checking if there are optimal alternatives and if there are alternatives that can be eliminated due to dominance

3 - A Group Multicriteria Decision Support System for Rank a Finite Set of Alternatives

Pavel Alvarez Carrillo, Universidad de Occidente, 80020, Culiacán, pavel@uas.uasnet.mx, *Alfonso Duarte*, *Juan Carlos Leyva-Lopez*

This paper presents an Internet-based Group Decision Support System (GDSS) prototype built around MCDA models, which provides support to collaborative decision makers in reaching a consensus when they try to solve a ranking problem in an asynchronous and distributed environment. It includes the sequential and parallel coordination modes. The first is processed with the ELECTRE III — MOEA methodology and the second is processed with the ELECTRE GD — MOEA methodology.

■ TB-31

Tuesday, 10:40-12h00

8.2.15

OR and Ethics II

Stream: OR and Ethics

Invited session

Chair: *Haavard Koppang*, Gimle Terrasse 3., 0264, Oslo, Norway, haavard.koppang@bi.no

1 - Modeling Distributive Justice

John N. Hooker, Tepper School of Business, Carnegie Mellon University, 15213, Pittsburgh, PA, United States, john@hooker.tepper.cmu.edu

This talk describes mathematical programming models for distributive justice. It derives sometimes surprising structural properties of optimal distributions that result from utilitarian and Rawlsian (lexmax) objectives. It investigates the extent to which they require egalitarianism when some individuals are more productive than others. It shows that mixed integer modeling of combined utilitarian and Rawlsian criteria can be highly nontrivial, and indicates how models can nonetheless be constructed using disjunctive modeling principles.

2 - The compromise efficiency vs. egalitarianism among generations with an infinite horizon

José Carlos R. Alcantud, Universidad de Salamanca, Facultad de Economía y Empresa, Campus Unamuno, E37007, Salamanca, Spain, jcr@usal.es

This work concerns ethical aggregation of infinite utility streams. Position i is typically interpreted as the endowment of generation i . We analyze the broad question: In order for the social welfare to increase, the interest of how many generations can be respected if we intend to be ethical? Here "ethical" refers to verifying adequate equity axioms, and case-studies cover: Hammond Equity-related principles; or extensions of restricted non-substitution; together with the usual Anonymity axiom.

3 - In bed with the military: Ethics dilemmas for humanitarian organizations

Bent Erik Bakken, St. Georgs vei 4, 0280 OSLO, 0280 OSLO, Norway, Oslo, beerikba@online.no

Humanitarian organizations and military organizations sometimes cooperate, such as in current Afghanistan. A System Dynamics model is built to investigate the interrelationships between such cooperation and the degree to which humanitarian organizations might cross boundaries for ethical behavior. It is shown that using a consequentialist framework for ethics, humanitarian organizations should cooperate with military organizations. Using other frameworks lead to different conclusions.

4 - A Reflection on OR, Freedom and Responsibility

João Clímaco, Faculdade de Economia da Universidade de Coimbra and INESC-Coimbra, 3004-512, Coimbra, Portugal, jlclimaco@fe.uc.pt, *José Antonio Peixoto*

There is an increasing interest in integrating OR in global and local sustainable development directives for assessments. This demands a public/democratic validation of the ways relations between Humanity and Nature are realized, namely, to model the interaction between theoretical and practical knowledge. We discuss the ethical tradition of the classical OR paradigm and the actual demands, arguing that, constrained by the "imperative of performance", the analysts should critically update references and criteria for evaluations from a new perspective of freedom and responsibility.

■ TB-32

Tuesday, 10:40-12h00

8.2.17

OR in Agriculture

Stream: OR in Agriculture and Forest Management

Invited session

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

1 - Effects of Education and Investment in Research in Agricultural Production in Brazil

Eliane Gomes, Brazilian Agricultural Research Corporation, Parque Estação Biológica, W3 Norte final, Asa Norte, 70770901, Brasília, DF, Brazil, eggomes@yahoo.com.br, *Geraldo Souza*, *Rosaura Gazzola*, *Antonio Flavio Avila*

We use census data (1996 and 2006) to model the agricultural production at state level in Brazil. Cost efficiency measurements are computed using data envelopment analysis and the response is assessed via censored regressions. We study the effects of region, education and investment in agricultural research on the economic efficiency. Education has a strong significant effect, as well as investment in research. The intensity of the effects varies over regions for education, and is statistically the same for investment in research.

2 - Optimal Multiobjective Crop Rotation Planning Using Evolutionary Algorithms

Ruth Pavón Mendoza, Facultad Politécnica, Universidad Nacional de Asunción, sn, Asunción, Paraguay, rpavon@pol.una.py, Ricardo Brunelli, Christian von Lucken

Crop rotation is the agricultural practice of planting different types of crops in the same land area in sequential seasons. The use of crop rotations is an effective practice for disease, insect and weeds control. When planning a rotation, a farmer wants to choose those crops that best fit the soil characteristics in order to obtain the maximum benefit with the least possible cost and risks. This work presents the crop rotation problem in a multiobjective context considering simultaneously economic and ecological factors.

3 - A linear optimization approach for vegetable crop production planning

Marcos Arenales, Dept of Applied Mathematic and Statistics, universidade de São Paulo, Av. do Trabalhador São-Carlense, 400 - Centro - CP 668, 13560-970, Sao Carlos, SP, Brazil, arenales@icmc.usp.br, Lana Mara Santos, Alysson Costa, Ricardo Henrique Santos

We deal with crop rotation scheduling in the context of vegetable crop production under some ecological criteria. Three planning problems based on different practical situations are presented and a core mathematical model called the crop rotation scheduling model is developed. We present a general modeling framework, a solution methodology based on column generation technique and a set of computational experiments using instances based on real-world data.

4 - A Model for Balancing Production Lines in a Packing Plant

Marcela Gonzalez, Departamento de Modelación y Gestión Industrial, Universidad de Talca, Merced 437, s/n, Curicó, Región del Maule, Chile, mgonzalez@utalca.cl, Hugo Santelices

We have developed a mixed integer programming model for balancing workers allocation in different stages of the production process in a packing plant. The results were implemented in a packing plant located in Chile.

■ TB-33

Tuesday, 10:40-12h00
8.2.19

Renewable Energy Production

Stream: Energy, Environment and Climate [c]

Contributed session

Chair: *Gonçalo Cardoso*, Instituto Superior Técnico, Av. Rovisco Pais, 1041-009, Lisbon, Portugal, goncalo.cardoso@ist.utl.pt

1 - Impact of bio-fuels in the adoption of small CHP units in the Portuguese building sector

Gonçalo Cardoso, Instituto Superior Técnico, Av. Rovisco Pais, 1041-009, Lisbon, Portugal, goncalo.cardoso@ist.utl.pt, Paulo Ferrao, Ana Paula Barbósa-Póvoa

Efficient and sustainable energy supply solutions for buildings are nowadays an emerging problem. DER-CAM is a MILP model that addresses this problem and provides optimal energy supply solutions for buildings or groups of buildings. These include optimal selection of supply technologies, installed capacity and hourly dispatch. This paper introduces bio-fuels to DER-CAM and analyzes how its use may influence the adoption of small combined heat and power (CHP) units in the Portuguese building sector. Sensitivity analyses are made considering CO₂ emissions, financial incentives and fuel pricing.

2 - A Network Integration Oriented Model to Evaluate New Wind Power Generation Projects

Halil Cobuloglu, Industrial Engineering, University of Yalova, Suleymanbey Mah. Tukenmez Sk., Feribot Iskelesi Karsisi, 77100, Yalova, Turkey, halil.cobuloglu@gmail.com, Ilhan Or, Gürkan Kumbaroglu

In this paper, a series of optimization models oriented on the network integration of new wind power projects is proposed. In one group of models, the objective is cost minimization, while desired minimum additional capacity is taken as a constraint. In another group of models, the aim is to maximize installed wind power capacity and delivered energy. The existing high voltage transmission network constitutes the primary constraints. The output gives the choice of wind power projects to be invested and place of network connection. The models are run with data representing the case of Turkey. Results will be discussed.

3 - Investment scenarios in new generation power grids across the mediterranean

Elena Claire Ricci, Università degli Studi di Milano and Fondazione Eni Enrico Mattei, Italy, elenaclaire.ricci@unimi.it, Emanuele Massetti

The paper aims at evaluating changes in climate-stabilization policy costs and in the electricity mix when Super-Grid is added to the portfolio of available options to reduce the electricity sector carbon footprint. We extend the WITCH model including the possibility for Europe to import electricity generated by large scale concentrated solar power plants in Middle-East and North Africa. The aim is to compute the optimal timing and investments, and evaluate the economic attractiveness by means of a long-term optimization where economic resources are allocated efficiently across sectors and time.

■ TB-34

Tuesday, 10:40-12h00
8.2.23

Model Formulations and Real World Applications of Lot Sizing and Scheduling IV

Stream: Lot-sizing and Scheduling, Economic Order Quantity

Invited session

Chair: *Alistair Clark*, Dept of Mathematics and Statistics, University of the West of England, Frenchay Campus, Coldharbour Lane, BS16 1QY, Bristol, United Kingdom, Alistair.Clark@uwe.ac.uk

1 - An integrated blending and lot-sizing problem in a cotton spinning industry

Victor C. B. Camargo, Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, 14010-070, São Carlos, SP, Brazil, victor@icmc.usp.br, Bernardo Almada-Lobo, Franklina Toledo

The Brazilian textile sector is an important generator of jobs and regional development. Its supply chain is composed of seven steps, which are addressed in a disaggregated fashion. We propose to study the integration of two production planning problems in a cotton spinning industry, the blending of raw material and the sizing of yarns lots. The yarns must be produced respecting quality limits, while satisfying the demand without backlog. We present a mathematical model to the integrated problem and its results from computational tests.

2 - Lot-sizing and Scheduling Problems with Small Time Buckets

Waldemar Kaczmarczyk, Department of Operations Research & Information Technology, AGH University of Science & Technology, ul. Gramatyka 10, 30-067, Krakow, Poland, waldek@agh.edu.pl

This paper deals with two modeling issues arising in short term manufacturing planning. Firstly, new MIP model formulations are proposed for the PLSP with set-up times longer than a period. Experimental results prove that they are easier to solve with standard MIP methods than already known models. Secondly, correct setting of inventory holding cost parameters is discussed. Sometimes real time periods, macro-periods, are subdivided into shorter fictitious micro-periods. In such problems inventory holding costs may be accounted either in all micro-periods or at the end of every macro-period.

3 - Planning printers production by a lot-sizing and scheduling model

Joao Flavio F. Almeida, UFMG, Brazil, joaoflavio.ufmg@gmail.com, Marcio Mariano Junior, Magno Silverio Campos

A real problem of lot-sizing and scheduling printer's production was found in an EMS company where the setup and inventory must be optimized over the horizon. Simultaneous classical and reformulated capacitated models were evaluated for this NP-hard problem and solved by CPLEX mixed-integer programming. Results were compared with the past practices and improvements in cost, lead time and planning's quality were evidenced, reducing to zero the number of delays on product's delivery. This model will be graphically interfaced once managers have validated this decision support tool.

■ TB-35

Tuesday, 10:40-12h00
6.2.46

Facilitated Modelling in Action Research

Stream: Facilitated Modelling in OR

Invited session

Chair: *L. Alberto Franco*, Warwick Business School, University of Warwick, ORIS Group, Gibbet Hill Road, CV4 7AL, Coventry, United Kingdom, alberto.franco@warwick.ac.uk

1 - A Systematic Procedure to Evaluate the Impact of Multi-Methodology Interventions

Felipe Henao, Faculty of Management, ICESI University, ICESI University, Calle 18# 122 - 135, Pance, Pance, Cali, Valle del Cauca, Colombia, jfhenao@icesi.edu.co, *L. Alberto Franco*

This paper discusses a systematic procedure to assess the impacts of multi-methodology (MM) in practice. The approach uses the principles of Critical Theory, particularly Habermas' notions of human cognitive interests, as the basis for understanding MMs' impacts in real situations. A case study in Colombia is employed in order to test the approach. The case shows how MMs' benefits can be categorised in terms of intervention stages and Habermas' three worlds. The evidence suggests that MM can improve team members' interactions and the quality of their work.

2 - Using Action Research on the Process of Decision Support with VIP Analysis Software

Alecsandra Ventura, Faculty of Economics, University of Coimbra, Rua Paulina Maria de Mendonça, 771 - Mangabeiras, 57037-110, Maceió, Alagoas, Brazil, alecsandra.ventura@gmail.com, *Luis C. Dias, João Clímaco*

This work is a contribution to suggest an Implementation Model of Decision Support with the VIP Analysis Software including the proposal of using Cognitive Maps as a Problem Structuring Method (PSM) and using Multi-Attribute Utility Theory (MAUT) to elaborate Additive Value Functions.

In a real-world intervention, Action Research was selected as a research method because it enables the assessment of acceptability of VIP Analysis Software in Organizations; at the same time it makes possible the implementation of a decision aiding process by the researcher.

3 - Creating a Shared Language in Multi-Disciplinary Teams through Facilitated Modelling: A Case from the Innovation Sector

Donna Champion, Business School, Loughborough University, Epinal Way, LE11 3TB, Loughborough, United Kingdom, d.champion@lboro.ac.uk

Inventors of new high technology platforms often lack the resources to develop products with commercial appeal and so they work with other business managers to develop their products. Multi-disciplinary teams often have to bridge a language gap between the different professions. This paper will report on the process of an innovation team working to develop a shared language and creating a set of performance indicators to monitor relationship development supported by a facilitated modelling approach employing systems maps and the PEArL framework.

4 - Methodological Criteria for the Internal Validity and Utility of Practice Oriented Research

Hubert Korzilius, Institute for Management Research, Radboud University Nijmegen, Netherlands, h.korzilius@fm.ru.nl

For conducting practice oriented research different research strategies are available. In this paper a typology is developed for differentiating between practice oriented research strategies that are data based and participatory research strategies. The former category involves quantitative and qualitative data based research strategies. The latter category, participatory research strategies, includes knowledge based research and practice based research. At present, methodological criteria for assessing the quality of practice oriented research heavily rely on those developed for theory oriented research, in particular internal and external validity and reliability. However, we argue that for assessing the results of practice oriented research other criteria are necessary. In this paper, methodological criteria are formulated for evaluating the internal validity and practical utility of practice oriented research with the help of a Delphi study using research methodologists as experts. They agree upon the criteria of verifiability, comprehensibility and acceptance of the results, as well as holism. Moreover, different categories of participatory and data based research strategies are compared to these criteria. Practice based research and qualitative data based research are best equipped to fulfill these criteria. These findings may enable researchers to make a more deliberate choice for a specific research strategy in practice oriented research.

■ TB-36

Tuesday, 10:40-12h00
3.1.05

Forecast based on fuzzy logic or neural networks

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence [c]

Contributed session

Chair: *Heinrich Rommelfanger*, Economics and Business Administration, Goethe University, Niebergallweg 16, 65824, Schwalbach a. Ts., Hessen, Germany, Rommelfanger@wiwi.uni-frankfurt.de

1 - Market Share Forecasting by Using Fuzzy Multiple Objective Piecewise Logistic Model and Delphi Method

Jing-Rung Yu, Information Management, National Chi-Nan Univ., 470 Univ. Road, 545, Pu-Li, Nan-Tau, Taiwan, jennifer@ncnu.edu.tw, *Fang-Mei Tseng*

It is very important for a firm to be able to make a prediction on their sales. The piecewise concept is adopted to highlight the impact of a new generation to the market so that the effective length of sales forecasting intervals would be obtained. After collecting some period data for the future by Delphi method, an interpolation by the fuzzy multiple objective piecewise logistic growth model is performed. Then the result considers quantitative and qualitative criteria would be achieved. Four television technologies, CRT, RP, PDP and LCD TVs, are demonstrated by our proposed model.

2 - A New Approach to Forecast Neural Network-Based Fuzzy Time Series

Ozer Ozdemir, Statistics, Anadolu University, Anadolu University Faculty of Science, Department of Statistics, Eskisehir, Turkey, ozerozdemir@anadolu.edu.tr, *Memmedaga Memmedli*

Neural network-based fuzzy time series models have been applied to improve forecasting of fuzzy time series. Hence, we proposed a new method to improve forecasting with adjustment all degrees of membership in establishing fuzzy relationships by using neural network. Differing from previous studies, we adjust not only three degrees of membership but also all degrees of membership. A well-known time series which are enrollment data for the University of Alabama is chosen to demonstrate comparison results. It is found that proposed method outperforms the other methods proposed in the literature.

3 - Neural Network Approach for Product Return Rate Forecasting in Reverse Logistics

Gül Tekin Temur, Management Engineering, Istanbul Technical University, ITU Isletme Fakultesi Macka Besiktas, 34267, Istanbul, Turkey, temurg@itu.edu.tr, *Bersam Bolat, Lütfü Yakupoğlu, Volkan Yılmaz*

The complexity of reverse logistics problems increases due to high uncertainty in quantity, quality and time of product returns. In this study, quantity of returned products that depends on numerous variables such as environmental regulations, lifecycle of products, technical innovation level, etc. is predicted by using Artificial Neural Network (ANN) method. In this pursuit, firstly a wide literature is searched for product returns in reverse logistics. Then, the proposed model is generated based on relevant effective factors and implemented to an electric-electronic firm.

4 - Prediction of Exchange Rates with Parametric and Non Parametric Techniques: A Comparison Study

Slim Chokri, EMQ, ISCAE, Manouba, TUNISIA, 2010,
Manouba, TUNISIA, Tunisia, chokri.slim@iscae.rnu.tn

Several forecasting techniques have been proposed in order to predict exchange rate. We propose a parametric techniques such as autoregressive integrated moving average (ARIMA), vector autoregressive (VAR) and co-integration techniques, and nonparametric techniques such as support vector regression (SVR) and artificial neural networks (ANN). These have been employed to predict currency exchange rate between USD/TND, EURO/TND, GPB/TND and JPY/TND. The performance of the proposed models have been evaluated and have been compared. It is observed that the ANN model performs the best.

■ TB-37

Tuesday, 10:40-12h00

3.1.09

Meeting the targets: policy and measures

Stream: Long Term Planning in Energy, Environment and Climate

Invited session

Chair: *Nadia Maïzi*, Center for Applied mathematics, MINES ParisTech, Rue C. Daunesse, BP 207, 06904, Sophia-Antipolis, France, nadia.maizi@mines-paristech.fr

1 - Regional impacts of post Copenhagen emission reduction pledges using TIAM-FR

Sandrine Selosse, Centre for Applied Mathematics, MINES ParisTech, Rue Claude Daunesse, 06904, Sophia Antipolis, France, sandrine.selosse@mines-paristech.fr, *Edi Assoumou*, *Nadia Maïzi*

The aim of this paper is to analyze the outcomes of different coordination schemes, derived from the submitted pledges, and associated to intermediate targets levels. The study relies on the TIAM-FR approach performing the optimization of the energy system in the long-term with descriptions of the technologies.

2 - Impact of the price of CO2 certificates on the energy system of the EU-27

Markus Blesl, IER, University of Stuttgart, 70565, Stuttgart, Germany, Markus.Blesl@ier.uni-stuttgart.de

TIMES PanEU is used through variation of CO2 prices (for ETS and Non-ETS sectors), and reduction potential curves are constructed. Based on two scenarios runs with a reduction target of -15 % and -40 % in 2020 compared to Kyoto base year and the resulting CO2 prices, the frame of CO2 prices variation is set. Using the results of the different scenarios, the emission reduction compared to the case of the lowest CO2 prices (10 EUR/t in 2020) are evaluated. The total reduction over all sectors is displayed, with a focus on the different energy sectors and the reduction technologies are analysed.

3 - Modelling technology pathways for oil use reduction in Swedish passenger car transport

Martin Börjesson, Energy and Environment, Chalmers University of Technology, 412 96, Göteborg, Sweden, martin.borjesson@chalmers.se, *Erik Ahlgren*

A strongly decreasing oil dependency is a key energy policy objective in many countries. In this study, an application of the well-established, cost-optimizing MARKAL model is used in order to estimate energy and technology costs associated with a strong reduction of oil use in Swedish passenger car transport until 2030. The model application, which describes the entire energy system of Sweden, is used with a simulating approach in which potential transport technology pathways are evaluated for different levels of oil use reduction and in different energy market and climate policy scenarios.

4 - Theory versus reality in the residential buildings sector: analysis of a gap and its consequences.

Benoit Allibe, EDF R&D - CIRED, France, benoit.allibe@gmail.com

Modelling of dwelling stock thermal performance is of great interest for long term energy planning and policy-making. Recently, the number of energy standards has increased but empirical evidence shows discrepancy between normative energy calculations and reality. However, all actors increasingly use these standards as they provide a simple and common language. We show how normative calculations can be misleading in terms of effort intensity required to reach quantified objectives and highlight the need for calculations based on a double metrics including normative and observed consumptions.

■ TB-38

Tuesday, 10:40-12h00

6.2.44

Stochastic Valuation of Derivatives and Commodities I

Stream: Stochastic Valuation for Financial Markets

Invited session

Chair: *Martin Rainer*, Inst. Applied Mathematics, METU Ankara, ENAMEC Inst., Glockengasse 15, D-97070 Würzburg, 97070, Würzburg, Germany, martin.rainer@enamede.de

Chair: *Ömür Uğur*, Institute of Applied Mathematics, Middle East Technical University, 06531, Ankara, Çankaya, Turkey, ougur@metu.edu.tr

Chair: *Javier de Frutos*, Matematica Aplicada, Universidad de Valladolid, Facultad de Ciencias, Prado de la Magdalena s/n, 47005, Valladolid, Spain, javier.defrutos@gerad.ca

1 - An Empirical Study on R&D Value Based upon Modified Finite Compound Option Models

Yu Wen Lan, Finance and Banking, Lunghwa University of Technology and Science, No.300,Sec.1,Wanshou Rd.,Guishan,Taoyuan County 33306,Taiwan (R.O.C.), 33306, Taoyuan County, Taiwan, Taiwan, 93441007@cc.ncu.edu.tw, *Tze Chin Huang*

Bellalah (1999) firstly incorporate the factor of information cost into a real option model for R&D valuation. However, the Bellalah's model has default on catching the change of R&D's payoff due to undefined events within project's lifetime. Lo and Lan (2009) partly solve the problems as to incorporate exponential decay and Poisson event, but it cannot deal with cases of investment opportunity which do not exist permanently. We develop new models based upon the finite compound option setting in Black-Scholes fashion as the solution.

2 - Information Costs Impacts on Real Options Valuation

Jean-Michel Sahut, Amiens School of Management, 18 place Saint Michel, 80000, Amiens, jmsahut@gmail.com

We present a simple framework for the analysis, valuation and simulation of several real options in the presence of shadow costs of incomplete information. Information costs can be viewed as sunk costs in the spirit of Merton's model of capital market equilibrium with incomplete information. We incorporate these costs in standard discounted cash flow techniques and present the basic concepts of real options. We present valuation procedures and simulations for the values of common real options in the presence of shadow costs of incomplete information.

3 - Callable Russian options with the finite maturity

Atsuo Suzuki, Meijo University, Nijigaoka 4-3-3, Kani, Gifu, 5090261, Japan, atsuo@urban.meijo-u.ac.jp, *Katsushige Sawaki*

We consider callable Russian options with the finite maturity. Callable Russian option is a contract that the seller and the buyer have the rights to cancel and to exercise it at any time, respectively. We discuss the pricing model of callable Russian options when the stock pays dividends continuously. We show that the pricing model can be formulated as a coupled optimal stopping problem which is analyzed as Dynkin game.

■ TB-39

Tuesday, 10:40-12h00

6.2.45

Advances in Control Problem

Stream: Optimal Control

Invited session

Chair: *Robert Baier*, Department of Mathematics, University of Bayreuth, Chair of Applied Mathematics, D-95440, Bayreuth, Germany, robert.baier@uni-bayreuth.de

1 - Virtual Control Concept for Linear Quadratic Optimal Control Problems with state constraints

Bjoern Huepping, Institut für Mathematik, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074, Würzburg, Germany, bjoern.huepping@mathematik.uni-wuerzburg.de, *Matthias Gerdt*

In this talk, a regularization for Linear Quadratic Optimal Control Problems will be presented. This approach ensures the existence of feasible solutions without interfering with the original control. The regularized problems can be solved efficiently using a function space Newton's method. Conditions for convergence are presented, and numerical examples illustrate the idea of the algorithm and its application in a model predictive controller.

2 - On the optimal control of a cascade of hydro-electric power stations

Maria do Carmo Guedes, Matematica, FCUP, Rua do Campo Alegre, 687, 4169-007, Porto, Portugal, mmguedes@fc.up.pt, *Ana Ribeiro*, *Georgi Smirnov*, *Sonia Vilela*

In modern reversible hydroelectric power stations, associated with reservoirs along a river basin with a cascade structure, it is possible both to turbine water from upstream to produce electric power and to pump from downstream to help to refill an upstream reservoir. Our objective is to maximize the profit of producing power providing at the same time some guidelines on when, how much and in what direction to allow the water flow. This is modeled as an optimal control problem with mixed constraints, solved using penalty functions and derivative free methods.

3 - Optimal control of a flexible server in a queueing network with operation costs

Dimitrios Pandelis, Mechanical Engineering, University of Thessaly, Pedion Areos, 38334, Volos, Greece, d_pandelis@mie.uth.gr

We consider queueing networks with Poisson arrivals at each node. Jobs move from node to node or exit the network according to certain probabilities. Service times are exponentially distributed and linear holding costs are incurred by the jobs during the time they remain in the network. There are dedicated servers, one for each node, and one flexible server that can serve in any node. This flexible server incurs linear operating costs during his busy time. We use a Markov Decision Process formulation to derive structural properties of an optimal allocation strategy for the flexible server.

■ TB-41

Tuesday, 10:40-12h00

3.1.06

Applications of System Dynamics Modeling I

Stream: System Dynamics Modeling

Invited session

Chair: *Lukas Schmid*, Institute for Modeling and Simulation, FHS St.Gallen, University of Applied Sciences, Poststrasse 28, 9000, St.Gallen, Switzerland, lukas.schmid@fhsg.ch

Chair: *Katrin Hügel*, Institute for Modelling and Simulation, University of applied science St.Gallen, Poststrasse 28, 9001, St.Gallen, Switzerland, katrin.huegel@fhsg.ch

1 - Quality Assurance in Education — How Does the Selection of Applicants Matter?

Peter Bradl, Business Administration, University of Applied Sciences Wuerzburg-Schweinfurt, Muenzstr. 12, 97070, Wuerzburg, Germany, bradl@fh-wuerzburg.de

Education is a serious topic for countries and their public universities — and a big business for private businesses. The focus of that paper is to detect how the selection of the students should be undertaken to assure quality in schooling and finally of the graduates — in accordance with the strategy of the school. The paper deals with these issues by providing models that show dependencies between different stakeholders and tries to identify some key factors of success in education and training. Using CLD and SFD feedback behavior is modeled and critical impacts are described.

2 - Animated visualizations of structure and behavior in System Dynamics

Ricardo Sotaquira Gutierrez, Facultad de Ingenieria, Universidad de la Sabana, Campus Puente El Comun, Chia, Cundinamarca, Colombia, ricardo.sotaquira@unisabana.edu.co

Traditional visual representations of structure and behavior in System Dynamics (SD) are static. Time doesn't flow in a causal map, or even in a time graph. The user of the model has to imagine a living phenomena based on "frozen" images of structure and behavior. Inspired by the field of information visualization, we propose a new type of visual tools: SD animated diagrams. They have key differences with previous uses of animation in SD. We tested these animated diagrams with novice and expert users, and observed an improved understanding of the relationship between structure and behavior

3 - Spreading System Dynamics to SMEs by using generic structures

Katrin Hügel, Institute for Modelling and Simulation, University of applied science St.Gallen, Poststrasse 28, 9001, St.Gallen, Switzerland, katrin.huegel@fhsg.ch, *Lukas Schmid*

The implementation of SD models supporting strategic decisions in SMEs is often marred by validation problems: The availability of historical data may be limited and the views of experts often have to be challenged, as psychological studies indicate. Generic structures offer a promising solution to this, as they are capable of aggregating experience from diverse cases. The value of this approach is also suggested by evidence from engineering and the natural sciences. Moreover, practicability of generic structures is indicated by a case study conducted with 4 companies.

4 - Success Dynamics: An Application of System Dynamics to Corporate Success Logic

Lukas Schmid, Institute for Modeling and Simulation, FHS St.Gallen, University of Applied Sciences, Poststrasse 28, 9000, St.Gallen, Switzerland, lukas.schmid@fhsg.ch, *Katrin Hügel*, *Marcel Loher*

The principle of bounded rationality postulates that decision makers rely on mental models which have serious limitations. However, simulation models may complement these mental models and provide decision support. This circumstance was explored in the context of strategic management by addressing the general issue of business success. Four individual system dynamic models were developed according to the manager's conception about the corporate success logic. In order to design the modeling process more practicable an application-oriented concept was derived using generic building blocks.

■ TB-42

Tuesday, 10:40-12h00

3.1.07

Data Analysis and Decision Making

Stream: Data Mining and Applications [c]

Contributed session

Chair: *Vadim Strijov*, Computing Center of the Russian Academy of Sciences, Klara Zetkin 13-79A, 127299, Moscow, Russian Federation, strijov@ccas.ru

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

1 - Stable Group Purchasing Organizations

Greys Sasic, Marshall School of Business, University of Southern California, Bridge Hall 401, 90089, Los Angeles, CA, United States, sasic@marshall.usc.edu, Mahesh Nagarajan, Hao Zhang

GPOs exist in several sectors and benefit its members through quantity discounts and negotiation power when dealing with suppliers. However, GPOs may suffer from member dissatisfaction due to unfair allocations of the savings. We consider several allocation mechanisms and identify stable buyer alliances for them by using a dynamic stability concept. We look at discount schedules that seem to encompass a large class of practical schedules and analyze both exogenous and endogenous purchasing requirements of the members.

2 - Development of Competitive Marketing Strategy using Conjoint Analysis and Game Theory

Marija Kuzmanovic, Department for Operations Research and Statistics, Faculty of Organizational Sciences, Jove Ilica 154, 11000, Belgrade, Serbia, mari@fon.rs, Milan Martić

This paper explores the possibility of combining two well-know concepts, Nash equilibrium and Conjoint analysis, in the procedure of competitive marketing strategy development. In order to overcome the shortcomings of each concept when used individually, directions in which it is possible to combine them will be proposed. It will be shown that Conjoint data can be used either for specifying demand function in the first stage of procedure, or for pre-selection of a set of acceptable strategies, taking into account consumer preferences and their impact on market share.

3 - Ship's trajectory analysis in Lisbon harbor

João Paiva, Portuguese Naval School, Portugal, tremoceiro.paiva@marinha.pt

The purpose of this paper is to create a tool that gives port authorities information about the pattern of the maritime traffic so that they develop activities with better planning and security. The algorithm for the detection of intensity traffic zones is based on density clustering techniques. The algorithm for the anomalous trajectory detection is based in a method developed by Piciarelli, Foresti and Snidaro, they use a dynamic method for the creation of clusters, clusters will change with the allocation of new trajectories as time pass.

4 - A Neighborhood-based Clustering Validity Index

Tulin Inkaya, Industrial Engineering, Middle East Technical University, METU Industrial Engineering Department, 06531, Ankara, Turkey, tulin@ie.metu.edu.tr, Cem Iyigun

Cluster validity indices aim to find the quality of the clusters obtained by clustering algorithms. In this work, a new validity index is proposed to evaluate the clusters with arbitrary shapes. Considering the data set as a proximity graph, a neighborhood structure is defined for each point in the data set. Compactness and separation of the clusters are determined according to the dispersion of points in the neighborhoods. Performance of the proposed index is tested on various data sets.

■ TB-43

Tuesday, 10:40-12h00
8.2.02

Revenue Management III

Stream: Demand, Pricing and Revenue Management
Invited session

Chair: *Claudius Steinhardt*, Department of Analytics & Optimization, University of Augsburg, Universitätsstraße 16, 86159, Augsburg, Germany, claudius.steinhardt@wiwi.uni-augsburg.de

1 - Overbooking with last-hour voluntary standby

Leonardo Lustosa, Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro, Rua Marquês de S. Vicente, 225, Gávea, 22451-900, Rio de Janeiro, RJ, Brazil, leonardo.lustosa@gmail.com, Cristina Araneda-Fuentes

When an overbooked flight is likely to become overcrowded, some airlines offer a compensation for checking-in passengers to renounce their boarding rights and join the standby queue for a future fly. Having accepted the deal, the passenger will gain an additional compensation if not boarded on the original flight. This policy is analyzed from the airline viewpoint and compared with other frequent practices. Favorable and unfavorable conditions for adoption of this policy are commented and ways of dimensioning its parameters are presented.

2 - The pull-to-center effect in newsvendor problems — behavioral evidence from experiments with skewed demand distributions

Christian Koester, Institute of Management and Economics, Clausthal University of Technology, Julius-Albert-Straße 2, 38678, Clausthal, Niedersachsen, Germany, christian.koester@tu-clausthal.de, Heike Schenk-Mathes

Empirical research has found ordering behavior in newsvendor problems to deviate from theoretical predictions. We present an experimental study of a simple supplier-retailer wholesale price contract facing a skewed distribution of market demand. This modification of related research, that almost exclusively uses uniformly distributed market demand, explores if the commonly found "pull-to-center" effect is present in more complex ordering scenarios. We furthermore examine the validity of the currently most discussed explanatory theories of the observed inventory behavior.

3 - Dynamic pricing and Efficient Management of Repairs and Provisions Resources

Rupal Rana, Business School, Warwick University, University of Warwick, cv4 7al, coventry, United Kingdom, Rupal.rana06@phd.wbs.ac.uk, Fernando Oliveira

We analyse a problem faced by a telecommunication company who manage a free repair service and paid for service provision service. We analyze the allocation of teams to Provisions and Repairs and its relationship with demand cycles. This is a problem in which two products are interdependent (as they share the same resource) and in which one of the products is free (repairs) but subject to regulatory constraints, and the other product (provisions) can be priced dynamically. The importance of this article arises from the ability of the proposed algorithm to address the interactions between regulation and dynamic pricing. Our main objective is to improve the allocation of resources so that we can increase profits and, at the same time, keep the lead times under acceptable levels of quality. We attempt to improve the management of demand through dynamic pricing using reinforcement and the management of resources through the schedule of work team members and overtime work in the most efficient way. We have shown that, even in such an industry, the pricing policy can be used both to reduce the consumption of resources, to improve consumers' welfare and increase the companies revenue.

■ TB-44

Tuesday, 10:40-12h00
8.2.03

Simulation Decision Support in Enterprises

Stream: Simulation Based Decision Support
Invited session

Chair: *Mirosljub Kljajic*, Faculty for organizational sciences, University of Maribor, Kidriceva cesta 55, 4000, Kranj, Slovenia, mirosljub.kljajic@fov.uni-mb.si

1 - Simulation Based Decision Support System for Inventory Control with Stochastic Lead Time and Demand

Davorin Kofjac, Laboratory of Cybernetics and DSS, University of Maribor, Faculty of Organizational Sciences, Kidriceva cesta 55a, 4000, Kranj, Slovenia, davorin.kofjac@fov.uni-mb.si, Mirosljub Kljajic, Valter Rejec

This article describes web based decision support system for inventory optimization for products with stochastic lead time and demand. To ensure the real time inventory optimization the optimization core was implemented with C# programming language while the web based graphical interface was implemented with PHP. Several inventory control algorithms were analyzed with a goal of producing lower total inventory control costs than the actual costs provided by the observed company. Web based solution was utilized for predictive validation of algorithms in the real environment.

2 - Approach to determination of manpower transition strategies — modeling, problems and methods

Andrej Skraba, Faculty of Organizational Sciences, University of Maribor, Kidriceva cesta 55a, 4000, Kranj, Slovenia, slovenia, andrej.skraba@fov.uni-mb.si, Mirosljub Kljajic, Davorin Kofjac

Proposed paper will address modeling of strictly hierarchical transition system of human resources, which is generally applicable for transitions between particular job ranks, where only sequential transitions are allowed. The model will be represented in the form of state space and system dynamics. The problem of the oscillations in several optimization approaches will be presented. Determination of optimal strategies will be addressed, which define the transitions between particular ranks.

3 - The simulation model for agricultural policy decision making with respect to organic agriculture

Črtomir Rozman, Chair of Agricultural Economics and Rural Development, University of Maribor, Faculty of Agriculture and Life Sciences, Pivola 10, SI 2311 Hoce, -, Slovenia, crtomirrozman1@gmail.com, Pazez Karmen, Miroljub Kljajic, Andrej Skraba

Proposed paper will address the development of a system dynamic simulation model. Model will be used by agricultural policy makers for organic farming development. The model will incorporate main variables and feedback loops influencing the organic farming system relevant for strategic plan of sustainable development of organic farming. Simulation model will be used for simulation of different policy scenarios for organic farming and their impact on economic and environmental parameters of organic production at an aggregate level. Developed platform will also include sensitivity analysis.

■ TB-45

Tuesday, 10:40-12h00

8.2.12

Restricted and Unrestricted Clustering

Stream: Geometric Clustering

Invited session

Chair: Peter Gritzmann, Mathematics, TU München, Arcisstr. 21, D-80290, Munich, Germany, gritzman@ma.tum.de

Chair: Andreas Brieden, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85579, Neubiberg, Germany, andreas.brieden@unibw.de

1 - On clustering bodies and their applications

Peter Gritzmann, Mathematics, TU München, Arcisstr. 21, D-80290, Munich, Germany, gritzman@ma.tum.de, Andreas Brieden

We study convex sets that occur naturally in geometric clustering, our prime application being the consolidation of farmland. While the underlying convex optimization problems are NP-hard, polynomial-time approximation algorithms can be devised whenever appropriate polyhedral approximations of their related clustering bodies are available. We give various structural results that lead to tight approximations and report on their practical applications.

2 - Data Classification by Cell Decompositions

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

The characterization of the vertices of a special polytope yields a combinatorial optimization approach to data classification: For a given geometric training set X and fixed cluster sizes, we can efficiently calculate a k -clustering of X and a full cell decomposition of the geometric space so that each cluster lies in its own cell. Having such a cell decomposition leads to intuitive and efficient operations for the classification of new data points and the prediction of data values.

3 - Partition problems: Optimality and Clustering

Uriel G. Rothblum, Industrial Engineering and Mgt., Technion, Technion City, 32000, Haifa, Israel, rothblum@ie.technion.ac.il

Partition problems constitute a large class of combinatorial optimization problems. Of particular interest are problems where it is possible to restrict attention to solutions that exhibit clustering properties, facilitating the solution of the partition problem in polynomial time. The talk will introduce a classification of partition problem and survey of numerous approaches to solve such problems by focusing on partitions that exhibit clustering properties. The main technique concern the study of vertices of corresponding partition polytopes.

4 - Minimizing risk and costs - two applications of geometric clustering

Andreas Brieden, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85579, Neubiberg, Germany, andreas.brieden@unibw.de, Peter Gritzmann

Finding risk adequate premiums in insurance and determining a best reallocation of farming lots seem to be completely different tasks. This talk demonstrates that both problems can be attacked by geometric clustering and also reports on a software especially designed for applying cluster optimization in practice.

■ TB-46

Tuesday, 10:40-12h00

8.2.14

Agent-Based Modeling of Electricity Markets

Stream: Agent-Based Modeling

Invited session

Chair: Massimo Genoese, Institute for Industrial Production, University of Karlsruhe, Hertzstraße 16, 76187, Karlsruhe, Germany, massimo.genoese@kit.edu

1 - Are agent-based simulations robust? The wholesale electricity trading case

Augusto Rupérez Micola, Business and Economics, Universitat Pompeu Fabra, Ciutadella Campus, Ramón Trías Fargas 25, 08005, Barcelona, Spain, augusto.ruperezmicola@gmail.com, Albert Banal-Estanol

Agent-based computational economics is becoming widely used in practice and this paper explores the consistency of some of its standard techniques. As a particular case, we focus on prevailing wholesale electricity trading simulation methods. We include different supply and demand representations and propose Experience Weighted Attractions to include several behavioral algorithms. We compare the results across assumptions and to economic theory predictions. The match is good under best-response and reinforcement learning but not under fictitious play. The simulations perform well under flat and upward sloping supply bidding, and also for plausible demand elasticity assumptions. Learning is influenced by the number of bids per plant and the initial conditions. The overall conclusion is that agent-based simulation assumptions are far from innocuous. We link their performance to underlying features, and identify those that are better suited to wholesale electricity markets.

2 - An Agent-Based Model of the Relationship between Forward and Spot Electricity Markets

Fernando Oliveira, Operations Management, ESSEC Business School, Cergy, France, oliveira@essec.fr

An important research topic in electricity markets is the relationship between forward and spot markets. We present an evolutionary model that we use to test the stability of the different strategies available for the agents regarding generation quantity and forward trading, taking into account uncertainty. We test under which conditions the trading models are robust under learning and under which conditions they fail to converge to equilibrium. In this model the agents learn by exploring the environment, by trial and error, in order to improve their profit.

3 - Agent-based participatory simulation of the German electricity market

Massimo Genoese, Institute for Industrial Production, University of Karlsruhe, Hertzstraße 16, 76187, Karlsruhe, Germany, massimo.genoese@kit.edu, Dominik Möst, Wolf Fichtner

We modify an existing agent-based simulation model for the German electricity market to integrate real participants into the decision process of the model. This is proposed as agent-based participatory simulation (Guyot and Honiden, 2006). In the simulation, a spot market for electricity is modelled, where real participants trade representing electricity generation companies. The bids for the electricity demand is inelastic and generated by the software agents. The participants have information about demand, outages, a price forecast for electricity, and fuel and certificate prices.

■ TB-47

Tuesday, 10:40-12h00

8.2.16

Stochastic Models for Service Operations I

Stream: Stochastic Models for Service Operations

Invited session

Chair: *Giorgio Romanin-Jacur*, Management and Engineering, University of Padova, Stradella San Nicola, 3, 36100, Vicenza, Italy, romjac@dei.unipd.it

1 - A location model for planning hospital networks under uncertain demand

Ana Mestre, Departamento de Engenharia e Gestão, Instituto Superior Técnico, Av. Rovisco Pais, 1, 1049-001, Lisboa, Portugal, anamestre@ist.utl.pt, *Mónica Oliveira, Ana Paula Barbósa-Póvoa*

Location models have been widely used to support hospital network planning where decisions like opening/closing facilities are usually driven by demand. Future demand for hospital services is hard to predict since it depends on several uncertain parameters, such as on demographic projections, utilization rates and technological changes. Therefore uncertainty should be considered. This study proposes a stochastic hierarchical, multiservice and multiperiod location model that aims to improve equity within a National Health Service structure and explicitly includes future demand scenarios.

2 - Pediatric palliative care network organization

Giorgio Romanin-Jacur, Management and Engineering, University of Padova, Stradella San Nicola, 3, 36100, Vicenza, Italy, romjac@dei.unipd.it, *Giada Aspergh, Paola Facchin, Anna Ferrante, Laura Visona_Dalla_Pozza*

Pediatric palliative patients are children suffering for incurable pathologies. They present a wide pathologies spectrum, a large lifetime distribution and frequent changes in their conditions. The assistance aims at obtaining a clinical equilibrium permitting an acceptable life, utilizing hospital and territorial (medical and social) structures. We build up a simulation model describing patients' movements among the structures, also in case of evolving assistance organization; it evidences lacks in satisfying requests and competitions for hospital admissions with ordinary patients.

3 - Quality and Efficiency Tradeoff in Systems with Flexible Workforce

Eser Kirkizlar, School of Management, State University of New York - Binghamton, PO Box 6000, School of Management, 13902, Vestal, New York, United States, eser@binghamton.edu, *Sigrun Andradottir, Hayriye Ayhan*

We consider a tandem system with flexible servers and exponential service times. We study the effective dynamic assignment of servers to stations with the objective of maximizing the long-run average profit. We assume that a revenue is earned each time a job is completed and that the quality of service is inversely proportional to the time a job spends in the system (we capture this deterioration in quality with a positive holding cost). We determine the optimal server assignment policy for small systems and provide effective server assignment heuristics for larger systems.

4 - Investigating whether it is optimal to make replenishments simultaneously in a dual source model

Soheil Abginehchi, Business Studies, CORAL, Aarhus School of Business, Aarhus University, Fuglesangs Allé 4, DK-8210, Aarhus V, Denmark, soha@asb.dk, *Christian Larsen*

In multiple sourcing, when supplier lead times are stochastic it makes sense to split any replenishment order into several smaller orders to pool lead time risks. In literature it is always assumed these orders are issued simultaneously to the suppliers. Here we let this simultaneousness assumption be relaxed. We study a dual source system with non-identical suppliers and model the problem as a semi-Markov decision model, allowing the decision maker the choice whether he will simultaneously issue two orders to both suppliers or he will issue the orders to suppliers at two different times.

■ TB-48

Tuesday, 10:40-12h00

8.2.04

Heuristics 2

Stream: Nonlinear Programming

Invited session

Chair: *Ana Maria A.C. Rocha*, Production and Systems, University of Minho, Campus de Gualtar, 4710-057, Braga, Portugal, arocha@dps.uminho.pt

1 - Modified differential evolution for nonlinear global optimization

Md. Abul Kalam Azad, Algoritmi R&D Center, University of Minho, Portugal, School of Engineering, Campus de Gualtar, 4710-057, Braga, Braga, Portugal, akazad@dps.uminho.pt, *Edite M.G.P. Fernandes*

Many real world optimization problems can be described only by nonlinear relationships, which introduce the possibility of multiple local minima. The task of global optimization is to find a point where the objective function obtains its smallest value. Differential evolution is a population based heuristic approach that has been shown to be very efficient for solving bound constrained nonlinear problems. To handle general constraints, we propose a modified differential evolution based on a constraint fitness priority-based ranking method. We test our method with a benchmark set of problems.

2 - Heuristic and Exact Approaches to the Pipeline Network Design Problem

Gustavo Dias, PEP, COPPE/UFRJ, Rua General Severiano, 209/302, Botafogo, 2290-040, Rio de Janeiro, Rio de Janeiro, Brazil, dias.silva@gmail.com, *Laura Bahiense, Virgílio José Martins Ferreira Filho*

This paper presents computational tools to support technical and economic evaluation of building pipe networks to transport fuel. The combinatorial nature of the network design problem coupled with the non-linear equations ruling flow energy balance in pipes lead to convex and non-convex MINLP problems. These programs are solved through reformulated linear relaxations generated mainly by the RLT methodology, heuristic ad hoc algorithms and an exact OA algorithm. Experiments were conducted with five pseudo-real instances to assess robustness and efficiency of the proposed solution approaches.

3 - EXACT AND HEURISTIC APPROACHES FOR MINLPs IN PRODUCTION PLANNING OF OIL REFINING

Ormeu Coelho, COPPE-Production Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Bloco F, Sala 103, Cidade Universitária, Ilha do Fundão, 21945-970, Rio de Janeiro, Rio de Janeiro, Brazil, ormeucoelho@gmail.com, *Laura Bahiense, Virgílio José Martins Ferreira Filho*

In the present work we present exact and heuristic approaches to solve a problem of production planning of oil refining arising in two Brazilian refineries. The problem is formulated as non-convex MINLP in which discrete decisions are related to the selection of operational modes and the use of additional oil quantities. Computational experiments are conducted with real instances taken from these refineries. They are solved exactly by Spatial Branch-and-Bound. The heuristic solutions are obtained with Outer Approximation and Feasibility Pump, and improvements were possible via Local Branching.

4 - A Genetic Algorithm for Stabilization of a Quadruped Robot Locomotion

Lino Costa, Dept. Production and Systems, University of Minho, School of Engineering, Campus de Gualtar, 4710-057, Braga, Portugal, lac@dps.uminho.pt, *Ana Maria A.C. Rocha, Cristina Peixoto Santos*

An optimization approach for the locomotion gaits stabilization of quadruped walking robots is presented. To model the locomotion of the robot dog, a motion architecture based on CPGs oscillators is used. The optimization problem addressed has seven decision variables concerning the amplitude, offsets and knee angles. The main goal is to minimize the body vibration, maximize the velocity and the wide stability margin through genetic algorithms. Several experimental results show the effectiveness of this proposed approach.

Tuesday, 12:20-13:40

■ TC-01

Tuesday, 12:20-13:40

Aula Magna

Keynote Talk 7

Stream: Keynote Speakers

Invited session

Chair: *Denis Bouyssou*, Université Paris Dauphine, CNRS-LAMSADE, Place du maréchal de Lattre de Tassigny, 75775, Paris Cedex 16, France, bouyssou@lamsade.dauphine.fr

1 - Bilevel programming and price optimization problems

Martine Labbé, computer Science, Université Libre de Bruxelles, CP210/01, Boulevard du Triomphe, 1050, Bruxelles, Belgium, mlabbe@ulb.ac.be

Consider a general pricing model involving two levels of decision-making. The upper level (leader) imposes prices on a specified set of goods or services while the lower level (follower) optimizes its own objective function, taking into account the pricing scheme of the leader. This model belongs to the class of bilevel optimization problems where both objective functions are bilinear. In this talk, we review this class of hierarchical problems from both theoretical and algorithmic points of view and then focus on two special cases. In the first one, tolls must be determined on a specified subset of arcs of a multicommodity transportation network. In this context the leader corresponds to the profit-maximizing owner of the network, and the follower to users travelling between nodes of the network. The users are assigned to shortest paths with respect to a generalized cost equal to the sum of the actual cost of travel plus a money equivalent of travel time. The second case consists in determining optimal prices for bundles of products given that each customer will buy the bundle that maximizes her/his own utility function. Among others, we present complexity results, identify some polynomial cases and propose mixed integer linear formulations for those pricing problem.

■ TC-02

Tuesday, 12:20-13:40

3.2.14

Cooperative Games and Combinatorial Optimization

Stream: Combinatorial Optimization

Invited session

Chair: *Nelson Uhan*, School of Industrial Engineering, Purdue University, 315 N. Grant Street, Grissom Hall 262, 47907, West Lafayette, Indiana, United States, nuhan@purdue.edu

1 - cooperative games and fractional programming

Walter Kern, Applied Math, Twente University, P.O. Box 217, 7500 AE, Enschede, Netherlands, kern@math.utwente.nl, *Xian Qiu*

Straightforward analysis of the so-called epsilon-core of cooperative games leads to certain fractional optimization problems which are usually difficult and largely unexplored in the mathematical programming community. We focus on two interesting special cases (TSP and bin packing) and investigate complexity/approximation issues.

2 - Optimal and fair partitions in additively separable hedonic games

Haris Aziz, Computer Science, LMU Munich, Theoretical Computer Science, Oettingenstr. 67, 80538, Munich, Bavaria, Germany, haris.aziz@gmail.com, *Felix Brandt*, *Hans Georg Seedig*

We study a natural succinct representation of hedonic coalition formation games known as additively separable hedonic games. Among other results, we show that computing a partition with the maximum egalitarian or utilitarian social welfare is NP-hard. We also show that verifying whether a given partition is Pareto optimal is NP-hard even for symmetric preferences. In contrast, we present a simple algorithm to compute a Pareto optimal partition when preferences satisfy certain mild conditions.

3 - Cost Sharing for Economic Lot-Sizing Problems with Remanufacturing Options

Nelson Uhan, School of Industrial Engineering, Purdue University, 315 N. Grant Street, Grissom Hall 262, 47907, West Lafayette, Indiana, United States, nuhan@purdue.edu, *Mohan Gopaladesikan*

We consider a class of cooperative games that model the cost sharing issues that arise from the economic lot-sizing problem with remanufacturing options. By investigating the properties of various mathematical programming formulations and relaxations for the underlying lot-sizing problem, we obtain some insights into the existence of cost allocations in the core and the approximate core of these games, as well as the algorithmic aspects of computing such cost allocations.

■ TC-03

Tuesday, 12:20-13:40

3.2.15

Inventory and routing problems

Stream: Metaheuristics

Invited session

Chair: *Yury Kochetov*, Information Technology Department, Novosibirsk State University, Pirogova str., 2, 630090, Novosibirsk, Russian Federation, jkochet@math.nsc.ru

Chair: *Jonata Araujo*, Master Program in Applied Informatics, University of Fortaleza, Av. Washington Soares, 1321, 60811-905, Fortaleza, CE, Brazil, ljonata@gmail.com

1 - A deterministic annealing algorithm for the simultaneous routing of loaded and empty container movements

Kris Braekers, Transportation Research Institute (IMOB), Hasselt University, Universiteit Hasselt, campus Diepenbeek, Wetenschapspark — gebouw 5, 3590, Diepenbeek, Belgium, kris.braekers@uhasselt.be, *Gerrit Janssens*, *An Caris*

Our problem is to create efficient vehicle routes fulfilling both loaded and empty container transport requests. Based on demand and supply, optimal empty container allocations are determined by an allocation model. The resulting problem is a full truckload pickup and delivery problem with time windows. An initial solution is obtained by a parallel insertion heuristic. After finding a local optimum, several local search operators are embedded in a deterministic annealing algorithm to improve the solution. Results show that we are able to find good solutions in a small amount of time.

2 - An Iterated Local Search to solve a Multiobjective Integrated Distribution Problem

Helena Ramalhinho Lourenço, Departamento de Economía y Empresa, Universitat Pompeu Fabra, R. Trias Fargas 25-27, 08005, Barcelona, Spain, helena.ramalhinho@upf.edu, *Angel A. Juan*, *Rita Ribeiro*

The problems arising in the logistics of commercial distribution are complex and involve several players and decision levels. One important decision is the design of the routes to distribute the products, in an efficient and inexpensive way. This article studies a multi-objective multi-period routing model with two objectives. The first one is the minimization of the total distance of the routes and second one is related with strategies that tight relationships with customers, by having the same driver delivered to the same customers along several periods. We propose a metaheuristic based on the Iterated Local Search to solve this problem. Results of the computational experiment are reported.

■ TC-04

Tuesday, 12:20-13:40

3.2.13

Industrial and city problems

Stream: Metaheuristics

Invited session

Chair: *Luc Muyltermans*, Business School, Nottingham University, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, luc.muyltermans@nottingham.ac.uk

Chair: *Christophe Duhamel*, LIMOS, Université Blaise Pascal, campus des Cézeaux, 63173, Aubière, France, christophe.duhamel@isima.fr

1 - Co-collection and postponement strategies: a kerbside household waste collection case study

Gu Pang, Newcastle Business School, Northumbria University, City Campus East, NE8 1ST, Newcastle Upon Tyne, United Kingdom, g.pang@northumbria.ac.uk, *Luc Muyltermans*

We study co-collection and postponement strategies and their impact on the total routing distance in Beeston, UK. Our aim is to provide the Waste Collection Authorities with a broader understanding of the collection alternatives that may improve routing efficiency. The collection options are modelled as Single and Multi-Compartment Capacitated Arc Routing Problems. A Guided Local Search metaheuristic was developed to solve the problems. The results suggest that significant reductions in routing distance are possible when co-collection and/or postponement strategies are applied.

2 - Ants solve the Integrated Vehicle and Crew Scheduling Problem in the public urban bus system of Ljubljana, Slovenia

David Pas, Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaska 8, 6000, Koper, Slovenia, david.pas@student.upr.si, *Balazs David*, *Jozsef Bekesi*, *Miklos Kresz*, *Andrej Brodnik*

We will present a new and unconventional approach to the important integrated vehicle and driver scheduling problem in the public urban bus transit that is based on ACO. Although the predominant technique for that problem is the Lagrangian relaxation with column generation it is known to be inflexible in modeling real world constraints and to incur long computational times. The ACO meta-heuristic has been applied to real-world data provided by the public bus companies in Ljubljana (Slovenia) and Szeged (Hungary). Moreover, we will evaluate the potential gain from parallelization.

3 - Heuristics for the mobile oil recovery problem

Christophe Duhamel, LIMOS, Université Blaise Pascal, campus des Cézeaux, 63173, Aubière, France, christophe.duhamel@isima.fr, *Joan-Manuel Ortega-Ardila*, *Andréa C. Santos*

The Mobile Oil Recovery Problem consists in organizing a fleet of vehicles to collect the maximal amount of oil on a field in a working day. This problem generalizes the VRP and thus it is NP-hard. The total travelled distance has to be minimized as a secondary criteria. We propose several heuristics to build feasible solutions. A VND-like local search is also defined. It uses add/drop moves and some k-opt moves. The VND is embedded into a VNS metaheuristic and a GRASP. The efficiency of both approaches is compared on real-size instances.

4 - Solving the bus network design problem for the suburban area in Hong Kong by a Hybrid Genetic Algorithm

Wai Yuen Szeto, Department of Civil Engineering, University of Hong Kong, Department of Civil Engineering, University of Hong Kong, 000, HK, HK, Hong Kong, ceszeto@hku.hk, *Yongzhong Wu*, *S.c. Wong*

This paper proposes a hybrid genetic algorithm to solve the bus network design problem for the suburban area in Hong Kong with the objective of improving the number of transfers and total travel time of passengers. In the proposed algorithm, a genetic algorithm is used to tackle the route design problem and a neighborhood search heuristic is used to tackle the frequency setting problem. A new representation scheme and specific genetic operators are also developed. The proposed method reduces the number of transfers and total travel time by 20.6% and 7.0%, respectively

■ TC-05

Tuesday, 12:20-13:40

3.2.16

Location under uncertainty

Stream: Location Analysis

Invited session

Chair: *Laureano Fernando Escudero*, Dept. de Estadística e Investigación Operativa, Universidad Rey Juan Carlos, c/Tulipan, S/n, 28933, Mostoles (Madrid), Spain, laureano.escudero@urjc.es

1 - On the solving the multi-period location problem under uncertainty

Antonio Alonso-Ayuso, Statistics & Operations Research Department, Rey Juan Carlos University, c/Tulipan s/n, 28933, Mostoles, Madrid, Spain, antonio.alonso@urjc.es, *Maria Albareda Sambola*, *Laureano Fernando Escudero*, *Elena Fernandez*, *Celeste Pizarro Romero*

We present a framework for solving the strategic problem of timing the location of facilities and customers assignment in a multi-period environment under uncertainty in the setup and maintenance costs, customers assignment cost, and the periods at which each customer has demand, among others. By considering a compact representation of the Deterministic Equivalent Model, we specialize the so-called Branch-and-Fix Coordination algorithm. Computational experience is reported.

2 - A stochastic location problem of k-centers on graph

Biljana Panic, Faculty of Organizational Sciences, Belgrade, Serbia, bilja@fon.rs, *Mirko Vujosevic*, *Ognjen Pantelic*, *Tamara Valok*

While most of location models have deterministic inputs, there are a lot of problems with stochastic nature of parameters. An original stochastic k-center location problem is presented in the paper. At the beginning, node reliability, i.e. the reliability of covering a node from k centers is defined. A new algorithm is proposed to calculate this reliability. The optimization problem is to maximize the defined criterion function as minimal node reliability.

3 - Stochastic Set Packing Problem

Laureano Fernando Escudero, Dept. de Estadística e Investigación Operativa, Universidad Rey Juan Carlos, c/Tulipan, S/n, 28933, Mostoles (Madrid), Spain, laureano.escudero@urjc.es, *Mercedes Landete*, *Antonio Manuel Rodríguez-Chía*

The Set Packing Problem (SPP) under uncertainty studied via scenario analysis. A maximization of a composite function of the expected value minus the weighted excess probability is performed. The splitting variable representation is decomposed by dualizing the nonanticipativity constraints that link the deterministic SPP with a 0-1 knapsack problem for each scenario under consideration. The Lagrange multipliers updating is performed by using the Volume Algorithm.

4 - On the location of Lottery Terminals in Spain

Daniel Serra, Economics and Business, Universitat Pompeu Fabra, Trias Fargas 25-27, 08005, Barcelona, Spain, daniel.serra@upf.edu

In this paper we study the location of new lottery terminals in Spain. Actually, more than 14.000 terminals are already located, but the model presented here aims at finding new market "niches" to open new outlets, considering to minimize the impact on the income of existing ones, and taking into account the buying power of the catchment area of each outlet. An integer formulation is presented, together with some results.

■ TC-06

Tuesday, 12:20-13:40

8.2.30

DEA Application II - Education

Stream: DEA and Performance Measurement

Invited session

Chair: *Maria Portela*, Rua Diogo Botelho, 1327, 4169- 005 Porto, Porto, Portugal, csilva@porto.ucp.pt

1 - Efficiency evaluation of distance education in Rio de Janeiro

João Carlos Soares de Mello, Engenharia de Produção, Universidade Federal Fluminense, Rua Passo da Pátria 156, São Domingos, 24240310, Rio de Janeiro, RJ, Brazil, jcsmello@pesquisador.cnpq.br, *Fernando do Valle Silva Andrade*, *Luana Carneiro Brandão*, *Lidia Angulo-Meza*

This work quantitatively evaluates the Undergraduate Distance Educational Centre of Rio de Janeiro (CEDERJ). Preliminarily, we use basic Data Envelopment Analyses (DEA) in order to have its results as a reference. Then, we cluster the different poles into homogeneous groups and use advanced evaluation models for each one of them and therefore obtain more suitable benchmarks than when using basic DEA. Finally, we consider all of the centres together using Non Homogeneous Decision Making Units techniques.

2 - Efficiency Evaluation of Private teaching Institutions by Data Envelopment Analysis

Abdullah Korkut Üstün, Industrial Engineering, Eskisehir Osmangazi University, Eskisehir Osmangazi Universitesi Endüstri Mühendisliği Bölümü, 26030, Eskisehir, Turkey, korkut.ustun@gmail.com, *Ezgi Aktar Demirtas*

Data envelopment analysis (DEA) is a technique that measures the relative efficiencies of decision making units. In this study, we try to determine the efficiency scores of private teaching institutions in a city in Turkey. We also determine the sources of inefficiency in these institutions.

3 - Comparative Performance of Public Universities in Malaysia Using Data Envelopment Analysis

Wan Rohaida Wan Husain, Warwick Business School, The University of Warwick, Warwick Business School, The University of Warwick, CV4 7AL, Coventry, United Kingdom, W.R.Wan-Husain@warwick.ac.uk

This paper presents a study into the performance of public universities in Malaysia. The current research involves a small sample of twenty public universities in Malaysia, yet six variables have been identified as relevant inputs and outputs. This raises a concern of the discriminatory power of DEA assessment. We overcome the problem of the small sample size by combining two approaches. First, we use the hybrid returns-to-scale (HRS) model that allows us to combine the features of both CRS and VRS models in one formulation and achieve a significant improvement in discrimination compared to the standard VRS model. Second, we enrich the HRS model by the use of weight restrictions. The latter are constructed using the trade-off approach which preserves the technological meaning of our DEA model.

4 - Performance assessment of Portuguese secondary schools

Maria Portela, Rua Diogo Botelho, 1327, 4169- 005 Porto, Porto, Portugal, csilva@porto.ucp.pt, *Ana Camanho*, *Diogo Borges*

This paper describes a performance assessment of Portuguese secondary schools using data envelopment analysis. Schools are assessed through a value added perspective, where average grades on exit of secondary education are contextualised by average grades on entry on secondary education. An assessment of all Portuguese secondary schools was undertaken showing best performers and worst performers. Assurance regions were used to prevent unreasonable weighting schemes of exam average grades on exit (output weights were linked to the number of exams of the school in each course).

■ TC-07

Tuesday, 12:20-13:40

8.2.47

DEA - General topics II

Stream: DEA and Performance Measurement

Invited session

Chair: *Dimitris Despotis*, Department of Informatics, University of Piraeus, 80, Karaoli & Dimitriou Street, 18534, Piraeus, Greece, despotis@unipi.gr

1 - Using FDH technology to determine anchor points in DEA

Abolfazl Keshvari, Math, IUST, Iran, Islamic Republic Of, abkeshvari@gmail.com, *Mohammad Reza Alirezaee*

We present a new algorithm to determine anchor points in VRS DEA by using FDH model. In this algorithm, we use FDH instead of regular VRS model; and because FDH models can be solved by the enumeration method, the entire process will be much faster and simpler. Also, we discuss problems without inputs or outputs. In these problems, all extreme efficient DMUs are anchor points and we can determine anchor points by use of FDH model. Also, we present a comparison of algorithm in Bounol and Dula (2009) and the proposed algorithm and show that the proposed algorithm requires fewer computations.

2 - A Performance Study on Business Centers of Chunghwa Post Company in Taiwan

Chin-Piao Lin, Department of Management, Fo Guang University, 26247, Yilan, natureosho@gmail.com, *Shinn Sun*

The purpose of this paper is to assess m The purpose of this paper is to evaluate the performance of 23 practiced business responsibility centers of Chunghwa Post Company in Taiwan over the years of 2003 to 2008. Overall performance, service performance and productivity growth of the 13 centers are examined. The important remarks regarding center performance are concluded.

3 - Congestion in stochastic data envelopment analysis: An input relaxation approach

Luka Neralic, Faculty of Economics and Business, University of Zagreb, J. F. Kennedy 6, Stefaniceva 7, 10000, Zagreb, Croatia, lneralic@efzg.hr

The input relaxation model and its stochastic version, recently introduced in Data Envelopment Analysis (DEA) literature, uses more flexibility in changes of the used input combination to find maximum possible output and can be useful to resource management. We study congestion issues in this setting. Deterministic equivalent to the stochastic congestion model is obtained. The deterministic equivalent is typically non-linear. It is, however, shown that under fairly general conditions this non-linear model can be replaced by an ordinary deterministic DEA model. When allowable limits of data variations for evaluating decision making unit is permitted, sensitivity analysis is studied.

4 - Banknote Printing at Modern Central Banking: Trends, Costs and Efficiency

Miguel Sarmiento, International and Monetary Affairs Division, Central Bank of Colombia, Carrera 11B # 119-36 Apto 302, 4152, Bogota, Colombia, nsarmipa@banrep.gov.co

This paper examines trends in banknote printing during the 2000-2005 period for a cross-section of 56 central banks. A cost function using a panel data model with random effects was estimated. Based on these results, a DEA model was used to measure technical cost efficiency and changes in productivity. It was found that the technical efficiency of most central banks increased during the period, especially when the private sector became involved. The Malmquist Index showed a moderate increase in productivity, mainly due to increases in scale efficiency rather than technical change.

■ TC-08

Tuesday, 12:20-13:40

6.1.36

Production Scheduling

Stream: Project Management and Scheduling

Invited session

Chair: *Dirk Briskorn*, Department for Supply Chain Management and Operations Management, University of Cologne, Albertus-Magnus-Platz, 50923, Köln, Germany, briskorn@wiso.uni-koeln.de

1 - Yield vs. Flow-Time Tradeoff in a Production System

Israel Tirkel, Industrial Engineering & Management, Ben-Gurion University, 8/3 Ha'Zamir St., 90805, Mevasset Zion, tirkel@bgu.ac.il, *Gad Rabinowitz*

Modern industry struggles with Yield and Flow-Time (FT) tradeoff due to their impact on profit, but considers them separately. Our study originates in semi-conductors but applies to other industries. Analytical and simulation models are developed to investigate the impact of inspections on Yield and FT in a deteriorating production system. Results indicate Yield and FT increase with growing inspection rate until Yield reaches a maximum and starts to decline, while FT continues to increase. Decision support tool is provided for applying inspections while simultaneously considering Yield and FT.

2 - Rolling stock maintenance planning

Francis Sourd, Innovation & Research, SNCF, Paris, France, francis.sourd@sncf.fr, Mathilde Carlier, Raphaël Even

Rolling stock maintenance consists of a series of periodic operations that are to be scheduled with respect to maximal time-lags. In order to optimize maintenance costs, each operation must be scheduled as late as possible. In order to model real-life problems, we use a resource consumption model derived from the resource-constrained scheduling problem (RCPSp) and a generic representation of the maintenance cycles. The model is solved with a heuristic algorithm which is based on a large neighborhood search.

3 - Scheduling flexible maintenance activities on a single machine

Dirk Briskorn, Department for Supply Chain Management and Operations Management, University of Cologne, Albertus-Magnus-Platz, 50923, Köln, Germany, briskorn@wiso.uni-koeln.de, Stefan Bock, Andrei Horbach

We focus on single machine scheduling subject to machine deterioration. The maintenance level specifies the machine's current maintenance state. While jobs are processed the maintenance level drops by a certain — possibly job-dependent — amount. A maintenance level of less than zero is associated with the machine failure. Consequently, scheduling maintenance activities that raise the maintenance level may become necessary in order to prevent maintenance level becoming negative. We present complexity results and approaches considering two types of maintenance activities.

■ TC-09

Tuesday, 12:20-13:40

6.2.53

Mathematical Programming, Machine and Statistical Learning

Stream: Mathematical Programming

Invited session

Chair: Tamas Terlaky, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

1 - On the Rescaling Algorithms for Linear Optimization

Tamas Terlaky, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu, Dan Li

The perceptron algorithm is not a polynomial time algorithm to solve linear inequality systems, but Dunagan/Vempala showed that with high probability the largest inscribed ball can be inflated sufficiently to reach polynomial solvability. We extend the rescaling idea used to improve the complexity of the von Neumann algorithm, herewith opening the road to improve the complexity of the colourful feasibility problem. Various properties and parallelizability of the re-scaling phase are analyzed, too.

2 - Comparison of Performance of All-together Support Vector Machines for Multiclass Classification

Keiji Tatsumi, Division of Electrical, Electronic and Information Engineering, Osaka University, Yamada-Oka 2-1, 565-0871, Suita, Osaka, Japan, tatsumi@eei.eng.osaka-u.ac.jp, Tetsuzo Tanino

In this paper, we focus on a new all-together method of support vector machines (SVMs) for multiclass classification called multiclass multiobjective SVM (MMSVM), which maximizes geometric margins in the sense of multi-objective optimization. However, all of its many Pareto solutions are not guaranteed to have high generalization ability, and it is not known what kind of classifier each Pareto solution corresponds to. Thus, through numerical experiments, we compare solutions obtained by MMSVM and other methods with respect to geometric margins and generalization.

3 - On the Incomplete Oblique Projections Method for Solving Box Constrained Least Squares Problems

Hugo Scolnik, Computer Science, University of Buenos Aires, Ciudad Universitaria, Pabellon I, 1428, Buenos Aires, Argentina, hscolnik@gmail.com

This paper aims to extend the applicability of the IOP algorithm (Scolnik, Echebest, Guardarucci, Vacchino) for solving inconsistent linear systems to the box constrained case which arise in many important applications and optimization problems. The new algorithm employs incomplete projections onto the set of solutions of the augmented system $Ax-r=b$, together with box constraints. Convergence is analyzed and numerical experiments are presented comparing its performance with some well-known methods.

4 - Gaussian kernel models for irregular demand processes

José Luís Carmo, CIO and University of Algarve, Portugal, jlcarmo@ualg.pt, Antonio Rodrigues

This work focuses on the study of forecasting problems and optimal decision making, in the context of inventory management, given irregularly observed demand processes. We propose adaptive models based on gaussian kernels, either for point forecasting, or for density forecasting, of the time of occurrence and the magnitude of future demand. Optimal decisions, under asymmetric cost functions, are derived from quantiles computed from the density forecasts. We produce encouraging empirical results of this approach, tested with both simulated and real irregularly spaced time series.

■ TC-10

Tuesday, 12:20-13:40

6.2.56

Graphs and Networks VIII

Stream: Graphs and Networks

Invited session

Chair: Bernard Ries, Warwick Business School, University of Warwick, CV4 7AL, Coventry, Switzerland, Bernard.Ries@wbs.ac.uk

1 - 11 Methods for proving infeasibility of IP's.

Anastasia Kouvela, Operational Research, London School of Economics and Political Science, 29 Abercorn Pl, Flat 171, NW89DU, London, United Kingdom, a.kouvela@lse.ac.uk, Dimitris Magos, Gautam Appa, Yiannis Mourtos

We present a summary of different methods to tackle infeasibility and evaluate their viability for large scale 0-1 Integer Programming Problems. A challenging example is that of proving the non-existence of three 10x10 Mutually Orthogonal Latin Squares; which has been formulated as a five index assignment problem. We discuss methods extensively analysed in the literature, such as Hermite Normal Form, Aggregation, Lattice Basis Reduction and the Nullstellensatz Certificate of infeasibility; and some recent ideas that derive from the study of the intersection and row-column Graph.

2 - The metric dimension of generalized Petersen graphs

Mirjana Cangalovic, Department for Mathematics, Statistics and Operational Research, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, Belgrade, Serbia, Serbia, canga@fon.rs, Jozef Kratica, Vera Kovacevic Vujcic

We consider the problem of determining the metric dimension of the generalized Petersen graph $G(n,k)$. It is proved that the metric dimension of $G(n,k)$, for parameter k not smaller than 2, is greater or equal to 3. For k equal to 2 we find explicitly a metric basis of the cardinality 3 and the corresponding metric coordinates of all vertices of the graph. It follows that the metric dimension of $G(n,2)$ is equal to 3.

3 - A Branch-and-Price Mechanism for Bimodal Multicommodity flow problems

Ashwin Arulselvan, Warwick Business School, University of Warwick, Room E1.02 (Social Studies Building), Warwick Business School university of warwick, CV4 7AL, Coventry, Warwickshire, United Kingdom, ashwin.arulselvan@wbs.ac.uk, Steffen Rebennack, Panos Pardalos

We provide a path based formulation for a bimodal multicommodity flow problem and solve it using a branch-and-price approach. We also study some stabilization techniques to accelerate the convergence.

■ TC-11

Tuesday, 12:20-13:40

8.2.38

Advances in the Use of Information Technology II

Stream: Emerging Applications of OR

Invited session

Chair: *Sevgi Ozkan*, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, İsmet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Reducing product development complexity through information management

Ahm Shamsuzzoha, Department of Production, University of Vaasa, Lindroosintie 2, C19, FI-65101, Vaasa, Finland, ahsh@uwasa.fi, *Petri Helo*

Product Development process is a collaborative network to drive increased productivity. The focus of this research is to integrate the essential features of information flow with product development process. An empirical study is conducted through a case company. Existing dependency pattern and required information flow were collected and review meetings conducted. We considered to mitigate the complexity of information flow or dependency pattern between component-to-component and component to customer requirement. Several recommendations were proposed.

2 - Marketing Information Systems (MIS) as a Tool for Performance Measurement in Nigeria Aluminium Industry: Operations Research Perspective

Joshua Magbagbeola, ACTUARIAL SCIENCE AND INSURANCE, JOSEPH AYO BABALOLA UNIVERSITY, P.M.B. 5006, ILESHA, IKEJI-ARAKEJI, OSUN STATE, 234, IKEJI-ARAKEJI, ILEHSA, OSUN STATE, Nigeria, kunle_magbagbeola@yahoo.com

More than 90% of Nigerian's income is from exporting of crude oil. To expand and search for new avenue for revenue, other industrial areas like the Aluminium industry have to be investigated. The study examined among other things the performance of Aluminium industry in Nigeria with particular reference to the secondary sector of the industry and special cognisance to the appreciation of Operations Research as a veritable tool in Information Systems. Questionnaires were carefully prepared, administered and analyzed accordingly.

3 - Multicriteria Decision Analysis and Geographic Information Systems (GIS)

Ceren Gundogdu, administration, Yıldız Technical University, Barboros Bulvarı Yıldız Kampusu, H-Blok, 34349, İstanbul, Turkey, ceren_erdin@yahoo.com

Geographic Information Systems (GIS) is an information-technology based knowledge system providing all kinds of positional and spatial descriptive information in a related format. GIS is required in almost all types of enterprises today and they play an important role in the solution of corporate problems. By using GIS we show some example related to supply chain management, electronic business platform and mobile GIS in corporate decision support system and for solving some problems.

4 - Evaluate Collaboration Design Systems Performance based on CEGRA

Cheng-Ru Wu, Yuanpei University, Taiwan, alexru00@ms41.hinet.net, *Chiu-Chin Chen*

This study focused on using the cause-effect grey relational analysis (CEGRA) decision support tools for the Taiwan bureau's control information systems (CIS) analysis the collaboration design information systems performance case studies. CEGRA in the combination-based approach, this article provides decision-makers are doing collaboration design, to more practical and accurate in line with the standard structure of domestic industries to enhance the control of collaboration design the overall effectiveness of information systems.

■ TC-12

Tuesday, 12:20-13:40

8.2.39

ANP 03

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Yasemin C. Erensal*, Industrial Engineering, Marmara University, Göztepe, 34000, İstanbul, Turkey, yerensal@gmail.com

1 - Sequencing Attributes of Energy Portfolio Optimization in Industrial Regions

Alp Muzaffer Arslan, Management Faculty, ITU, Kaptan Arif Cad. Tonozlu Sk. No: 32/23, 34710, İstanbul, Turkey, muzalparslan@gmail.com, *Gulgun Kayakutlu*

Different technologies of renewable energy are critical for industrial regions but to be used in a portfolio. This study aims to identify, classify and prioritize the influential factors. Classes of factors are defined as technological, political, social and environmental. Dependency among attributes and among classes caused the application of ANP in order to determine the priorities. Initial survey is run among the academics of energy field; further work is continued with the small and medium companies. Case in Turkey shows that the most influential attribute is the European energy policies.

2 - EThe process of a Taiwan pharmaceutical company selects drugs for international contract manufacturing

Su-Chuan Shih, Business Administration, Providence University, 200 Chung Chi Road, Business Administration, 43301, Taichung City, Taiwan, Taiwan, scshih@pu.edu.tw

This research evaluated the group decision-making strategies of contract manufacturing in different drug types by applying the Analytic Network Process (ANP) method. The results had revealed that while accepting big pharmaceutical companies' orders of contract manufacturing, the efficiency and effectiveness of management is the most important facet that Taiwan's pharmaceutical company considered, the other ones are the innovative partner relationship and the industry factor. The results of index weighing ranking are Return on Assets (ROA), establishing partnerships with big pharmaceutical companies, and reduce risks in contract manufacturing.

3 - An ANP Based BOCR Approach for Marketing Strategy Selection

Tuncay Gürbüz, Industrial Engineering, Galatasaray University, Çiragan cad. No.36, Ortakoy, 34357, İstanbul, Turkey, tuncaygurbuz09@gmail.com, *Y. Esra Albayrak*, *Yasemin C. Erensal*

In today's world, producing is important and yet its importance is not even comparable to that of selling. As the competition is fierce, the companies has to attach greater importance to the sales. And for a good performance in sales, the company has to have an effective marketing strategy. Because the chosen strategy can work out pretty good and rise the sales as well as it can be a quite wrong strategy and hence drop the sales. In order to choose a suitable marketing strategy, in this study, a BOCR model will be built and analyzed with ANP. For each dimension, a suitable strategy will be chosen but at the end the final aggregation will give us the overall best strategy to follow.

4 - The Relationship of Salary and Performance for Food and Beverage Industry Based on DEMATEL with a MCDM Model

Yi-Chun Chen, Department of Leisure Management, Taiwan Hospitality & Tourism College, No 268 Chung-Hsing ST., Feng-Shan Village, Shou-Feng County, 974, Hualien, Taiwan, chen.vivien@gmail.com, *Gwo-Hshiung Tzeng*

The Purpose of This Paper Is to Analyze and evaluate the Food and Beverage Industry Employees Salary Verses Employees performance. In This Research DEMATEL Technique is Used to Build the Network Relationship Map Between Salary and Performance; Then ANP Relative Importance Weights Can Be Obtained Based the Results of DEMATEL Technique; Finally a MCDM Model is Conducted to Evaluate and Improve Satisfaction of Employee Needs. However, the Main Contribution of This Study is to help the employer clarify the needs of employees and the related factors.

■ TC-13

Tuesday, 12:20-13:40

2.2.21

Reliability in Location

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 - Location Problems with Two Unreliable Facilities on a Line

Mozart Menezes, MIT-Zaragoza International Logistics Program, Zaragoza Logistics Center, 50197, Zaragoza, Zaragoza, Spain, mmenezes@zlc.edu.es, *Oded Berman*, *Dmitry Krass*

We study the 2-Median and 2-Center problems for facilities that may be subject to (possibly correlated) disruptions; customer demand is uniformly distributed over a unit segment. Two variants of the problem are analyzed: (1) the customers have full information on the status of facilities, and (2) no such information is available. In addition analyzing location patterns, we provide the decomposition of the optimal cost into the components corresponding to the cost of travel, unreliability and incomplete information. The sensitivity of the optimal location and optimal cost to the probability of disruption and to the correlation of failures is presented and managerial insights are discussed.

2 - Hedging against territorial disruptions in capacitated distribution systems

Federico Liberatore, Kent Business School, University of Kent, Annexe, CT2 7PE, Canterbury, United Kingdom, fl51@kent.ac.uk, *Maria Paola Scaparra*

We present a multi-level model to improve the reliability of supply systems in the face of disastrous events that affect wide geographical areas. Examples of areal disruptions are: floods, earthquakes, hurricanes, and the spreading of biological and chemical agents. Two optimal solution approaches are proposed and compared.

3 - An Exact Linear Reformulation of the Expected Maximum Covering Problem

Jesse O'Hanley, Kent Business School, University of Kent, CT2 7PE, Canterbury, United Kingdom, j.ohanley@kent.ac.uk, *Sergio Garcia Quiles*, *Maria Paola Scaparra*

In this talk we consider the expected maximum covering problem, which can be used to design coverage networks that are robust to random facility failures. Although naturally represented in nonlinear form, we show how the model can be reformulated as an exact mixed integer linear program using simple linear constraints to iteratively evaluate high-degree polynomial terms involving probability products. Results and analyses are presented for various test problems showing the effectiveness of the new formulation in comparison to an approximation model and heuristic methods.

4 - Optimal Solution to n-Median With Unreliable Facilities on a Line

Dmitry Krass, Operations Management, University of Toronto - Rotman School of Management, 105 St. George Street, M5S-3E6, Toronto, Ontario, Canada, Krass@Rotman.Utoronto.Ca, *Oded Berman*

We present an approach for solving an n-facility median problem with unreliable facilities. The direct approach leads to loss of tractability for $n > 3$. However, by recasting the problem as a weighted combination of median problems an general case can be solved.

■ TC-14

Tuesday, 12:20-13:40

2.2.15

Vendor Managed Inventory

Stream: Supply Chain Planning [c]

Contributed session

Chair: *Michael Vidalis*, Business Administration, University of Aegean, Sachtouri 19 Agios Dimitrios, 17341, Athens, Greece, mvid@ath.forthnet.gr

1 - Implementing a Supplier Managed Inventory Policy in an Internal Logistics Setting

Tim Govaert, Industrial Management, University of Ghent, Technologiepark 903, 9052, Zwijnaarde, tim.govaert@ugent.be, *El-Houssaine Aghezzaf*, *Sofie Van Volsem*

This paper discusses the issue of effective inventory control and internal logistics management within a complex production and assembly system. The main objective of this investigation is to examine the performance of inventory control policies based on the concept of supplier managed inventory (SMI) and in the same time to optimize the relevant internal logistic Costs. We first start by defining the structure of inventory system and its critical parameters and then discuss the related internal logistics. We assume that there is a large off-site warehouse that supplies raw materials and components to the facility. This warehouse supplies a small area within the facility which in turn supplies the production and assembly operations. The supply is fully controlled using an SMI based policy. We investigate the effect of the critical parameters related to inventory as well as to the internal logistics (the number of incoming/outgoing trucks from suppliers/to retailers, the number of forklifts and lift trucks, etc.). The ultimate goal is of course an effective allocation of internal resources and increase of the service level.

2 - Coordination of Production and Dispatching Decisions in Vendor Managed Inventory Systems

Onur Kaya, INDR, Koc University, Koc University, Eng 206, Sariyer, 34450, Istanbul, Turkey, okaya@ku.edu.tr, *Deniz Kubali*, *E. Lerzan Ormeci*

We focus on the coordination of transportation and production policies between a manufacturer and a retailer in a vendor-managed inventory system. The manufacturer needs to determine the length of the production cycle as well as the shipment timings and the quantities to the retailer. We consider both the deterministic and the stochastic cases in a general setting and we also consider simpler dispatch policies, like time-based and quantity-based shipments. We also do a computational study to compare the performances of these policies and to analyze the effects of the parameters to the system.

3 - Supplier managed inventory in case of stochastic demand and finite supply

Sofie Van Volsem, Industrial Management, Ghent University, Technologiepark 903, BE 9052, Gent, Belgium, sofie.vanvolsem@ugent.be, *El-Houssaine Aghezzaf*, *Tim Govaert*

The typical IRP deals with distribution of a single product to a set of customers with constant demand rates, from a single distribution center (DC) with an unlimited supply, but these assumptions do not always reflect reality. We consider finite DC capacity and stochastic customer demands. Under these assumptions, DC stockouts can occur, causing backorders and possibly customer stockouts. We introduce an SMI—model to analyze the trade-off between all costs involved. Furthermore, the influences of customer clusters and timetables on DC inventory are analyzed and improvements are proposed.

4 - Modeling a Supply Chain with two members, (S, s) inventory policy Poisson external demand and Coxian-2 lead time

Michael Vidalis, Business Administration, University of Aegean, Sachtouri 19 Agios Dimitrios, 17341, Athens, Greece, mvid@ath.forthnet.gr, *Vassilios Vrisagotis*

We model a dynamic supply network with two members, stochastic demand and replenishment. External demand is pure Poisson, retailer follows (S,s) policy and the lead time follows a Coxian-2 distribution. The supply network is modeled as a continuous time Markov process with discrete states. The structure of the transition matrix is explored and a computational algorithm is developed to generate this for different values of system characteristics. Performance measures such as fill rate, WIP and flow time are obtained. Also expressions for the holding costs and shortage costs are derived.

■ TC-15

Tuesday, 12:20-13:40

2.2.12

Dynamic and Stochastic Vehicle Routing

Stream: Vehicle Routing

Invited session

Chair: *Lars Magnus Hvattum*, Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, Sentralbygg 1, N-7491 Trondheim, Norway, 7491, Trondheim, Norway, lars.m.hvattum@iot.ntnu.no

1 - Real-time delivery of perishable goods using past request data to increase customer service quality

Francesco Ferrucci, WINFOR (Business Computing and Operations Research), University of Wuppertal, Gausstrasse 20, 42119, Wuppertal, NRW, Germany, fferrucci@winfor.de, *Stefan Bock*, *Michel Gendreau*

In this talk, we focus on a real-world variant of the well-known Dynamic Vehicle Routing Problem (DVRP). In the considered DVRP, goods have to be delivered under high time pressure because of their high perishability. In order to reduce delivery times and to increase quality of customer service experience, future demands are anticipated. For this purpose, sophisticated methods for analyzing historical data and request forecasting are applied. Recent computational results on designed and real-world data are presented.

2 - Robust optimization of internal transports

Brigitte Werners, Wirtschaftswissenschaft, Ruhr-University Bochum, Universitätsstr, 44780, Bochum, Germany, or@rub.de

Significant reductions in internal transports at one of the Deutsche Post DHL's main parcel sorting centers can be achieved by applying the robust solution of a modified three-dimensional linear assignment model. The suggested MILP model minimizes necessary manual transportation effort by layout modifications. Specific requirements are taken into account and uncertain data are handled by applying robustness criteria which can be generally applied to develop robust solutions in a dynamic decision situation.

3 - Metaheuristics for the dynamic stochastic dial-a-ride problem with expected return transports

Michael Schilde, Department of Business Administration, University of Vienna, Brünner Straße 72, Bauteil 2, Raum 179, 1210, Vienna, Austria, michael.schilde@univie.ac.at, *Karl Doerner*, *Richard Hartl*

The Austrian Red Cross faces the problem of designing vehicle routes to serve dynamically arising transportation requests from patients' home locations to hospitals using a fixed vehicle fleet. Each request may cause a return transport in the opposite direction on the same day. Some stochastic information about these return transports is available. We show that using this kind of information while designing the vehicle routes can be beneficial to solution quality. Different modifications of the variable neighborhood search metaheuristic were tested using real world inspired test instances.

4 - Using Decision Trees for a Stochastic Maritime Routing Problem

Lars Magnus Hvattum, Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, Sentralbygg 1, N-7491 Trondheim, Norway, 7491, Trondheim, Norway, lars.m.hvattum@iot.ntnu.no, *Eystein Fredrik Esbensen*, *Kjetil Fagerholt*, *Bjørn Nygreen*

A real-world shipping company services two types of requests. The first has a fixed starting time and late arrivals result in severe penalties. The second has no time windows, but the total amount of goods transported in any time interval is restricted by contracts. The main stochastic element is port congestions, which may result in a substantial risk of arriving late for a fixed time contract. The size and structure of the case allow a solution method based on decision trees. Simulation results are provided illustrating the usefulness of the method.

■ TC-16

Tuesday, 12:20-13:40

2.2.14

OR Applications in Railways

Stream: Public Transport

Invited session

Chair: *Dennis Huisman*, Econometric Institute, Erasmus University, Rotterdam, Netherlands, huisman@ese.eur.nl

1 - Integrated Planning of Railway Transportation Resources

David De Almeida, Innovation & Research Department, SNCF, 45 rue de Londres, 75379, Paris CEDEX 08, France, david.de_almeida@sncf.fr, *Faten Benhizia*, *Stéphane Dazere-peres*

In this presentation, we deal with the integration of rolling-stock and driver planning in railway production. This prospective research is partly motivated by previous works in the airline industry and in public transportation. We first propose a mixed integer linear programming model where coupling constraints are introduced to ensure the consistency in the use of the two resource types. Some preliminary numerical experiments obtained with a standard solver are presented. Alternatives for handling problems of industrial size in reasonable calculation times will be further discussed.

2 - Solving Large Scale Crew Scheduling Problems Efficiently

Ricardo Saldanha, Innovation, SISCOG - Sistemas Cognitivos, SA, Campo Grande 378-3, 1700-097, Lisboa, Portugal, rsaldanha@siscog.pt, *Erwin Abbink*, *Luis Albino*, *Twan Dollevoet*, *Dennis Huisman*, *Jorge Roussado*

We address the problem of assigning anonymous drivers and conductors to more than 60,000 trips (complete trains or parts of trains) running on a standard week period. Typically huge problems like this are solved in several steps where in each step only part of the decision variables is considered. We show that solving the problem considering a priori all decision variables together results in solutions that are significantly more efficient. This is only possible with the use of advanced techniques and algorithms capable of tackling the additional complexity of the problems to be solved. We test our approach with real-life data supplied by the Dutch railway operator, Netherlands Railways.

3 - Tram traffic management at signalised junctions with tram stops

Jeremi Rychlewski, Civil and Environmental Engineering, Poznań University of Technology, Piotrowo 5, 61-138, Poznań, Poland, jeremi.rychlewski@put.poznan.pl

The aim of this paper is to discuss strategies for managing priority tram traffic at junctions with traffic lights and tram stops at entry or at exit of the junction. Problems with tram stops at junction entry include variable service time at the tram stop, but also turnout and traffic light management when two trams going in different directions are to be served. Tram stop platforms at junction exit should not be too long, but that puts a risk of a second tram blocking the junction. The problems are based on experience from Poznan and other Polish cities.

4 - Developments in crew re-scheduling at Netherlands Railways

Dennis Huisman, Econometric Institute, Erasmus University, Rotterdam, Netherlands, huisman@ese.eur.nl, *Daniel Potthoff*

After a major disruption, the re-scheduling of train drivers and guards is the bottleneck in the operation of Netherlands Railways (NS). For example, there were hardly any trains running on time during a week with snowfall in December 2009. OR based algorithms can help to solve these problems. In this talk, we present the latest developments in these algorithms and we discuss how NS want to apply them during the day of operations.

■ TC-17

Tuesday, 12:20-13:40

1.3.14

Models for Vehicle Routing

Stream: Transportation Planning

Invited session

Chair: *Nurul Mohamed*, Kent Business School, University of Kent, 1 Kingsmead Road, CT1 1BN, Canterbury, Kent, United Kingdom, nurul.h@gmail.com

1 - Multi-depot vehicle routing problem (MDVRP): comparative study of alternative formulations

Tânia Ramos, Department of Management and Centro de Estudo de Gestão do IST, ISCTE-IUL and IST-UTL, Avenida das Forças Armadas, Edifício ISCTE, 1649-026, Lisboa, Portugal, tania.ramos@iscte.pt, *Maria Isabel Gomes*, *Ana Paula Barbósa-Póvoa*

The MDVRP appears as a generalization of the classical VRP. There are different mathematical formulations of VRP used in the literature. This paper aims to compare exact formulations to solve MDVRP. We worked with the three index formulation adapted to the MDVRP and proposed the two-commodity flow formulation for the MDVRP. In the three index formulation, we compared three alternative formulations based on Miller-Tucker-Zemlin constraints to eliminate subtours. The mixed-integer linear programming models developed are applied to some small and medium size scale instances.

2 - Two objective functions for a special Split Delivery Vehicle Routing Problem

Marc Uldry, Département d'Informatique, Université de Fribourg, Boulevard de Pérolles 90, 1700, Fribourg, Switzerland, marc.uldry@unifr.ch, *Marino Widmer*

Different products have to be delivered by trucks. Due to the trucks capacity, each order is split into one or more deliveries supplied from a main depot or from local depots. Simple and complex constraints have to be satisfied as drivers and trucks availability or the fact that only specific trucks can be fulfilled in local depots. A MIP considers two different objective functions. The first one defines a vehicle routing where the total travel time is minimized while the second one defines a vehicle routing where the number of different trucks supplying each individual customer is minimized.

3 - Branch-and-price for the multi-depot pickup and delivery problem with heterogeneous fleet and soft time windows

Andrea Bettinelli, Dipartimento di Matematica, Università degli Studi di Milano, via Saldini 50, 20133, Milano, Italy, andrea.bettinelli@unimi.it, *Alberto Ceselli*, *Giovanni Righini*

The multi-depot pickup and delivery problem with heterogeneous fleet and soft time windows calls for finding a minimum cost routing for a fleet of vehicles with different capacities and based at different depots, satisfying a given set of customers. For each customer a demand must be picked up at a source and delivered at a destination in the same route. Each location has a time window for the service that can be violated at the cost of a linear penalty. We propose a branch-and-price algorithm. The pricing problem is solved through a bidirectional dynamic programming method.

4 - Split Delivery Vehicle Routing Problem

Nurul Mohamed, Kent Business School, University of Kent, 1 Kingsmead Road, CT1 1BN, Canterbury, Kent, United Kingdom, nurul.h@gmail.com, *Said Salhi*, *Gábor Nagy*

Split Delivery Vehicle Routing Problem (SDVRP) is one of Vehicle Routing Problem (VRP) variants where each customer can be served more than once. We will explore and analyse some new approaches based on the saving and sweep algorithms together with some refinement schemes to solve the SDVRP. A set partitioning based approach is put forward and used in ILOG Cplex to get a better solution. Preliminary results will be highlighted along future research.

■ TC-18

Tuesday, 12:20-13:40

1.3.15

Complex Systems under Uncertainty: Networks and Data Mining

Stream: Stochastic Modeling and Simulation

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

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - On a Class of Branching Problems in Broadcasting and Distribution

Sohail Chaudhry, Management and Operations, Villanova University, Villanova School of Business, 800 Lancaster Avenue, 19085, Villanova, PA, United States, sohail.chaudhry@villanova.edu, *Edward Rosenthal*, *In-Chan Choi*, *Jinbong Jang*

The class of branching problems in broadcasting and distribution (BBD) that we introduce in this paper represents a large class of combinatorial and network optimization models. We introduce the following network optimization problem: given a finite directed graph with a cost function on the arcs, demands at the nodes, and a single source s , find the minimum cost connected subgraph from s such that its total demand is no less than lower bound D .

Theoretically, BBD generalizes several known discrete optimization problems, including the knapsack problem, Edmonds' minimum branching problem, the partially ordered knapsack problem, and certain scheduling problems. BBD has broad practical application as well. We show how BBD models disaster relief efforts such as food or medicine distribution. In addition, we describe a "broadcasting" application which shares the same properties as the distribution problems, which, loosely speaking, are to maximize effect at minimum cost. We prove that our problem is strongly NP-complete, give an integer programming formulation, outline two heuristic approaches, and illustrate them with a numerical example. In addition, we report on our computational experience on randomly generated problems.

2 - Data mining approach for network intrusion detection using mobile agent

Djamal Dris, Lamos laboratory, université de Bejaia, route de Targua ouzemmour Bejaia, 06000, Bejaia, Bejaia, Algeria, drisdjamal@hotmail.com, *Lynda Sellami*, *Khaled Sellami*, *Mohamed Ahmed-nacer*

A data mining techniques that incorporates the mobile agent system based Intrusion Detection System (IDS) has been defined to guaranty an efficient computer network security architecture. We provide an overview on data mining algorithms that we have implemented: association rules algorithm. Whose is used to compute the intra- and inter-audit record patterns, which are essential in describing program or user behavior. We propose an agent-based architecture for intrusion detection systems where the learning agents continuously compute and provide the updated (detection) models to the detection agents.

3 - Probabilistic Analysis of Multidimensional Assignment Problems

Pavlo Krokhmal, Mechanical and Industrial Engineering, University of Iowa, 3131 Seamans Center, 52242, Iowa city, IA, United States, krokhmal@engineering.uiowa.edu

We consider a class of multidimensional assignment problems (MAPs) that generalize the well-known Linear and Quadratic Assignment Problems. Properties of large-scale randomized instances of MAPs are investigated under assumption that their assignment costs are iid random variables. For a broad class of probability distributions, we demonstrate that optimal values of random MAPs converge in L_1 and almost surely as problem size increases. Computational properties of large-scale randomized MAPs are discussed, including polynomial algorithms that deliver epsilon-approximate solutions almost surely

4 - Operating Overall Production under Chance Constraints

Baruch Keren, Industrial Engineering and Management Department, SCE - Shamoon College of Engineering, Bialik/Basel Sts., P.O.B. 950, 84100, Beer Sheva, Israel, baruchke@sce.ac.il, *Zohar Laslo*, *Gregory Gurevich*

A single product can be manufactured in n plants with heterogeneous characters. Each plant has its specific stochastic production capability. The expected capability and the standard deviation of each plant can be increased by allocation of additional budgets. The periodic demands for the product are forecasted and given by a probability function for each period. The problem is to determine the total budget needed and its distribution among the n plants in order to ensure a complete fulfillment of the demands according to the due dates and the pre-given confidence levels.

■ TC-19

Tuesday, 12:20-13:40

1.3.20

Universality in complex systems

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *Rui Gonçalves*, Engenharia Civil, Faculdade de Engenharia da U. Porto, R. Dr. Roberto Frias, 4200-465, Porto, rjasg@fe.up.pt

1 - Euclidean Jordan algebras, generalized Krein conditions and strongly regular graphs with one eigenvalue in modulus less than one

Luís Vieira, Engenharia Civil, Faculdade de Engenharia do Porto, R. Dr. Roberto Frias, 4200-465, Porto, lvieira@fe.up.pt

Let G be a strongly regular graph. We first present the generalized Krein parameters of G in the environment of Euclidean Jordan algebras and we analyze the spectra of G when one of the eigenvalues distinct from the regularity is in modulus less than one. Next, we analyze the generalized Krein parameters of G when its order is big and establish some theorems on the spectra and on the parameters of G . Finally, we present some conditions on the Krein parameters of a strongly regular graph H recurring to the generalized Krein parameters of H .

2 - The Relationship between Crude Oil Prices and Exchange Rates

André Salles, Industrial Engineering, 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

This work uses a Bayesian approach: to study the risk and returns of the oil prices; and examines the relationship between crude oil prices and exchange rate. The methodology used here takes in consideration the violation of homoscedasticity and Gaussian distribution, in the construction of the models. The data used in this study consists of the daily closing exchange rate, of US dollar to Euro, and oil prices, from June 2006 to March 2009.

3 - Universality in the stock market

Rui Gonçalves, Engenharia Civil, Faculdade de Engenharia da U. Porto, R. Dr. Roberto Frias, 4200-465, Porto, rjasg@fe.up.pt, *Helena Ferreira*, *Alberto Pinto*

We compute the analytic expression of the probability distributions $F_{Ip,+}$ and $F_{Ip,-}$ of the normalized positive and negative I_p index returns $r(t)$, with periodicity p . We study North American, European and World wide indices, energy sources and exchange rates. We define the alpha re-scaled I_p index returns that we call, after normalization, the alpha positive and alpha negative fluctuations. We use the Kolmogorov-Smirnov statistical test, as a method, to find the values of alpha that optimize the data collapse of the histogram of the alpha fluctuations with the Bramwell-Holdsworth-Pinton (BHP) probability density function. Since the BHP probability density function appears in several other dissimilar phenomena, our results reveal a universal feature of the stock exchange markets.

■ TC-21

Tuesday, 12:20-13:40

6.2.47

Software for OR/MS I - Optimization

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

1 - Why is Maximal Software Now Giving Away Free Development Copies of the MPL Modeling System?

Bjarni Kristjansson, Maximal Software, Ltd., Boundary House, Boston Road, W7 2QE, London, United Kingdom, bjarni@maximalsoftware.com, *Sandip Pindoria*

In today's challenging economy, many are now looking for ways to save on their IT budget, including when purchasing optimization software. We at Maximal have now decided to fundamentally change how we sell our software, by greatly reducing how much you pay for development copies of MPL, in many cases bringing the actual cost down to zero. We will explain several new programs: "Pay Maintenance Only," "Subscription-Based Pricing," "Free Development Copies of MPL" and "Free Software for Academics."

2 - 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.

3 - Xpress-Kalis: Automatic Linear Relaxations for Combined CP-MIP Problem Solving with Application to Nuclear Power Plant Maintenance Outage Scheduling

Susanne Heipcke, Xpress team, FICO, 54 rue Balthazar de Montrou, 13004, Marseille, susanneheipcke@fico.com, *Fabrice Buscaylet*

After a brief overview of the capabilities of the Xpress-Mosel language for handling multiple problems and multiple solvers, we explain the concepts behind automatic linear relaxations for combined CP-MIP solving with Xpress-Kalis and Xpress-Optimizer. As an application example demonstrating the suitability of the implementation for large-scale optimization problems, we show how the problem of planning nuclear power plant maintenance outage for 50+ reactors over several years has been modeled and solved using the automatic linear relaxations functionality.

4 - Adaptable Robust Optimization and Chance Constraints approximation using automatic model generation in AIMMS

Ovidiu Listes, AIMMS, Paragon Decision Technology, Schipholweg 1, 2034 LS, Haarlem, Netherlands, o.listes@aimms.com

We illustrate how AIMMS is able to generate automatically the Robust Counterpart of a model in case the uncertain data belongs to uncertainty sets like Box, Ellipsoid, Polyhedron or Scenarios. The automatic generation extends to adjustable variables following Linear Decision Rules, as well as to robust approximations of Chance Constraints. We show how the intuitive, effective modeling concepts in AIMMS allow for fast, flexible experiments and comparison of results based on various uncertainty sets.

■ TC-22

Tuesday, 12:20-13:40

3.1.10

Health Care Policy Making I

Stream: Health Care Management [c]

Contributed session

Chair: *Dave Worthington*, The Management School, Lancaster University, Dept. Of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, d.worthington@lancaster.ac.uk

1 - New Integer-Programming Formulation for Kidney Exchange Problem

Dorien de Regt, TU Delft, Mekelweg 4, 2628 CD, Delft, Netherlands, D.N.deregt@student.tudelft.nl, *Abdur Rais*, *Miguel Constantino*, *Ana Viana*

A kidney transplant patient having an associated kidney donor may not receive the donor kidney because of incompatibility. However, by exchanging donor kidneys between two or more incompatible patient-donor pairs, successful transplants can be performed. For a set of incompatible patient-donor pairs, Kidney Exchange Problem (KEP) finds optimal matching of patients and donors across the incompatible pairs for successful kidney transplants. In this talk, a new IP formulation for the KEP will be presented. The new description and computational results will be compared to other known formulations.

2 - Setting Staffing Requirements for Time Dependent Queueing Networks: The Case of Accident and Emergency Departments

Navid Izady, Lancaster University, United Kingdom, n.izady@lancaster.ac.uk, *Dave Worthington*

An incentive scheme aimed at reducing patients waiting times in A&Es was introduced by the UK government in 2000. It requires 98 percent of patients to be served within 4 hours of arrival. Setting the minimal hour by hour staffing levels for achieving the target, in the presence of complexities like time-varying demand, is the subject of this talk. We propose an iterative scheme which uses queueing models and simulation to produce a good solution. The implementation of this method in a typical A&E suggests that significant improvements can be achieved without increasing total staff-hours.

3 - Optimal Multileaf Collimator Leaf Sequencing in IMRT Treatment Planning

Z. Caner Taşkın, Department of Industrial Engineering, Boğaziçi University, Bebek, 34342, Istanbul, Turkey, caner.taskin@boun.edu.tr, *Cole Smith*, *Edwin Romeijn*, *James Dempsey*

Intensity modulated radiotherapy (IMRT) is a powerful technique for radiotherapy treatment delivery. We discuss the problem of efficiently delivering a given beam intensity profile. In particular, we need to decompose the intensity profile into a set of beam shapes satisfying the consecutive-ones property. We propose an exact algorithm to solve this problem under different efficiency criteria. Our results indicate that several clinical instances can be solved to optimality within a few minutes.

4 - Measuring the Effect of Workers' Health on Productivity

Fredrik Odegaard, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond Street North, N6A 3K7, London, Ontario, Canada, fodegaard@ivey.uwo.ca, *Pontus Roos*

In this paper we present a methodology to study the interaction between health and productivity. Health refers to the physical and mental condition of an individual, while productivity refers to the physical output and quality of a firm. Health is modeled as a latent variable, and considered in the framework of the capability approach. We illustrate the methodology with results from a workplace intervention study of four large Swedish manufacturing firms over the years 2000-2003.

TC-23

Tuesday, 12:20-13:40
6.2.49

MOO: Facility Location Problems

Stream: Multi-Objective Optimization

Invited session

Chair: *Carlos Ferreira*, Dep. of Economics, Management and Industrial Engineering, University of Aveiro, Campus Universitario de Santiago, 3810-143, Aveiro, Portugal, carlosf@ua.pt

1 - The embedment of a GIS in a decision support system for bicriteria location problems

Sérgio Fernandes, Instituto Politécnico de Setúbal, Escola Superior de Tecnologia, Campus do Instituto Politécnico de

Setúbal, Estefanilha, 2910-761, Setúbal, Portugal, sergiof@est.ips.pt, *Maria Eugénia Captivo*, *João Clímaco*

SABILOC is a Decision Support System aimed at supporting decision making concerning bicriteria location models. When the facilities to be located have environmental effects, they usually depend on different factors like the altitude and the morphology of the potential locations, the winds, the temperature, the humidity, etc, most of which can be more easily evaluated with a Geographical Information System (GIS). In this work we describe and exemplify the qualitative added value of the embedment of a GIS platform in SABILOC.

2 - An interactive method for multi-objective integer and mixed-integer programming applied to a facility location problem

Carlos Ferreira, Dep. of Economics, Management and Industrial Engineering, University of Aveiro, Campus Universitario de Santiago, 3810-143, Aveiro, Portugal, carlosf@ua.pt, *Rui Borges Lopes*, *Beatriz Sousa Santos*

We propose an interactive method following an open communication protocol for multi-objective integer and mixed-integer programming. In each step of the human/computer dialogue, the decision maker (DM) provides indications about the sub regions he/she desires to continue the search for non-dominated solutions (nds). The method enables to progressively eliminate criteria regions, either by dominance or unfeasibility, and ends when the DM considers to have sufficient knowledge about the set of nds. The proposed method is applied to a facility location problem (the set covering problem).

3 - A multi-objective evolutionary algorithm for the capacitated location-routing problem

Rui Borges Lopes, Dep. of Economics, Management and Industrial Engineering, CIO / University of Aveiro, Campus Universitario de Santiago, 3810-143, Aveiro, Portugal, rui.borges@ua.pt, *Carlos Ferreira*, *Beatriz Sousa Santos*

We consider a discrete multi-objective Capacitated Location-Routing Problem (CLRP) with two levels (depots and clients) and a capacitated and homogeneous vehicle fleet. For this model, an evolutionary (genetic) algorithm is presented. The algorithm uses a new chromosome encoding and Pareto ranking for crossover selection. The method aims at obtaining a good approximation of the whole non-dominated set. Results for some instances adapted from the CLRP literature are presented and discussed.

4 - Routing Location Multi Criteria Optimization Metaheuristics

Claudia Margarita Villagran de Leon, Faculty of Medicine., University San Carlos of Guatemala, 9 Avenida 9-45 Zona 11, Centro Universitario, CUM, Colonia Roosevelt., 01011, Guatemala, Guatemala, Guatemala, margavilla2008@hotmail.com

Location Routing problems appear in many applications with different constraints, depending on the application, which are studied by several algorithms in (OR). We Consider a Multi Criteria routing location problem analyzing economical as well as social criteria, deriving a metaheuristic solution for a Travel Touristic Management Plan.

TC-24

Tuesday, 12:20-13:40
6.2.50

Data Mining in Bioinformatics

Stream: Computational Biology, Bioinformatics and Medicine

Invited session

Chair: *Giovanni Felici*, IASI, CNR, 00185, Rome, Italy, giovanni.felici@iasi.cnr.it

1 - Genetic Programming for feature extraction in supervised learning

Mauro Castelli, DISCO- Department Informatics, Systems and communication, University of Milano Bicocca, viale sarca 336,

20126, milan, castelli@disco.unimib.it, *Ilaria Giordani, Francesco Archetti, Enza Messina, Leonardo Vanneschi*

In this talk we address the problem of reducing the dimensionality of the space of features for machine learning systems in case of large datasets. We propose a GP based approach for a combined feature extraction/classification method, which creates a fixed and limited number of new features, to be considered during the classification process. The approach uses multi-objective optimization, with the following criteria: classification performances; size and complexity of the classifier and the extracted features expressions; Entropy of the extracted features. Experimental results will be discussed.

2 - Metaheuristics for sequences consensus problems

Paola Festa, Dept. of Mathematics and Applications, University of Napoli Federico II, Compl. MSA - Via Cintia, 80126, Napoli, Italy, paola.festa@unina.it

It has been shown that a large number of molecular biology problems can be formulated as combinatorial optimization problems, including sequence alignment problems, genome rearrangement problems, string selection and comparison problems, and protein structure prediction and recognition. This paper defines some string selection and string comparison problems, also known as consensus problems, and describes several metaheuristic approaches for finding good-quality solutions.

3 - Feature Selection with Hyperspheres

Paola Bertolazzi, CNR, IASI, 61980, Rome, Italy, paola.bertolazzi@iasi.cnr.it, *Giovanni Felici, Paola Festa*

In this paper we consider a class of integer and mixed integer programming models used to represent Feature Selection (FS) problems in very high dimensional spaces. FS arises in Data Analysis and Data Mining to properly reduce the dimension of the space where the data are represented. Such dimensional reduction is performed to make the analysis tractable while retaining the largest amount of information, given the specific objective of the data analysis task. We consider a new variant where the target space can be considered an affine transformation of the original one where the data lie in hyperspheres of homogeneous classes. Such problem is modeled with linear and mixed integer programs and solved with commercial softwares when tractable, else with ad-hoc heuristics. The proposed space transformation presents several interesting features for the separation of data as it is shown in the experiments reported.

4 - Feature Discretization and Clustering in the DMB logic mining environment

Paola Bertolazzi, CNR, IASI, 61980, Rome, Italy, paola.bertolazzi@iasi.cnr.it, *Giovanni Felici, Emanuel Weitschek, Guido Drovandi*

Feature Discretization is applied to the numerical attributes of a dataset and consists of the identification of a possibly small set of intervals of values for each attribute, than can then be mapped in a qualitative or binary scale. In Feature Clustering, the discrete features can be aggregated in clusters with common properties. We present two algorithms for discretization and clustering integrated in the DMB (Data Mining Big) software system, a logic data mining system for classification in large data sets. In particular, we consider biological data, often represented by large arrays of integer or real numbers, that correspond to measures on the objects (e.g. gene expressions by microarray).

TC-25

Tuesday, 12:20-13:40

6.2.48

Volatility Spillover and Liquidity Risk

Stream: Financial Mathematics and OR

Invited session

Chair: *Emrah Sener*, Computational Finance, Ozyegin University, Kusbakisi Cad. No: 2, Altunizade, 34662, Istanbul, Turkey, emrah.sener@ozyegin.edu.tr

Chair: *Feyzullah Egriboyun*, Finance, Sabanci University, Istanbul, Turkey, feyz@alumni.cmu.edu

1 - Dynamic spillover effects of deviation in covered interest rate parity through term structure

Feyzullah Egriboyun, Finance, Sabanci University, Istanbul, Turkey, feyz@alumni.cmu.edu, *Sait Satioglu, Emrah Sener*

We investigate if there is a dynamic relationship between the collapse of short-term covered interest rate parity and the long-term cross currency basis swap market during the 2008 crisis. Our investigation spans an unusual period of unrest in the money markets of six emerging and four developed currencies. Our analysis suggests that the deviation in FX swap market has significant spillover effects on the basis swaps as a result of higher liquidity concerns. Volatility and mean spillovers are detected in developed countries while in emerging countries, volatility spillover is not observed.

2 - Discrete and continuous-time liquidity models

Selim Gokay, Mathematik, ETH Zurich, Ramistrasse 101, 8092, Zurich, Switzerland, selim.gokay@math.ethz.ch, *Mete Soner*

Illiquidity risk incorporates the effect of the size and the time of the trade into the price process of the asset. This price impact might be permanent or temporary. In this talk we will address some temporary and permanent illiquidity models for option pricing. In particular, we will focus on the supply curve model introduced by Cetin, Jarrow and Protter. This is an example of a temporary impact model and we will explore the recent works of Cetin, Soner and Touzi in continuous-time and Gokay and Soner in discrete-time concerning this model.

3 - Volatility Spillover Dynamics between the Emerging CDS, Bond and Equity Markets

Emrah Sener, Computational Finance, Ozyegin University, Kusbakisi Cad. No: 2, Altunizade, 34662, Istanbul, Turkey, emrah.sener@ozyegin.edu.tr, *Sevan Ulutas, Osman Yilmaz*

We analyze the impulse response relationship, variance decomposition and volatility spillover dynamics between the CDS, equity, and bond markets. In order to investigate the volatility transmission, we use a multivariate GARCH model. Our research includes three emerging markets (Turkey, Russia and Brazil) during the pre-crisis, crisis and post-crisis periods. The findings show that all three markets transmit volatility to each other and hence innovations from one market increase trading activity in the other two markets.

TC-26

Tuesday, 12:20-13:40

3.1.11

Cooperative Games and Applications

Stream: Cooperative Game Theory

Invited session

Chair: *M^a Luisa Carpena*, Matemáticas, University of La Coruña, Campus de Elviña, 15071, A Coruña, luisacar@udc.es

1 - The proportional coalitional Shapley value

Francesc Carreras, Applied Mathematics II, Technical University of Catalonia, ETSEIAT, Colom 11, 08222, Terrassa, Catalonia, Spain, francesc.carreras@upc.edu, *José María Alonso_meijide*

We propose a modification of the Shapley value for monotonic games with a coalition structure. The resulting coalitional value is a twofold extension of the Shapley value since: (1) the amount obtained by any union coincides with the Shapley value of the union in the quotient game; and (2) the players of the union share this amount proportionally to their Shapley value in the original game. We provide axiomatic characterizations of this value that are close to those existing in the literature for the Owen value and include applications to coalition formation in bankruptcy and voting problems.

2 - Bilateral assignment markets with the same core

Javier Martinez de Albeniz, Matematica Economica, Financera i Actuarial, Universitat de Barcelona, Av. Diagonal, 690, 08034, Barcelona, Spain, javier.martinezdealbeniz@ub.edu, *Marina Nunez, Carles Rafels*

In the framework of the bilateral assignment games, we study the set of matrices leading to assignment markets with the same core. We state conditions, in terms of the matrix entries, that ensure that the related assignment games have the same core and we prove that the set of matrices leading to the same core form a join-semilattice with a finite number of minimal elements and a unique maximum. Conditions under which the join-semilattice reduces to a singleton or is in fact a lattice are also identified.

3 - The Shapley value and some stability conditions

M^a Luisa Carpena, Matemáticas, Universidade da Coruña, Faculdade de Informática, Campus de Elviña, 15071, A Coruña, Spain, luisacar@udc.es, *Balbina-Virginia Casas-Méndez*, *Ignacio García-Jurado*

We study the Shapley value solution for coalitional games in some situations in which there are upper bounds on the possible payoffs for some coalitions. We are concerned with the notion of the core and some stability conditions derived from these upper bounds. For instance, minimum cost spanning tree problems and some sequencing situations that have been studied in the literature under a pessimistic and an optimistic point of view fit perfectly in our setting.

■ TC-27

Tuesday, 12:20-13:40
8.2.06

FREIGHT TRANSPORTATION

Stream: Transportation and Logistics
Invited session

Chair: *Walter Ukovich*, ORTS - DEEI, University of Trieste, via Valerio, 10, 34127, Trieste, Italy, ukovich@units.it

1 - A simulation-optimization approach for drawing stowage plans for containerships

Rina Mary Mazza, DEIS - Dipartimento di Elettronica, Informatica e Sistemistica, Università della Calabria, Via P. Bucci 41C, 87036, Rende, (CS), Italy, rmazza@deis.unical.it, *M. Flavia Monaco*, *Marcello Sammarra*, *Gregorio Sorrentino*

We consider the Ship Stowage Plan Problem according to the terminal planner's point of view. Within the global aim of reducing the time to perform loading operations, the problem focuses on minimizing the number of reshuffles (un-productive moves) required to fetch a container from a stack on the terminal yard. The simulation-optimization solution methodology proposed uses a tabu search algorithm to explore the solution space combined with a discrete-event simulation model used to estimate the cost of each solution, i.e. container handling and transfer time from the yard to the ship.

2 - Freight transportation planning in railway networks with rapid transshipment terminals

Davide Anghinolfi, Università di Genova, 16100, Genova, Italy, davide.anghinolfi@unige.it, *Massimo Paolucci*, *Simona Sacone*, *Silvia Siri*

We propose a planning procedure for serving freight transportation demand in a railway network whose terminals are equipped with fast train to train transshipment devices. The demand consists of sets of boxes with different origins, destinations and delivery times. A plan gives for each box the routing, the sequence of trains and the assignment to train wagons. The planning procedure first finds the alternative sequences of trains for serving orders then solves a generalized assignment problem by a combined integer programming and heuristic approach. Some experimental results are shown.

3 - A Mathematical Programming Approach to the Multi-Port Master Bay Plan Problem

Massimo Paolucci, Dipartimento di Informatica, Sistemistica e Telematica, Università di Genova, Via Opera Pia 13, 16145, Genova, Italy, paolucci@dist.unige.it, *Daniela Ambrosino*, *Davide Anghinolfi*, *Anna Sciomachen*

We face the line planner problem of determining aggregate stowage plans for containerships to satisfy a transportation demand. This problem, denoted as Multi-Port Master Bay Plan Problem (MP-MBPP), consists in determining the stowage plan for each port on the ship route so that stability constraints are satisfied and port operations are optimized, i.e., the workload for the quay cranes is balanced and non-productive movements are minimized. We propose a mathematical programming approach combined with a heuristic approximation and we reporting experimental results showing its effectiveness.

4 - A Metamodeling Approach to the Management of Inter-modal Transportation Networks

Walter Ukovich, ORTS - DEEI, University of Trieste, via Valerio, 10, 34127, Trieste, Italy, ukovich@units.it, *Valentina*

Boschian, *Mariagrazia Dotoli*, *Maria Pia Fanti*, *Giorgio Iacobellis*, *Gabriella Stecco*

The contribution specifies an Integrated System (IS) devoted to the efficient management and control of Intermodal Transportation Networks (ITN). The proposed IS is designed to take both tactical decisions, in an off-line mode, and operational decisions, in real time. In either case, the core of the presented IS is a reference model that uses information from the real system. The reference model is based on a metamodeling approach: a top-down procedure based on the UML formalism, a graphic and textual language able to describe systems from structural and behavioral viewpoints. To show the IS application at the tactical decision level, an ITN real case study is considered and simulated.

■ TC-29

Tuesday, 12:20-13:40
8.2.11

Theory of Boolean Functions

Stream: Boolean Programming
Invited session

Chair: *Gyorgy Turan*, Math., Stat. and Comp. Sci., Univ. of Illinois at Chicago, 851 S.Morgan, M/C 249, 60608-7045, Chicago, IL, United States, gyt@uic.edu

1 - The arity gap of functions of Boolean variables and lattice polynomial functions

Miguel Couceiro, Mathematics, University of Luxembourg, University of Luxembourg, FSTC, 6, rue Richard Coudenhove-Kalergi, L-1359, Luxembourg, Luxembourg, miguel.couceiro@uni.lu

In this talk we consider the problem of determining the minimum decrease in the number of essential variables of a given function f when variables of f are identified (the so-called arity gap of f). We will present complete classifications of Boolean and pseudo-Boolean functions according to their arity gap. Using these results we shall derive an analogous classification of polynomial functions over arbitrary distributive lattices, showing that the only polynomial functions having arity gap 2 are the truncated median functions, and all other have arity gap 1.

2 - Construction and learnability of canonical Horn formulas

Marta Arias, Llenguatges i Sistemes Informàtics, Universitat Politècnica de Catalunya, C Jordi Girona 1-3, 08034, Barcelona, Barcelona, Spain, marias@lsi.upc.edu

In the talk I will describe an alternative construction of an existing canonical representation for definite Horn theories, the Guigues-Duquenne basis (or GD basis), which minimizes a natural notion of implicational size. I will show how this canonical representation can be extended to general Horn, by providing a reduction from definite to general Horn. If time permits, I will also show a striking connection between a well-known learning algorithm for Horn formulae by Angluin, Frazier and Pitt and this canonical representation. This is joint work with José L. Balcázar.

3 - Essential sets and Horn minimization

Endre Boros, RUTCOR, Rutgers University, 08854, Piscataway, New Jersey, United States, Endre.Boros@rutcor.rutgers.edu, *Ondrej Cepek*, *Alex Kogan*, *Petr Kucera*

We introduce a biology motivated classification of the implicants of a Horn function, and derive consequences for the minimum representations.

4 - On the approximate minimization of Horn formulas

Gyorgy Turan, Math., Stat. and Comp. Sci., Univ. of Illinois at Chicago, 851 S.Morgan, M/C 249, 60608-7045, Chicago, IL, United States, gyt@uic.edu

We consider the complexity of approximately minimizing propositional Horn formulas. An inapproximability result is proved under a complexity theoretic assumption. An efficient approximation algorithm is given with a sublinear performance guarantee in the Steiner-minimization version, where new variables can be added in a restricted manner. The algorithm is based on a procedure for partitioning bipartite graphs. We also consider the case when only the original clauses are allowed to be used.

Joint work with Amitava Bhattacharya, Bhaskar DasGupta and Dhruv Mubayi.

■ TC-30

Tuesday, 12:20-13:40

8.2.13

PROMETHEE: Axiomatic basis and other issues

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues

Invited session

Chair: *Gabriela Fernández Barberis*, Quantitative Methods, San Pablo CEU University, 23, Julián Romea St., 28003, Madrid, Spain, Spain, ferbar@ceu.es

1 - Semi Orders, Interval Orders and Pseudo Orders Preference Structures in Multiple Criteria Decision Aid Method

Gabriela Fernández Barberis, Quantitative Methods, San Pablo CEU University, 23, Julián Romea St., 28003, Madrid, Spain, Spain, ferbar@ceu.es

During the last decades, an important number of Multicriteria Decision Aid Methods have been proposed to help the decision maker to select the best compromise alternative. Meanwhile, the PROMETHEE family of outranking method has attracted much attention from academics and practitioners. In this paper, an extension of these methods is presented, consisting of analyze its functioning under New Preference Structures (NPS). The preference structures take into account are, namely: semi-orders, intervals orders and pseudo-orders.

2 - D-sight: a new decision aid software

Quantin Hayez, SMG - Faculty of Engineering, ULB - Brussels Free University, Boulevard du Triomphe CP210/01, 1050, Brussels, Belgium, qhayez@ulb.ac.be, *Yves De Smet*, *Bertrand Mareschal*

D-Sight is a new software that implements the PROMETHEE & GAIA methods, including their newer extensions. It introduces new visual modelling tools and graphical representations of the results of the multicriteria analysis. The interaction with the decision-maker has been emphasized through several sensitivity analysis tools. Numerical examples will be used to illustrate the features of the software.

■ TC-31

Tuesday, 12:20-13:40

8.2.15

Network Planning in Postal Logistics

Stream: OR Applications in Industry

Invited session

Chair: *Hans-Jürgen Sebastian*, Deutsche Post Endowed Chair of Optimization of Distribution Networks, RWTH Aachen University, Templergraben 64, 52062, Aachen, Germany, sebastian@or.rwth-aachen.de

1 - Allocation of international long-haul transportation lanes to sorting centers at Deutsche Post

Christoph Hemsch, Deutsche Post DHL, Sträßchensweg 10, 53113, Bonn, Germany, Christoph.Hemsch@deutschepost.de, *Andreas Marschner*, *Thomas Müller*

Deutsche Post delivers about 2.5 million parcels in Germany every day. A smaller volume is exported to European countries via an international long-haul road network. The preparation for export of parcels for a European country is concentrated at one of the 33 national parcel sorting centers. Thus, international long-haul lanes to gateways in this country are starting at the corresponding national sorting center. The talk presents a mixed-integer model formulated to determine the potential of alternative allocations of the international lanes under demanding service-level requirements.

2 - A Strategic Model to Simultaneously Find Optimal Locations, Allocations and Flows in Complex Network Environments

Thomas Müller, Deutsche Post Chair of Optimization of Distribution Networks, RWTH Aachen University,

Templergraben 64, 52062, Aachen, Germany, Mueller@or.rwth-aachen.de, *Julia Hillebrandt*

We observe a very large-scale distribution network where distinguishable items have to be transported from sources to sinks. Since the total quantity is very big, but the quantity going from a certain source to a sink is quite small, it is useful to consolidate item flows in hubs. We introduce a strategic network design model that simultaneously finds optimal locations for consolidation facilities, optimizes network flows going through the facilities, and allocates sources and sinks to these flows. Even big instances are solved to optimality using a mixed integer linear programming solver.

3 - Scheduling of Long-Distance Transports in a Service Network with Capacity and Time Constraints

Tobias Winkelkotte, Deutsche Post Chair of Optimization of Distribution Networks, RWTH Aachen University, Templergraben 64, 52062, Aachen, Germany, winkelkotte@or.rwth-aachen.de, *Li Sun*

We talk about tactical transportation scheduling in logistics networks where locations and allocations are given. Due to vehicle capacities, there are usually several transports on each connection, which have to be achieved in such a short time period that some distances cannot be overcome within this time. Therefore, we introduce service level constraints, such that only a certain fraction of the transports must arrive on time. Big instances of the model are solved, and numerical results are presented.

4 - Optimization of Postal Transportation Networks based on Opposite Travel Mode

Li Sun, Institute of System Engineering, Southeast University, Nanjing, China, sunsuper@126.com

China's postal transportation network is a multi-layer network based on the Postal Center Office System. It is needed to design an appropriate structure for each sub-network according to its unique characteristics. In order to lower the unloaded ratio of vehicles during transportation, we apply the opposite travel mode (OTM) to structure the delivery network in local postal areas. Therefore we develop a non-linear 0-1 planning model and a corresponding heuristic algorithm to improve the operating costs of local postal networks. A simulation test is also presented.

■ TC-32

Tuesday, 12:20-13:40

8.2.17

OR in Agriculture and Forest Management

Stream: OR in Agriculture and Forest Management [c]

Contributed session

Chair: *Paulo Borges*, University Of Lisbon, Lisbon, Portugal, pjborges@gmail.com

1 - Multiple criteria and multiple objectives decision-making for a Brazilian sugar and ethanol milling company

Fernando Marins, Production, UNESP - São Paulo State University, Av. Ariberto Pereira da Cunha, 333, 12516-410, Guaratinguetá, SP, Brazil, fmarins@feg.unesp.br, *Valério Salomon*, *José Arnaldo Montevechi*, *Aneirson Silva*

This paper presents a Lexicographic Goal Programming model combined with Analytic Hierarchy Process, for the aggregate production planning, commercialization, and distribution in a Brazilian sugar and ethanol milling company. The model depicts the comprehensive production process of sugar, ethanol, molasses and derivatives, including decisions on agricultural steps such as cutting phases, sugarcane load and transport — and on industrial steps, mainly those related to crushing, type of production process, weekly production and storage, as well as the distribution and commercialization stages.

2 - Modelling farmers' decision-making using multi-attribute utility theory: a comparative analysis

Laura Riesgo, Dept. of Economics, Pablo de Olavide University, Ctra. Utrera km.1, 41013, Seville, Spain, laurariesgo@upo.es, *José A. Gómez-Limón*, *Jordi Gallego*

The aim of this paper is: a) Can farmers' MAUFs be considered as structural elements (constant in the short and medium term)?, and b) among the different MAUF specifications already implemented in empirical studies, which one better fit farmers' behavior? Only answering the first question affirmatively, the MAUT can be considered a useful approach to simulate ex-ante agricultural systems' response to hypothetical future scenarios (policy reforms, etc). If this is the case, the response of the second question could help analysts to build more accurate models choosing the most realistic MAUF.

3 - A Model for Participative Forest Management in the Mediterranean Area

Concepcion Maroto, Estadística e Investigación Operativa, Universidad Politécnica de Valencia, Camino de Vera S/N, 46022, Valencia, Valencia, Spain, cmaroto@eio.upv.es, *Concepción Ginestar*, *Juan Uriol*, *Baldomero Segura*, *Juan Fernando Usó*

Decision making in the strategic management of public forest is a complex problem due to two factors. Firstly, public administrations need to balance several economic, environmental and social criteria and secondly, they should carry out a participation process with the different social groups or stakeholders involved. In this work we propose a model for strategic management of public forests in a Mediterranean area. This model integrates multiple criteria and group decision making techniques.

4 - Decision Analysis to address risk when assessing impacts of Agro Forestry Policies and Economic Scenarios - a Case Study in Southern Portugal.

Paulo Borges, University Of Lisbon, Lisbon, Portugal, pjaborges@gmail.com, *Brigite Botequim*, *Jose Borges*, *Jordi Garcia_Gonzalo*, *Rui Fragoso*

This paper demonstrates the use of a Decision Analyses approach to address risk when assessing impacts of Common Agricultural Policy (CAP) and/or of prices on land use patterns in rural areas. For testing and demonstration purposes, this research considered an application to the Alentejo, region in Southern Portugal, encompassing 31 farm types extending over 2106 ha. The approach was integrated in a Decision Support System (DSS) to generate scenarios and corresponding decisions and to analyze solutions. Results show the usefulness and relevance of the proposed approach.

■ TC-33

Tuesday, 12:20-13:40
8.2.19

Energy Planning Models

Stream: Energy, Environment and Climate

Invited session

Chair: *Carlos Henggeler Antunes*, DEEC, University of Coimbra and INESC Coimbra, Rua Antero de Quental 199, 3000-033, Coimbra, Portugal, ch@deec.uc.pt

1 - Risk Diffusion in Natural Gas Networks

Parviz Darvish, Operations Management, ESSEC Business school, Avenue Bernard Hirsch, BP 50105, Cergy, 95021, Cergy Pontoise cedex, Val d'Oise, France, parviz.darvish@essec.fr, *Fernando Oliveira*

Natural gas is a strategic source of energy to Europe as in many countries, it is essential for producing electricity, residential and industrial consumption. The infrastructure required to store, transfer, distribute and deliver natural gas to consumers is complex and exposed to many risks including demand uncertainty and supply disruptions due to natural disasters, terrorist attacks, or political conflicts. In this paper we study alternative topologies of the network, analyzing how risk averse, profit-maximizing firms, are affected by different risk factors in different areas of the network.

2 - A multi-sectoral multiobjective model with interval coefficients to study E3 interactions

Carla Henriques, INESC Coimbra, Rua Antero de Quental, 199, 3000-030, Coimbra, Portugal, coliv@inescc.pt, *Carlos Henggeler Antunes*

Multi-sectoral economy-energy-environment (ME3) models enable a prospective analysis of the economic structure and the energy system, including the environmental impacts, for decision support in policy making. Multiobjective (MO) approaches provide a framework for dealing with the conflicting axes of evaluation in sustainability problems. MO linear programming models based on input-output analysis are used to study the interactions between those concerns. A MOLP ME3 model with interval coefficients to capture the uncertainty of the coefficients is proposed for assessing E3 impacts of distinct policies.

3 - Flexible design of sustainable energy systems under uncertainty

Gonçalo Pereira, DEM - Departamento Engenharia Mecânica, Instituto Superior Técnico, Lisbon, Portugal, goncalo.duarte.pereira@ist.utl.pt, *Alexandra Moutinho*, *Carlos Silva*

The design of sustainable energy systems requires that decision makers have access to a planning tool to evaluate different investment scenarios, taking into account the uncertainty of different parameters in order to decide upon what, how and when investments should be made. This paper presents a long-term energy planning tool that proposes flexible investment strategies, allowing the evaluation of which is the best option under different scenarios that describe different uncertain parameters. The tool uses a short-term energy model to take into account the dynamics of renewable resources.

4 - Analyzing the Impact of Wind Power in the Electricity Market Prices of Portugal

Ruben Ramalho, IN+ Center for Innovation, Universidade Técnica de Lisboa, Taguspark Campus of IST - Av. Prof. Dr. Aníbal Cavaco Silva, 2744-016, Porto Salvo, Portugal, ruben.s.ramalho@ist.utl.pt, *Filipa Amorim*

The main goal of this paper relies in determining this balance for the wind power technology in the Portuguese wholesale electricity market. A secondary goal is to determine the economic benefits of wind power technology related to GHG emissions and associated costs for the Portuguese power system. Finally, a third goal is to make an overall balance considering the impact of wind technology in the total costs of the Portuguese power system that include private investment in generation capacity, RES support schemes costs, operation costs and the wind effect in the wholesale market prices.

■ TC-34

Tuesday, 12:20-13:40
8.2.23

Generalized Convexity I

Stream: Convex Optimization

Invited session

Chair: *Gyula Maksa*, Department of Analysis, University of Debrecen, Institute of Mathematics, University of Debrecen, 4010, Debrecen, Hungary, maksa@math.klte.hu

1 - Pseudoconvexity of the ratio between a quadratic function and an affine function on the non-negative orthant

Laura Martein, department of statistics and applied mathematics, University of Pisa, via Ridolfi, 10, 56124, Pisa, Italy, lmartein@ec.unipi.it

The pseudoconvexity of the ratio f of a quadratic function and an affine one has been recently characterized on the domain D corresponding to the positivity of the denominator. Motivated by the fact that in optimization problems the decision variables are often required to be non-negative, in this paper we will characterize, firstly, the maximal domains of pseudoconvexity of f and, successively, we will specialize the obtained results in order to obtain conditions which guarantee that the maximal domains of pseudoconvexity of f contain the non-negative orthant. At last, some methods are suggested for constructing pseudoconvex functions which are the ratio of a quadratic function and an affine one.

2 - A class of generalized convex functions: optimality and duality results

Laura Carosi, Statistics and Applied Mathematics, University of Pisa, Via Ridolfi, 10, 56124, Pisa, Italy, lcarosi@ec.unipi.it, *Riccardo Cambini*

We introduce a class of generalized convex functions and we analyze its relationships with the generalized convex properties commonly studied in the literature. In particular, the proposed class is compared with the ones of invex and generalized invex functions. The new property is used to derive necessary and sufficient optimality conditions and to obtain duality results for vector optimization problems.

3 - Bernstein-Doetsch type results for h-convex functions

Attila Háyzy, Department of Applied Mathematics, University of Miskolc, Miskolci Egyetem, 3515, Miskolc-Egyetemváros, Hungary, matha@uni-miskolc.hu

In our talks we introduce the more general concept of the h-convexity, and the concept of the so called (H,h)-convexity. This type of h-convexity is a common generalization of the usual convexity, the Godunova-Levin functions, the Breckner s-convex functions and the so called P-functions.

The main goal of the talk is to prove some regularity and Bernstein-Doetsch type result for h-convex and (H,h)-convex functions. We also collect some facts on such functions and collect some interesting, easily-proved properties of h-convex functions.

4 - Regularity and convexity results on approximately h-convex functions

Pál Burai, Applied Mathematics and Probability Theory, University of Debrecen, Faculty of Informatics, Pf.: 12., 4010, Debrecen, Hungary, burai.pal@inf.unideb.hu, *Attila Háyzy*

In 1915 Bernstein and Doetsch proved the following: if a Jensen-convex function is bounded from above at a point of its domain, then it is continuous on the whole domain and convex. The main goal of this talk to prove a Bernstein-Doetsch type result on approximately h-convex functions.

TC-35

Tuesday, 12:20-13:40

6.2.46

Researching Facilitated Modelling

Stream: Facilitated Modelling in OR

Invited session

Chair: *Etiënne Rouwette*, Thomas van Aquinostraat 1.2.33, PO Box 9108, 6500 HK, Nijmegen, E.Rouwette@fm.ru.nl

1 - Shifting Perspectives from the Individual- to the Team-Level: The Role of Mental Model Convergence

Sara McComb, Texas A&M University, United States, mccomb@tamu.edu

How do individuals become team members? Why do teams that appear to be similar have very different outcomes? Understanding mental model convergence may provide insight into these types of questions. Individual team members create cognitive frameworks that facilitate team collaboration and converge across members over time. This paper describes the convergence process, as it may explain how team members shift their perspectives from the individual- to the team-level, and presents empirical results demonstrating the relationship between the convergence process and effective performance.

2 - Exploring the role of Cognitive Style on the Structuring and Definition of Ill-structured Management Problems.

L. Alberto Franco, Warwick Business School, University of Warwick, ORIS Group, Gibbet Hill Road, CV4 7AL, Coventry, United Kingdom, alberto.franco@warwick.ac.uk, *Luiz Felipe Nasser-Carvalho*

We report preliminary findings from a quasi-experimental field study on the role of managers' Need for Cognition and Need for Closure on characteristics of their: a) causal problem representations, b) problem definitions and, c) attitudes towards structuring ill-structured problems.

The findings suggest that while Need for Cognition influences positively managers' confidence in, and enjoyment of their structuring efforts, Need for Closure hinders managers' understanding of ill-structured problems. Implications for research and practice of Problem Structuring Methods are discussed.

3 - Strategy Maps as a Tool to Support Strategic Management — How to Optimally Map Your Strategy

Melanie Windolph, Chair of Management Accounting and Control, University of Goettingen, Platz der Goettinger Sieben 3,

37073, Goettingen, Germany, melanie.windolph@wiwi.uni-goettingen.de, *Judith Huelle*, *York Hagmayer*, *Klaus Moeller*

The study's purpose is to analyze main problems when creating strategy maps for supporting strategy's implementation. To examine key problems in the creation process, we conducted two experiments with students from the university of Goettingen and managers from the automotive industry. The results indicate that while participants did choose strategic goals covering global and specific aspects of the firm's strategy, they repeatedly failed in defining the main relations between the goals. Furthermore, participants' self-assessment was significantly better than the maps' objective evaluation.

4 - Decision Development in Facilitated Modelling Workshops

Etiënne Rouwette, Nijmegen School of Management, Radboud University Nijmegen, 6500 HK, Nijmegen, Netherlands, e.rouwette@fm.ru.nl, *L. Alberto Franco*

Facilitated modelling has its most direct impact on the way a convened group of participants produce their decisions. By facilitating the decision development process, and capturing the content of group discussions in the form of models, we attempt to provide effective group decision making support. Despite its central role in assisting the group decision development process, limited attention has been paid to this dimension in the literature of facilitated modelling. Indeed, although a large number of published cases studies of facilitated modelling interventions are available, the majority of these studies do not provide any detail below the level of the modelling workshop; that is, modelling procedures and general outputs and outcomes may be described but there is no portrayal of the decision development process within the workshop. To address this gap, we map the different conceptualisations of decision development that seem embedded within the facilitated modelling tradition, and contrast them with well-established theoretical models from the group communication field. Our analysis identifies a number of research possibilities for the study of facilitated modelling workshops from a decision development perspective, and suggests a research strategy that can help to further develop facilitated modelling theory and practice. Central to this strategy are interaction coding and analysis methods for the examination of facilitated modelling workshops. By adopting such a research strategy we show how a decision development focus can increase our understanding of the rich and complex nature of facilitated modelling 'as it happens'.

TC-36

Tuesday, 12:20-13:40

3.1.05

Fuzzy Decision Making and Applications

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence [c]

Contributed session

Chair: *Burcu Caglar*, Industrial Engineering, Uludag University, Uludag University Dept. of, Industrial Engineering Gorukle Campus, 16059, Bursa, Turkey, burcucaglar@gmail.com

1 - Fuzzy Reactive Project Scheduling

Dorota Kuchta, Informatics and Management, Wrocław University of Technology, ul. Smoluchowskiego 25, 50-372, Wrocław, Poland, dorota.kuchta@pwr.wroc.pl

In the literature no methods of project schedule control and modification (i.e. for reactive project scheduling) are known for the case of fuzzy activities duration times. We will propose a method of performing project control at regular time intervals and of updating the project schedule using updated information about the actual crisp duration of finished activities and about the (less and less) fuzzy duration of unfinished activities, as well as about the (also less and less) fuzzy number of available resources.

2 - Determining Strategic Priorities With Fuzzy TOPSIS Method

Ihsan Yüksel, Business Administration, Kirikkale University, Kirikkale University, IIBF, 71450, Kirikkale, Turkey, yuksel@kku.edu.tr, *Metin Dagdeviren*, *Erdem Aksakal*

Companies, under the series affect of inhibitive and incentive factors, try to achieve their goals with limited financial (stock, equity capital, business capital) and non-financial (human resources, knowledge, competence) resources. This can be possible after determining the strategic priorities of the company. The aim of this study is to determine the company strategies with fuzzy TOPSIS technique which depends on the strengths and weaknesses caused by internal environment, opportunities and threats caused by external environment.

3 - Multifactor Bullwhip Effect Analysis Using Fuzzy Model

Ronay Ak, Industrial Engineering, Istanbul Technical University, Istanbul Teknik Universitesi, Isletme Fakultesi, Endüstri Muhendisligi Bolumu, 34367, Istanbul, Turkey, ronay_ak@yahoo.com, *Gulgun Kayakutlu*, *Cafer Ethan Bozdog*

Bullwhip Effect (BWE) studies are focused on either the causes or the solutions of demand fluctuations. This study aims to measure the effects of demand and lead time fluctuations on a typical Supply Chain (SC) of three echelons representing supplier, manufacturer and retailer. In such a Supply Chain, demand is analyzed upstream despite the lead time flows downstream. Contribution of this study is the analysis of integrated fuzzy demand-lead time model. The proposed model will give an opportunity for better Supply Chain plans.

4 - Statistical Procedures for Robotic Assembly Line Balancing Problems

Burcu Caglar, Industrial Engineering, Uludag University, Uludag University Dept. of, Industrial Engineering Gorukle Campus, 16059, Bursa, Turkey, burcucaglar@gmail.com, *H. Cenk Özmutlu*, *Ali Yurdun Orbak*, *Seda Ozmutlu*

Robotic systems have been an essential part of assembly lines, because of their advantages such as flexibility and automation. This study presents an application of type II robotic assembly line balancing (rALB-II) problem, in which the assembly tasks have to be assigned to robots. In order to maintain a balanced workload while achieving a desired production cycle time, a fuzzy clustering based algorithm is employed for the job assignment problem. The proposed algorithm is applied to a real robotic assembly line system and its advantages over the existing system is explained.

TC-37

Tuesday, 12:20-13:40

3.1.09

Models for Decision 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: *Pascale Zaraté*, Institut de Recherche en Informatique de Toulouse, Toulouse University, 118 route de Narbonne, 31062, Toulouse, France, zarate@irit.fr

1 - Influence of the criteria in the bayesian ahp

Pilar Gargallo, Facultad de Económicas, Universidad de Zaragoza, Gran Vía 2, 50005, Zaragoza, Spain, pigarga@unizar.es, *José María Moreno-jimenez*, *Alfredo Altuzarra*

This work proposes different methodologies for measuring the influence of a set of criteria on the final priorities of the Analytic Hierarchy Process (AHP) in a global context (a hierarchy). The priorities have been obtained by means of the Bayesian prioritization procedure of Altuzarra et al. (2007). Cross-validation methods have been used when measuring the influence. The methodology is illustrated by means of an empirical example.

2 - Structuring and assessing large and complex decision problems using MCDA

Michael Bruhn Barfod, Department of Transport, Technical University of Denmark, Bygningstorvet, Building 115, DK-2800, Kgs. Lyngby, Denmark, mbb@transport.dtu.dk, *Steen Leleux*

This paper presents an approach for the structuring and assessing of large and complex decision problems using multi-criteria decision analysis (MCDA). The MCDA problem is structured in a decision tree and assessed using the REMBRANDT technique featuring a procedure for limiting the number of pair wise comparisons. A case study dealing with the structuring and prioritisation of projects from a large pool with limited funds is used for illustrating the approach. Finally, strengths and weaknesses in the MCDA approach are discussed and conclusions are made.

3 - Transitioning the Multistatic Tactical Planning Aid (MSTPA) towards Decision Support

Christopher Strode, Systems and Technology, NATO Undersea Research Centre, Viale S. Bartolomeo 400, 19126, La Spezia, Italy, strode@nurc.nato.int

The MSTPA tool is a multistatic sensor model able to determine the probability of detection, track holding, and classification of a target. This report surveys the approaches to be taken in order to transition the model towards decision support, that is, one that not only determines a performance measure for a proposed network geometry, but one that must determine an optimum geometry for a given scenario. This transition will require the addition of data mining, optimization and game theory modules to assist the operator in making the most informed decision.

TC-38

Tuesday, 12:20-13:40

6.2.44

Stochastic Valuation of Derivatives and Commodities II

Stream: Stochastic Valuation for Financial Markets

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Henrik Andersson*, Accounting, Stockholm School of Economics, P.O. Box 6501, 113 83, Stockholm, Sweden, Henrik.Andersson@hhs.se

1 - Pricing and Positioning of Remanufactured Products Using a Nested Logit Model

Necati Aras, Industrial Engineering, Bogazici University, Bebek, 34342, Istanbul, Turkey, arasn@boun.edu.tr, *Esra Mutlu*, *I. Kuban Altinel*

We focus on the selection of remanufactured products to be offered by a firm in addition to the existing brand-new versions. We develop a mixed-integer nonlinear programming formulation using nested logit model to determine the product's best prices so that the firm's profit is maximized. The model is solved by decomposing it into two sub-problems. The pricing sub-problem is solved by a modified simplex search procedure whereas the product selection problem is solved via complete enumeration. Using an extended model, we also find the optimal quality level of the remanufactured products.

2 - Comparative Evaluation of the Unique Elements in the Evolution of e- and m- Auctions

Charis Marentakis, Dept. of Industrial Management and Technology, University of Pireaus, Karaoli and Dimitriou Street, 18534, Pireaus, Greece, chmarent@unipi.gr, *Dimitrios Emiris*

The evolution of auctions conducted over the Internet and mobile networks (e and m auctions, resp.) created an interdisciplinary research area, combining Economics, OR, Information Technology and Communications (ICT). We bridge the gap between design mechanisms and ICT infrastructure. It employs an evolutionary, 3-level auction classification model to progressively determine the mechanism and adapts it to an e and/or m context. The unique design elements for each auction class are compared. Findings are tested and evaluated in a pragmatic freight transport services setting.

3 - When operating cash flows are mean-reverting

Henrik Andersson, Accounting, Stockholm School of Economics, P.O. Box 6501, 113 83, Stockholm, Sweden, Henrik.Andersson@hhs.se

This paper deals with investment analysis of mean-reverting cash flows and changing levels of utilization in the forest industry. Generally, mean-reversion enhances the value of a basic project and reduces the value of managerial flexibility due to less uncertainty. However, the outcome is crucially dependent upon whether the equilibrium price is above or below today's price. A generalized version of the Feynman-Kac formula is applied but as option modeling is no success in the business community, a rough cut approximation is suggested as a comparison to standard DCF-valuation.

4 - Progressive Design of Auctions for Freight Transportation Services

Ilias Petridis, Economic&Business Strategy, University of Piraeus, 94, Thoukididou str, 17455, Alimos - Athens, Greece, ilias_lat@yahoo.gr, *Dimitrios Emiris*, *Charis Marentakis*

Pricing and service composition through auctions is of great importance for the major stakeholders in the freight business, carriers and shippers. We stress the need for systematic design of complex auction mechanisms for freight transportation and describe a progressive auction mechanism development model. The model may be used as an evolutionary design template to standardize the auction design process, as a tool for the logistician to initiate an auction, to procure transportation services or to participate in auction-based marketplaces to trade for logistics services.

■ TC-39

Tuesday, 12:20-13:40

6.2.45

Optimal Control: Recent Advances I

Stream: Optimal Control

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Optimal Pricing of a Conspicuous Product During a Recession

Gustav Feichtinger, Institute for Mathematical Methods in Economics, Vienna University of Technology, Argentinierstr. 8/105-4, 1040, Vienna, Austria, gustav@eos.tuwien.ac.at, *Jonathan Caulkins*, *Dieter Grass*, *Peter M. Kort*, *Richard Hartl*, *Andrea Seidl*

The paper considers the problem of how to price a conspicuous product, when the economy is in recession, which is modeled as having two effects: it reduces demand and it freezes capital markets so borrowing is not possible. The firm faces the following trade-off. On the one hand it feels pressure to reduce the price to maintain sales volume in the face of reduced demand. On the other hand, reducing the price damages brand image and thus long term demand. It will be shown that a decision maker has to adapt the pricing strategy according to the severity of the recession.

2 - A Maximum Principle in Mixed Constrained Optimal Control Problems under Weakened Assumptions of Regularity

Dmitry Karamzin, FEUP, University of Porto, Porto, 4200-537, Porto, Portugal, dmitry_karamzin@mail.ru, *Aram Arutyunov*, *Fernando Pereira*

In the present work optimal control problems with mixed constraints are investigated. A novel weakening of the conventional regularity assumptions on mixed constraints is introduced. A maximum principle is derived in which the maximum condition is of nonstandard type: the maximum is taken over the closure of the set of regular points, but not over the whole feasible set.

3 - Time Reparameterization in Optimal Control of Hybrid Dynamic Systems

Maxim Staritsyn, Laboratory of Systems Analysis and Computational Methods, Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, 664033, Lermontov St., 134, Irkutsk, Russia, 664033, Irkutsk, Russian Federation, starmax@bk.ru

We address an optimal control problem for a hybrid dynamic system where the jumps of a trajectory may occur only if it hits a given surface. Such a system can be regarded as an impulsive one. A discontinuous time reparameterization techniques is suggested to reduce this problem to a problem with bounded controls under phase and functional constraints. By extending a solution concept we show that the reduced problem is equivalent to the optimization in the class of generalized solutions to the hybrid dynamic system.

4 - Sustainability, Optimality, and Viability in the Ramsey model

Noel Bonneuil, Ined-Ehess, 133, bld Davout, 75980, Paris, France, bonneuil@ined.fr

Viability in the Ramsey model is presented with a constraint of minimal consumption, then with an additional criterion of economic sustainability. The comparison of viability kernels with or without sustainability shows how much consumption should be reduced and when. The viable-optimal solution in the sense of inter-temporal consumption is obtained on the viability boundary of an auxiliary system. Technological progress works against population growth to favor the possibility for a given state of being viable or viable-sustainable.

■ TC-41

Tuesday, 12:20-13:40

3.1.06

Applications of System Dynamics Modeling II

Stream: System Dynamics Modeling

Invited session

Chair: *Markus Schwaninger*, Institut für Betriebswirtschaft, Universität St.Gallen, St.Gallen, Switzerland, markus.schwaninger@unisg.ch

1 - Exploring Anti Counterfeiting Strategies: Making the Case for Quantitative Strategy Evaluation and System Dynamics

Oliver Kleine, Industry and Service Innovations, Fraunhofer Institut for Systems and Innovation Research, Breslauer Straße 48, 76139, Karlsruhe, Germany, oliver.kleine@isi.fraunhofer.de, *Marcus Schröter*

Today, product counterfeiting and piracy are fully recognized as essential business risks to nearly any industry. However, as this scourge is prevailing, the strategies proposed to counter this threat often fail to yield the expected success when deployed in a company's specific business context. Besides still open issues in understanding the dynamic complexity of this phenomenon, it is in particular decision support tools that stand for an immediate management need. This paper elaborates on a previous contribution and extends the presented system dynamics framework for strategy evaluation.

2 - Urban water consumption management Using System dynamics

M Reza Abdi, School of Management, Bradford University, Emm Lane, BD9 4JL, Bradford, West Yorkshire, United Kingdom, r.abdi@bradford.ac.uk

The purpose of this paper is to develop a methodology for monitoring water consumption that highlights possible water saving strategies. The paper presents the process of building a system dynamics model of water consumption management using the VENSIM software. The model provides a formal causal-descriptive framework along with computer simulation for the analysis of dynamic, complex and socio-economic water consumption problems, which includes feedback loops and dynamic relationships over the time. In particular, the computer simulation methodology provides an experimental platform for the water consumption problems through a case study, and illustrates engagement of managerial roles with the society to establish the water efficiency strategies.

3 - Modelling of the Economic Crisis: Have We Learn the Lesson?

Markus Schwaninger, Institut für Betriebswirtschaft, Universität St.Gallen, St.Gallen, Switzerland, markus.schwaninger@unisg.ch, *Stefan Groesser*

The current economic crisis could deliver valuable lessons for economic agents. However, it seems that those have not learned essential lessons, continuing their "business as usual". A dynamic simulation model presented in this chapter highlights that this is likely to lead to the next crunch in the offing. Even before we have mastered this crisis the next one is already looming. Does prevention have a chance? How can it be achieved?

■ TC-42

Tuesday, 12:20-13:40

3.1.07

Data Mining and Forecasting

Stream: Data Mining and Applications [c]

Contributed session

Chair: *Vadim Strijov*, Computing Center of the Russian Academy of Sciences, Klara Zetkin 13-79A, 127299, Moscow, Russian Federation, strijov@ccas.ru

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

1 - Improving Forecasting Performance: A Meta-Model Approach

Coskun Hamzaçebi, Industrial Engineering, Karadeniz Technical University, Kanuni Campus, 61000, Trabzon, Turkey, hamzacebi@ktu.edu.tr, *Alper Aytekin*, *M.Fatih Bayramoglu*

Although there are some techniques used for time series forecasting, none of them is not the best in all situations. In this study, in order to improve forecasting performance an easy meta-model is proposed. Proposed model is tested with real-world and simulation time series.

2 - Forecasting consumption of bulk customers with frequent tank level readings

Natanel Sadres, Artelys, 75002, Paris, France, natanel.sadres@artelys.com, *Emmanuelle Patay*, *Louis-Philippe Kronek*, *Marie-Éléonore Marmion*

Air Liquide distribution of bulk products, as Oxygen, is structured by areas grouping hundreds of customers for which required deliveries have to be determined every day. It is critical to maintain a minimum quantity of product within vessels. Hence, it is crucial to have a continuous estimation of the consumption of each customer. Air Liquide and Artelys co-developed a forecasting method for this real-life challenge. An exponential smoothing model completed with a linear auto-regressive model has been coupled with physical-based pre-processing rules to provide an efficient adaptive method.

3 - Model generation for equity-futures spread forecasting

Roman Sologub, Innovations and High Technology, Moscow Institute of Physics and Technology, 508, 86, Altufievskoe sh., Moscow, 127349, Moscow, alucardische@gmail.com

The investigated problem is to make a short-term forecast of the equity futures price relative difference. This forecast is a part of the optimal in-day statistical arbitrage trade strategy. To make this forecast we use the model-generation approach. A model maps historical prices to future spread values. The model is defined by a set of superpositions of smooth functions. The model quality is calculated by the back-test. The model of the optimal structure was deployed on the real market. The results are compared with government bonds.

■ TC-43

Tuesday, 12:20-13:40

8.2.02

Global Optimization 1

Stream: Global Optimization

Invited session

Chair: *Leocadio G. Casado*, Computer Architecture and Electronics, Universidad de Almería, Ctra Sacramento s/n, La Canada de San Urbano, 04120, Almería, Spain, leo@ual.es

1 - On interval Branch-and-Bound for separable functions with common variables

Jose Luis Berenguel, Computer Architecture and Electronics, Universidad de Almería, Ctra. Sacramento s/n, La Cañada de San Urbano, 04120, Almería, Spain, jlberenguel@gmail.com, *Leocadio G. Casado*, *Eliquis M.T. Hendrix*, *I. Garcia*, *Frederic Messine*

Interval Branch-and-Bound methods are powerful methods which aim for guaranteed solutions of Global Optimization problems. The computational effort to reach this aim increases exponentially with the problem dimension in the worst case. For separable functions this effort is less as lower dimensional subproblems can be solved individually. We investigate possibilities to design specific methods for cases where the objective function can be considered separable, but common variables occur in the subproblems.

2 - Multidimensional Scaling Based on Universal Evolutionary Global Optimizer and Quadratic Programming

Juana López-Redondo, Computer Architecture and Electronics, University of Almería, Carretera Sacramento, S/N, 04120, Almería, Spain, jlredondo@ual.es, *Pilar M. Ortigosa*, *Julius Zilinskas*

Multidimensional scaling is a technique for exploratory analysis of multidimensional data defined by pairwise dissimilarities between objects. An essential part of the technique is optimization of a continuous function possessing many optimization-adverse properties. In this work a two-level optimization algorithm has been applied with universal evolutionary global optimizer in the upper level and quadratic programming at the lower level. The developed algorithm has been experimentally investigated and the results show that it performs better than other algorithms tested.

3 - 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*

Completely Positive (CpPP) and Copositive Programming (CoP) formulations for the Constrained Fractional Quadratic Problem (CFQP) and Standard Fractional Quadratic Problem (StFQP) are introduced. Dual and Primal attainability are discussed. Semidefinite Programming (SDP) formulations are proposed for finding good lower bounds to these fractional programs. A global optimization branch-and-bound approach is proposed for the StFQP. Applications of the CFQP and StFQP, related with the correction of infeasible linear systems and eigenvalue complementarity problems are also discussed.

4 - Comparison of global and local meta modelling approximations for global optimization

Sergei Kucherenko, Centre for Process Systems Engineering, Imperial College London, SW7 2AZ, London, United Kingdom, s.kucherenko@ic.ac.uk, *Balazs Feil*, *Nilay Shah*

We consider global and local meta modelling approximations for global optimization. The global meta modelling approach is based on the Quasi Random Sampling - High Dimensional Model Representation method. It is capable of dealing with high dimensional, multimodal problems of low or moderate complexity. It is also can be used for global sensitivity analysis of the objective functions. Global sensitivity analysis is an efficient technique for model analysis and complexity reduction and as such can be used for designing efficient global optimization strategies. The radial basis function (RBF) method utilizing the local modelling strategy shows very good performance on complex test problems.

■ TC-44

Tuesday, 12:20-13:40

8.2.03

Interregional Security Work

Stream: Simulation Based Decision Support

Invited session

Chair: *Viveca Asproth*, Information Technology and Media, Mid Sweden University, 83125, Östersund, Sweden, viveca.asproth@miun.se

Chair: *Stig C Holmberg*, Information Technology and Media, Mid Sweden University, Mid Sweden University, ITM - Q351, 83125, Östersund, Sweden, shbg@ieee.org

1 - C4I2 for Interreg Security

Erik Borglund, Department of Information Technology and Media, Mid Sweden University, 87188, Härnösand, Sweden, erik.borglund@miun.se, *Lena-Maria Öberg*

Collaboration between interregional actors in crisis management is costly and difficult to practice on regular basis. We argue that crisis management needs to take into account the unknown. The uncertainty of future crisis makes training, practice and design of C4I2 systems a real challenge. In this paper we present one possible method, which could help us to design C4I2 systems that minimize the unanticipated risk. We propose a combination of scenario planning and the interaction design technology, personas, as the silver bullet that prepare us for the unknown and reduce uncertainty.

2 - Spatial Information for Interregional Security Work

Andreas Ring, DSV, ITM, Mittuniversitetet, Akademigatan 1, Hus Q, SE-83125, Östersund, Sweden, andreas.ring@miun.se, *Viveca Asproth*

Disaster management demands rapid and timely coordination, not only between members within a team and between different teams. A system for exchange of experiences and models of response to emergence situations within and between nations may impede the emergence response. In this paper spatial information for a computer system for disaster management is discussed. Questions to be answered are: Which spatial information is needed? What is already present and how accessible is it? How should the information be aggregated and presented?

3 - Soft Early Warning for Regional Security

Viveca Asproth, Information Technology and Media, Mid Sweden University, 83125, Östersund, Sweden, viveca.asproth@miun.se, *Stig C Holmberg*, *Christina Nyström*

Awareness and preparedness are identified as being of paramount importance for the security level in geographical regions. A regional security systems according to those insights are here seen as a soft early warning system (SEWS). In such a security SEWS each individual living in a region acts as a networked human sensor. Out conception of a regional security SEWS will be given as an idealised design.

4 - Business Simulator as a Tool to Improve Learning Process - Experimental Results

Mirosljub Kljajic, Faculty for organizational sciences, University of Maribor, Kidriceva cesta 55, 4000, Kranj, Slovenia, mirosljub.kljajic@fov.uni-mb.si, *Mirjana Kljajic-Borstnar*, *Andrej Skraba*, *Davorin Kofjac*

The methodology in the decision assessment of complex systems using simulation model is described. Students took part in the experiment with the task of solving a management problem. Experimental results were analyzed and discussed in the students' projects. After the experiment, students had to complete an opinion questionnaire. The results of Criteria Function and student's opinion support the hypothesis that simulation model application contributes to greater understanding of the problem and greater convergence in the decision-making process.

■ TC-45

Tuesday, 12:20-13:40
8.2.12

OR in Military I

Stream: OR in Military

Invited session

Chair: *Ana Isabel Barros*, Information & Operations, TNO - Defense, Security and Safety, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - Procurement Decision Support for Portuguese MoD: The MACBETH Approach and the Acquisition of 8x8 AWV

Carlos Bana e Costa, Engineering & Management, IST, Institute of Science and Technology, Technical University of Lisbon, Avenida Prof. Dr. Cavaco Silva, 2780-990, Porto Salvo, Portugal, carlosbana@ist.utl.pt, *Mario Simoes-Marques*

Since 2003 the Portuguese MoD is using MACBETH to support tender evaluation processes. The paper describes a joint acquisition program of AWV that involved harmonizing requirements; issuing Tender Program and Technical Specs; proposal analysis; tests; negotiations; BAFO evaluation and award contract to the globally most attractive proposal. The MACBETH methodology, previously adopted on large national and international tenders, proved to be a flexible, consistent and robust decision support tool

2 - Equipment procurement systems methodology - the military equipment selection

Irena Peharda, FOI, Croatia, peharda@hotmail.com

This paper presents an overview of the equipment procurement methodology, with the goal of aligning the equipment characteristics and organizational goals. The possibility of combining value-focused thinking, risk evaluation, and negotiation procedure based on analytical modeling, is considered, to improve alignment. The described alignment methodology is tested on a complex decision-making problem: the military equipment selection for the Croatian Armed Forces, the 8x8 Armored Wheeled Vehicles.

3 - Optimization of U.S. Army Equipment Readiness

Javier Salmeron, Operations Research, Naval Postgraduate School, 1411 Cunningham Rd, 93943, Monterey, CA, United States, jsalmero@nps.edu, *David Alderson*, *Robert Dell*, *Lee Ewing*

The U.S. Army has sought analysis and guidance in support of their efforts to achieve the readiness goals set by Army Regulation 220-1, which is intended to prepare each Army unit to meet its Modified Table of Organization and Equipment requirements. We develop Optimal Readiness Allocation Model, a mixed-integer mathematical optimization model that maximizes readiness across the force. Computational results for a problem with 1,900 units and 2,500 items demonstrate readiness can be significantly improved, even when restrictions on unit-to-unit redistributions are present.

4 - A cost effective spare parts package for military equipment deployment

Ana Isabel Barros, Information & Operations, TNO - Defense, Security and Safety, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl, *Nicole van Elst*, *Karin de Smidt-Destombes*, *Jan Hontelez*, *Harm Mulder*

Many of today's technological systems, such as military equipment are characterised by a high level of complexity and sophistication. The military context requires a guarantee of high availability, since the consequences of equipment downtime can have very serious repercussions and may lead to mission failure. In order to achieve a high level of availability, the availability of spare parts is essential. Therefore, during the initial period of military deployment, when the re-supply lines cannot be guaranteed, a deployment spares package is required. We present a method to determine a cost effective spare parts deployment package when the total amount of available systems (aircraft) is larger than the required number of systems and where only the required number of systems is used (cold stand by redundancy on system level).

■ TC-46

Tuesday, 12:20-13:40
8.2.14

Agent-based Modeling I

Stream: Agent-Based Modeling

Invited session

Chair: *Massimo Genoese*, Institute for Industrial Production, University of Karlsruhe, Hertzstraße 16, 76187, Karlsruhe, Germany, massimo.genoise@kit.edu

Chair: *Markus Günther*, Department of Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, markus.guenther@univie.ac.at

1 - Spatial social networks in an agent-based model of new product diffusion

Elmar Kiesling, Department of Business Administration, University of Vienna, Brünnerstraße 72, 1210, Vienna, Austria, elmar.kiesling@univie.ac.at, *Markus Günther*, *Christian Stummer*, *Rudolf Vetschera*, *Lea M. Wakolbinger*

In recent years, agent-based modeling has become a popular tool for investigating diffusion processes and forecasting innovation adoption. In such models, information exchange between consumer agents plays a crucial role because it forms "information cascades" that considerably impact the emergent adoption patterns. In this talk, we present an approach for generating geographically dispersed social networks using real-world population density data and discuss experiences from an application in an agent-based simulation of the market introduction of a new product.

2 - A Class of Random Asymmetric Multi-Agent Models for Innovation Diffusion

Christos Emmanouilides, Department of Economics, Aristotle University of Thessaloniki, 541 24, Thessaloniki, Greece, cemman@econ.auth.gr

The paper presents a class of statistical models for the diffusion of innovations in a social space consisting of individual agents that interact randomly with each other across spatial hierarchies over time. The dynamics of the models is studied through numerical simulations. Models have multiple equilibria and in some case more complex attractors. Under suitable restrictive assumptions reduced models are derived. These models can be estimated using longitudinal data techniques that result to consistent and efficient estimates of the effects of complex multi-agent interactions on diffusion.

3 - Organizational Innovativeness and Diffusion of Innovation

Xiaohui Shi, York Management School, University of York, Heslington Road, YO10 4DR, York, United Kingdom, xs518@york.ac.uk, *Kiran Fernandes*

This paper seeks to understand and simulate the diffusion process from an economic and agent based view. We consider innovativeness as a dynamic characteristic of a firm and therefore use geographical spatial data in our model. We present innovation as a dynamic 'element' that can be adopted by a firm based on their level of innovativeness and use real world data to simulate states that change over a period of time. Output of this work should be of value to both academics and practitioners who are keen to understand the dynamic nature of organizational innovativeness and the diffusion process

4 - Intra-firm knowledge diffusion and the emergence of innovations: An agent-based simulation approach

Markus Günther, Department of Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, markus.guenther@univie.ac.at, *Christian Stummer*

In this talk, we introduce an agent-based simulation approach that addresses intra-firm knowledge diffusion and its impact on the firm's innovativeness. The model extends prior research on the impact of network structure on knowledge diffusion in several aspects. First and foremost, it supplements (purely) knowledge-based measures by innovation-oriented ones. Furthermore, the simulation allows for various knowledge enhancing activities as well as information decay over time.

■ TC-48

Tuesday, 12:20-13:40

8.2.04

Nonlinear Optimization and Applications 1

Stream: Nonlinear Programming

Invited session

Chair: *Isabel Espírito Santo*, Production and Systems, Minho University, Campus de Gualtar, 4710-057, Braga, Portugal, iapinho@dps.uminho.pt

1 - Dengue in Cape Verde: modelling and optimal control

Helena Sofia Rodrigues, Escola Superior de Ciências Empresariais, Instituto Politécnico de Viana do Castelo, Av. Miguel Dantas, 4930-678, Valença, Portugal, sofiarodrigues@esce.ipv.pt, *M. Teresa Torres Monteiro*, *Delfim F. M. Torres*

The dengue is a vector-borne disease common in tropical areas. In 2009, for the first time, an outbreak of dengue was reported in Cape Verde and affected more than 20000 persons. This paper proposes a model for dengue disease, that includes human and mosquitoes components. The aim is to analyze the relationship between several controls and consequently the number of affected persons. The data used is from the episode that happened in Cape Verde (October to December 2009).

2 - Offline Biplot Analysis of Nondominated Sets in Multi-objective Engineering Optimization

Lino Costa, Dept. Production and Systems, University of Minho, School of Engineering, Campus de Gualtar, 4710-057, Braga, Portugal, lac@dps.uminho.pt, *Pedro Oliveira*

Real-world problems often involve a large number of objectives. Several multi-objective evolutionary algorithms have emerged to tackle problems with increasing number of objectives. However, the representation and visualization of the nondominated sets is not simple since a large amount of information is involved. Thus, there are enormous difficulties concerning the decision making process. A methodology based on Biplot graphical representations is proposed to retrieve information from nondominated sets obtained for several engineering optimization problems.

3 - Comparison of Classic and Multi-objective Genetic Algorithms for Optimal Design and Control of Chemical Processes

Silvana Revollar, Universidad Simón Bolívar, 89000, Sartenejas, Venezuela, srevolla@usb.ve, *Rosalba Lamanna*, *Pastora Vega*, *Mario Francisco*

This work deals with the application of a methodology based on multiobjective genetic algorithms for the optimal design and control of chemical processes. The mathematical formulation results into a mixed-integer non linear dynamic optimization problem. In the proposed multi-objective GA the economic costs and dynamic performance indices are considered as separated optimization objectives. The activated sludge process is used to test the GA performance, comparing the multi-objective formulation to the classical one where only economic costs are optimized.

4 - Collision Avoidance for the ATM problem: A mixed 0-1 nonlinear approach

Francisco Javier Martin-Campo, Statistics and Operations Research, University Rey Juan Carlos, C/ Tulipán s/n, Departamental II Building, Office 045., 28933, Móstoles, Madrid, Spain, javier.martin.campo@urjc.es, *Laureano Fernando Escudero*, *Antonio Alonso-Ayuso*

The main objective of this work is tackling the Collision Avoidance Problem applied to the air traffic. We propose a mixed 0-1 nonlinear model that will be solved by using Taylor approximations for the nonlinear constraints, integrated into a simple algorithm based in a few iterations. This model is able to provide the best strategy for an arbitrary aircraft configuration such that the conflicts in the airspace are avoided, minimizing the acceleration changes, and forcing to return to the initial flight plan when no aircrafts are in conflict.

Tuesday, 14:00-15:20

■ TD-01

Tuesday, 14:00-15:20

Aula Magna

Keynote Talk 8

Stream: Keynote Speakers

Invited session

Chair: *David Pisinger*, DTU Management, Produktionstorvet 424, 2800, Kgs. Lyngby, Denmark, pisinger@diku.dk

1 - Can the computer make scientific discoveries?

Pierre Hansen, MQG, GERAD and HEC Montreal, 3000 Chemin de la Cote-Sainte-Catherine, H3T 2A7, Montreal, Quebec, Pierre.Hansen@gerad.ca

Is there a systematic method leading to scientific discovery? To this question, Francis Bacon answers yes, while both Albert Einstein and Karl Popper answer no. As in so many cases, enormous progress in computer power, and in its efficient use, renew the question. Taking examples from geometry, graph and number theory, physics and chemistry, we will illustrate some clear successes (and some failures). This will lead to some speculation on the balance between automation and inspiration in discovery.

■ TD-02

Tuesday, 14:00-15:20

3.2.14

Topics in Combinatorial Optimization

Stream: Combinatorial Optimization [c]

Contributed session

Chair: *Marek Libura*, Systems Research Institute, Polish Academy of Sciences, Newelska 6, 01-447, Warszawa, Poland, libura@ibspan.waw.pl

1 - Robustness analysis in combinatorial optimization.

Marek Libura, Systems Research Institute, Polish Academy of Sciences, Newelska 6, 01-447, Warszawa, Poland, libura@ibspan.waw.pl

We consider the generic combinatorial optimization problem in which the set of feasible solutions is fixed, but the weights of the ground set elements may vary. For such a problem we study subsets of weights for which an initially optimal solution remains robust. Our approach is therefore a natural extension of the standard stability analysis. We present results concerning the robustness region, robustness radius and robustness tolerances, which are defined as direct analogues of the stability region, stability radius and stability tolerances considered in the sensitivity analysis framework.

2 - Cooperative Cuts: Graph Cuts with Submodular Edge Weights

Stefanie Jegelka, Empirical inference, Max Planck Institute for Biological Cybernetics, Spemannstr. 38, 72076, Tuebingen, Germany, jegelka@tuebingen.mpg.de, *Jeff Bilmes*

We introduce cooperative cut, a minimum cut problem whose cost is a submodular function on sets of edges: the cost of an edge that is added to a cut set depends on the edges in the set. Applications are e.g. in probabilistic graphical models and image processing. We prove NP hardness and a polynomial lower bound on the approximation factor, and upper bounds via four approximation algorithms based on different techniques. Our additional heuristics have attractive practical properties, e.g., to rely only on standard min-cut. Both our algorithms and heuristics appear to do well in practice.

3 - New formulations for the k-club problem — a comparative study

Maria Almeida, Instituto Superior de Economia e Gestão-UTL/Centro de Investigação Operacional, Rua do Quelhas, 6, 1200-781, Lisboa, talmeida@iseg.utl.pt, *Filipa Carvalho*

A k-club is a clique relaxation which represents a dense structure in a graph if k is small (a 1-club is simply a clique). Finding a maximum cardinality k-club is NP-hard for any k. In this talk two types of formulations for the k-club problem are considered: formulations with node variables only and formulations that combine them with edge variables. We show how to strengthen these formulations with valid inequalities and how to embed the strengthened models in exact and heuristic algorithms to solve the problem. Comparative computational results are presented.

4 - Solving the Quadratic Assignment Problem by Means of General Purpose Mixed Integer Linear Programming Solvers

Huizhen Zhang, Statistics and Operations Research, Rey Juan Carlos University, C/ Tulipán s/n, 28933, Móstoles, Madrid, Spain, zhzyyz@gmail.com, *Cesar Beltran-Royo*

The Quadratic Assignment Problem (QAP) is one of the most difficult combinatorial optimization problems with a diversity of applications. Linearization is a well-known solution method for the QAP where one formulates the QAP as a (mixed) integer linear programming ((M)ILP) problem. Kauffmann and Broeckx's linearization (1978) is the smallest QAP-MILP formulation but it is also one of the weakest ones. In this work we analyze how Kauffmann and Broeckx's formulation can be tightened and used in the framework of the semi-Lagrangian relaxation in order to solve the QAP by means of general purpose mixed integer linear programming solvers.

■ TD-03

Tuesday, 14:00-15:20

3.2.15

Transportation and logistics

Stream: Metaheuristics

Invited session

Chair: *Christophe Duhamel*, LIMOS, Université Blaise Pascal, campus des Cézeaux, 63173, Aubière, France, christophe.duhamel@isima.fr

Chair: *Jalel Euchí*, Quantitatives Methods, Faculty of Economics and Management of Sfax, Route de l'aéroport km 4.5, 3018, Sfax, Sfax, Tunisia, jalel.euchi@fsegs.rnu.tn

1 - A Hybrid Tabu Search to Solve the Heterogeneous Fixed Fleet Vehicle Routing Problem

Jalel Euchí, Quantitatives Methods, Faculty of Economics and Management of Sfax, Route de l'aéroport km 4.5, 3018, Sfax, Sfax, Tunisia, jalel.euchi@fsegs.rnu.tn, *Habib Chabchoub*

The Heterogeneous Fixed Fleet Vehicle Routing Problem (HFFVRP) is a variant of the Vehicle Routing Problem (VRP) that aims to provide service to a specific customer group with minimum cost using a limited number of vehicles. We assume that the number of vehicles is fixed. We must decide how to make the best use of the fixed fleet of vehicles. In this paper we describe a Tabu Search algorithm embedded in the Adaptive Memory (TSAM) procedure to solve the HFFVRP. Computational experiments indicating the performance of the algorithm concerning quality of solution and processing time are reported.

2 - Scheduling of road construction projects by means of tabu search algorithm

Jacek Hejducki, Electronics, University of Technology Wrocław Poland, Wybrzeże Wyspiańskiego 27, 50-370, Wrocław, Dolnoslaskie, Poland, 163646@student.pwr.wroc.pl, *Zdzisław Hejducki*

This paper deals with some problems of synchronizing construction activities differing in their execution times. A matrix methodology of calculating the times of execution of the activities, ensuring that there will be no collisions between them, is presented. The methodology is illustrated with numerical examples showing the successive steps of the algorithm and is applied to road works modelled as the flow shop problem. Negative transport times are used to model the specific constraints of the road construction problem. The tabu search algorithm is adapted to solve the problem.

3 - Parallel Cooperative Grasp for the HVRP

Christophe Duhamel, LIMOS, Université Blaise Pascal, campus des Cézeaux, 63173, Aubière, France,

christophe.duhamel@isima.fr, *Philippe Lacomme, Caroline Prodhon, Christian Prins*

Parallel implementations of metaheuristics appear naturally as effective alternative to speed up search in approximate iterative framework including but not limited to tabu, memetic algorithm and grasp. This article focus on definition of a cooperative parallel grasp for the Heterogeneous Vehicle Routing Problem benchmarked on 94 instances with 80 to 300 nodes to service. The numerical experiments prove the method is strongly efficient and outperforms the sequential grasp in both term of solutions quality and computation time.

■ TD-04

Tuesday, 14:00-15:20

3.2.13

Agriculture, forestry and environmental problems

Stream: Metaheuristics

Invited session

Chair: *Bernard De Baets*, Applied Mathematics, Biometrics and Process Control, Ghent University, Coupure links 653, Gent, Belgium, Bernard.DeBaets@rug.ac.be

Chair: *Quintin Martin*, Statistic, University of Salamanca, Plaza los Caidos s/n, 37008, Salamanca, Spain, Spain, qmm@usal.es

1 - Local search based multiobjective metaheuristic for forest planning.

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*

In this work, we develop a non linear Multiobjective Combinatorial programming model for forest planning, which resolution is strongly conditioned by its complexity. Thus, we have implemented a Multiobjective Local Search procedure based on Scatter Search, and enhanced by a seeding procedure. The characteristics and effectiveness of this method are compared to other heuristic widely used in the literature, NSGA-II, through computational experiments on simulated plantations.

2 - A genetic algorithm for the optimization of land subdivision in the process of agrarian reform

Mayron César Oliveira Moreira, Applied Mathematics and Statistics, University of Sao Paulo, USP - Sao Carlos - ICMC - SME - Av. Trabalhador sao-carlense, 400 Cx. Postal 668 - São Carlos-SP - CEP 13560-970, Rua Cap. Alberto Mendes Jr., 346, apto. 22, Vila Costa do Sol - CEP 13566-010, São Carlos, São Paulo, Brazil, mayron@icmc.usp.br, *José Ambrósio Ferreira Neto, Urbano Fra Paleto, José Norberto Muniz*

Land subdivision in the projects of agrarian reform presents a major challenge to planners and decision makers responsible for project implementation in developing countries such as Brazil. This is due to the complexity of delineating new compact land parcels with a similar productive capacity in a varied environment and large geographical area. Usually, land varies highly in soil classes, yielding a very different agricultural aptitude. In order to increase the efficiency of the procedure and facilitate the land subdivision process, an application using Genetic Algorithm (GA) was developed.

3 - Subset Selection from Multi-Experiment Data Sets with Application to Milk Fatty Acid profiles

Karolien Scheerlinck, Department of Applied Mathematics, Biometrics and Process Control, UGhent, Coupure links 653, 9000, Ghent, Flanders, Belgium, karolien.scheerlinck@ugent.be, *Bernard De Baets, Ivan Stefanov, Veerle Fievez*

The development of routine analyses to allow for the handling of large amounts of samples and to avoid cost and time expensive analytical techniques is of high value. These routine analyses most often require calibration using the detailed analyses as reference values. A representative subset reflecting the complete range of the variables of interest is required for this purpose. In this paper this subset selection problem is tackled for multi-experiment data sets. Conventional techniques such as the Kennard and Stone algorithm and OptiSim are compared to a new approach based on Genetic Algorithms. The challenge here is to find an adequate objective function and to modify the standard crossover and mutation operators to keep the number of desired samples fixed. These techniques are applied on a data set containing the concentration of 45 fatty acids, determined by a simplified reference method, in 1033 milk samples, stemming from six different experiments. The objective is to select a subset of 100 samples in which each of the six different experiments is sufficiently represented. While there is no obvious way to generalize the conventional methods for multi-experiment data sets, this can quite easily be accomplished for Genetic Algorithms by modifying the objective function. Our results indicate that Genetic Algorithms are very capable of handling the subset selection problem for multi-experiment data sets.

4 - Heuristic Methods for Modelling the Behaviour of Climate Variables Using a Multilayer Perceptron

Quintin Martin, Statistic, University of Salamanca, Plaza los Caidos s/n, 37008, Salamanca, Spain, Spain, qmm@usal.es

An empirical methodology to fit a model for forecasting climate variables is developed. The method is based on an artificial neural network (ANN) of the multilayer perceptron type (MLP). To configure the model, the series of mean monthly minimum temperature (TminMean) data observed at a weather station in Avila (Central Spanish Plateau), belonging to the synoptic and climatological network of the Spanish National Institute of Meteorology (NIM), were used. Experiments were undertaken to determine the number of training and test patterns, the number of data per pattern, layer activation functions, the training algorithm, and the end-of-training condition that would allow later application of the model. We also experimentally determined the type of data pre-processing for which the model provided the best yield. The following were considered: differentiation, deseasonalisation, anomalies, normalisation and standardisation. The resulting model was applied to the TminMean series at the stations of the synoptic and climatological network of the NIM on the Spanish Central Plateau. A high degree of fitting was observed between the real and simulated series, as shown by the values of the determination coefficients (R²), and the mean square error (MSE) and the dispersion and sequence plots of the real and simulated series.

■ TD-05

Tuesday, 14:00-15:20

3.2.16

Parameter tuning and interactive metaheuristics

Stream: Metaheuristics

Invited session

Chair: *Martin Josef Geiger*, Logistics Management Department, Helmut-Schmidt-University, Holstenhofweg 85, 22041, Hamburg, Germany, m.j.geiger@hsu-hh.de

Chair: *Jana Ries*, Department of Mathematics, University of Portsmouth, United Kingdom, jana.ries@port.ac.uk

1 - On the importance of the initial setting when tuning on-line the parameters of metaheuristics

Paola Pellegrini, Applied Mathematics, Università Ca' Foscari, Dorsoduro, Venice, Italy, paolap@unive.it, *Thomas Stützle, Mauro Birattari*

Metaheuristics have a number of parameters that need to be instantiated. Several on-line tuning approaches have been proposed for adapting these parameters during a run, and hence for using the most suitable setting for each problem instance. In this study, we analyze the impact of the initial value of the parameters on the performance of two adaptation approaches: we apply two variants of an adaptive ant colony optimization algorithm to the traveling salesman problem and we study the effects of different initializations.

2 - Fuzzy Instance-specific Parameter Tuning of Instance Batches

Jana Ries, Department of Mathematics, University of Portsmouth, United Kingdom, jana.ries@port.ac.uk, *Patrick Beullens*

Parameter tuning and parameter control are established strategies for solving the Parameter Setting Problem for meta-heuristics. Instance-specific parameter tuning (IPTs) is designed such that a set of parameter values is found according to instance-characteristics a priori to the meta-heuristic. An approach is presented that models decision maker preference in an IPTs using fuzzy logic by comparing the size and the occurrence of specific tour length dimensions for a batch of instances. The results indicate that this batch model is a promising approach leading to a parameter-free heuristic.

3 - Interactive Heuristic Search and Decision Making for Multi-Criteria Timetabling Problems

Martin Josef Geiger, Logistics Management Department, Helmut-Schmidt-University, Holstenhofweg 85, 22041, Hamburg, Germany, m.j.geiger@hsu-hh.de

The talk presents a interactive search and decision making approach for a curriculum-based timetabling problem, based local search metaheuristics. Two different aggregation techniques are used and studied. First, a weighted sum aggregation, and second, a reference point based approach. Experimental investigations are carried out for benchmark instances taken from track 3 of the International Timetabling Competition ITC 2007. After ranking among the best five approaches world-wide in the ITC 2007, we now extend our work towards interactive search and decision making.

4 - Tabu Search parameters selection for Quadratic Assignment Problem based on General Factorial Design

Mahdi Bashiri, Shahed University, Iran, Islamic Republic Of, bashiri.m@gmail.com, *Hossein Karimi*

Tabu Search has been used in the literature for solving the Quadratic Assignment Problem and it has some parameters which must be determined to have a better algorithm performance. In this paper General Factorial Design has been used to select the parameters for QAP. We analyzed the proposed TS algorithm with two parameters of maximum iteration and short term memory size and the results show that the first parameter has no effect on objective value for the selected problem data. Finally the proposed method has been illustrated and the parameters for the example of QAP has been shown and analyzed

■ TD-06

Tuesday, 14:00-15:20
8.2.30

DEA Application III - Transportation

Stream: DEA and Performance Measurement

Invited session

Chair: *Sebastián Lozano*, Dept. of Industrial Management, University of Seville, Escuela Superior de Ingenieros, Camino de los Descubrimientos, s/n, 41092, Seville, Spain, slozano@us.es

1 - Operational Environment and its Influence on International Airports Performance

Rui Marques, Portugal, rmar@civil.ist.utl.pt, *Pedro Simões*, *Pedro Carvalho*

This paper computes the efficiency of the 141 international major airports using robust benchmarking non-parametric techniques. It employs data envelopment analysis (DEA) and the recent methods of bootstrap and order-m to provide robustness to the scores obtained. Moreover, some explanatory factors included, such as GDP, regulation, percentage of non-aeronautical revenues, etc., in order to evaluate their influence on airports' performance. The results of the research are here discussed and some policy suggestions and recommendations are provided.

2 - Efficiency comparison between 14 regions of RAI (Iranian Railway) using DEA

Mohammad Mehdi Movahedi, Management Department, Islamic Azad University, Firoozkough Branch, Islamic Azad University, Firoozkough Branch, Management Department, None, 0098, Firoozkough, Tehran, Iran, Islamic Republic Of, mmmovahedi@gmail.com, *Seyed Mohieddin Hoseini*

Safe, fast, efficient and effective railway is a main factor of economic development level of every country. This paper uses the DEA method to evaluate and compare the efficiency of 14 Regions of RAI. In addition, we introduce the reference unit(s) for every inefficient region, and determine the amount of input decrease and/or output increase needed for inefficient units to become efficient. Investigations on returns to scale indicate that 8 regions are operating under IRS and only one region under DRS. Our suggestion is that RAI further invests into the regions operating under IRS. We also submit suitable suggestion on how to improve the efficiency of the inefficient regions.

3 - Technical and scale efficiency of interstate bus companies in Brazil

Carlos Ernani Fries, Department of Production and Systems Engineering, Federal University of Santa Catarina, Campus Trindade - CTC/EPS, C.P. 476, 88010-970, Florianópolis, Santa Catarina, Brazil, ernani@deps.ufsc.br, *Antonio G.N. Novaes*, *Mônica M. M. Luna*, *Helena C. Medeiros*

Interstate bus transport in Brazil is regulated by the National Agency of Land Transport (ANTT). The system is formed by more than 200 bus companies. Since the production in passenger-kilometers is heavily concentrated, one important question is to investigate the existence of returns to scale in conjunction with technical efficiency and company size. The DEA approach was used in the analysis. The results show three groups of bus firms, ordered by size, with clear differences in efficiency. Additionally, 73% of the total production is represented by firms showing decreasing returns to scale.

4 - A Network DEA model of airlines

Sebastián Lozano, Dept. of Industrial Management, University of Seville, Escuela Superior de Ingenieros, Camino de los Descubrimientos, s/n, 41092, Seville, Spain, slozano@us.es, *Ester Gutiérrez*, *Placido Moreno*, *Jose L. Salmeron*

Conventional Data Envelopment Analysis (DEA) models consider the system as a single-process black box. Network DEA considers the system as composed by distinct processes or stages, each one with its own inputs and outputs and with intermediate flows among the stages. In this research, a network DEA approach to airlines efficiency assessment is presented. The network DEA approach has more discriminant power than single-process DEA and the computed targets, efficiency scores and rankings are more valid. However, more detailed data (i.e. at the process level) and more complex models are needed.

■ TD-07

Tuesday, 14:00-15:20
8.2.47

Scheduling problems in production and service

Stream: Project Management and Scheduling

Invited session

Chair: *Dirk Briskorn*, Department for Supply Chain Management and Operations Management, University of Cologne, Albertus-Magnus-Platz, 50923, Köln, Germany, briskorn@wiso.uni-koeln.de

1 - Scheduling painting shops with due date restrictions

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, *Kathrin Klamroth*

In this paper a painting shop with sequence-dependent setup costs is considered. Analogously to the approach of Gilmore and Gomory, setup costs are assumed to be proportional to absolute state differences. Since subsequent production stages need to be supplied according to a predetermined time table, due date restrictions incur. We show that the integration of due dates leads to a strongly polynomial problem if the number of setup states is a constant. By making use of new dominance rules, problem instances of larger size can be solved optimally by a Branch&Bound procedure.

2 - Detecting, Measuring and Repairing Instabilities in Schedules of Tasks with Skill Requirements

Murat Firat, Mathematics and Computer Science, Eindhoven University of Technology, Postbus 513, 5600 MB, Eindhoven, Netherlands, m.firat@tue.nl, *Cor Hurkens*, *Alexandre Laugier*

In this work we extend the notion of blocking pair in the classical model of Gale Shapley and define it in a framework with multiple many-to-one assignments in the context of multiple skills. We aim to find good quality schedules that are as stable as possible. Throughout our solution methodology we use IP models to measure instability and to assign the technicians to jobs.

3 - SAT-based local search for project scheduling

Andrei Horbach, Institute of Business Administration, University Kiel, Olshausenstrasse 40, D-24098, Kiel, Germany, horbach@bwl.uni-kiel.de

Encouraged by recent results of applying SAT to various optimization problems such as project scheduling (RCPSP) and sports league scheduling we consider further possibilities to employ the techniques of propagation and clause learning. Contrary to our previously reported results we make use of SAT techniques to do some important work in a heuristic search framework. We present our preliminary results for project scheduling with minimum total completion time objective.

4 - Scheduling of aircraft landings using aircraft classes

Raik Stolletz, Department of Management Engineering, Technical University of Denmark, Nils Koppels Alle, Building 426, 2800, Kgs. Lyngby, Denmark, raist@man.dtu.dk, *Dirk Briskorn*

This presentation focuses on the aircraft landing problem. We consider a set of aircraft classes such that two aircraft of the same class differ by their target landing time. We develop polynomial time algorithms to minimize total landing cost, where landing cost is specified by a piece-wise linear convex function of the landing time. Moreover, we present integer programming models and show how the developed optimality properties can be used to increase efficiency of standard solvers.

■ TD-08

Tuesday, 14:00-15:20

6.1.36

Scheduling Applications

Stream: Project Management and Scheduling

Invited session

Chair: *Natalia Shakhlevich*, School of Computing, University of Leeds, Woodhouse Lane, LS2 9JT, Leeds, United Kingdom, N.Shakhlevich@leeds.ac.uk

1 - An effective algorithm to solve Energygrass Supply Scheduling problem

Laszlo Torjai, BDE Research Nonprofit Public Benefit Ltd., Xavér str. 1., 7624, Pécs, Hungary, torjai@ktk.pte.hu

Energygrass Supply Scheduling (ESS) is a bi-objective scheduling model emerged from a real-life logistics problem. There are non-preemptive jobs with integer processing times and without precedence conditions. The length of the discrete-time horizon is equal to the number of jobs and every job has to be finished in different time period. Each job is processed on one of the identical machines. The first objective is to find a feasible schedule such that the number of machines is minimal. The second one, subject to minimal number of machines, is minimizing the idle times of them.

2 - Resource Allocation in Preclinical Pharmaceutical Research

John Gittins, Statistics, Oxford University, 1 South Parks Road, Oxford, OX1 3TG, Oxford, United Kingdom, gittins@stats.ox.ac.uk, *Shuo Qu*, *Anne-marie Oreskovich*

Models and software for the allocation of resources in preclinical pharmaceutical research will be described. The models are based on stochastic optimisation. The relationship between resource allocation and rate of progress, and the influence of competition, are modelled. Examples will be discussed, showing that large improvements in profitability are often possible as a result of applying more rational resource allocation policies

3 - ZigBee based sensor network design for indoor space gazing system

Jun Matsuo, Hokkaido University, Japan, matsuo@complex.eng.hokudai.ac.jp, *Hidenori Kawamura*, *Keiji Suzuki*, *Takeshi Ikeda*, *Akio Sashima*, *Koichi Kurumatani*

We realize space gazing system for achievement of safety and convenience that watches living indoor space such as home, shopping center. The service images include smooth navigation and avoidance of danger situation. At first, we adopt to build wireless sensor networks with ZigBee. In this network design, the problems are how the ZigBee which is a low rate and low power network technology processes much information and detects the indoor environment. These problems are depended not only the density of the information but also the indoor space properties including the group of human behaviors.

4 - Scheduling Patterns of Repetitive Tasks: A Case Study in Health Care

Natalia Shakhlevich, School of Computing, University of Leeds, Woodhouse Lane, LS2 9JT, Leeds, United Kingdom, N.Shakhlevich@leeds.ac.uk, *Alessandro Condotta*

Integrated pathway management has become an important concept in achieving waiting time targets and improving health care procedures. Our study is applicable to those health-care procedures which consist of a series of treatments delivered in accordance with strictly regulated standard protocols. Such protocols are typical, e.g., for chemotherapy treatments which are characterized by strictly pre-specified multi-day and intra-day patterns. We present the main features of the associated models, introduce our solution approach and discuss preliminary results obtained for real-world data.

■ TD-09

Tuesday, 14:00-15:20

6.2.53

Optimization of Transport Problems on Networks II

Stream: Mathematical Programming

Invited session

Chair: *Simone Göttlich*, Mathematics, TU Kaiserslautern, Post Box 3049, 67653, Kaiserslautern, Germany, goettlich@mathematik.uni-kl.de

1 - Solving Equilibrium Problems with Equilibrium Constraints via Relaxation Approaches

Sonja Veelken, Mathematics, RWTH Aachen University, Mathematik C, Templergraben 55, 52062, Aachen, Germany, veelken@mathc.rwth-aachen.de

Equilibrium Problems with Equilibrium Constraints (EPECs) arise for example as bilevel game-theoretic models used to describe electricity markets with locational prices. They form an extension of Mathematical Programs with Equilibrium Constraints (MPECs) and so far, little is known about what will be the numerical method of choice for this relatively new class of nonlinear programming. We study the generalization of a relaxation scheme to EPECs, that proved very successful for MPECs. Moreover, we test and compare a related numerical solution approach on a randomly generated test set.

2 - Column Generation Based Heuristic for Capacitated Arc Routing Problem with Soft Time Windows

H. Murat Afsar, Industrial Systems, University of Technology of Troyes, 12 rue Marie Curie, BP 2060, 10010, Troyes, France, murat.afsar@utt.fr

Capacitated arc routing problems are inspired by winter gritting and urban waste collection where a subset of edges on undirected graphs to be serviced. Each edge has a time window where the service cost is minimal. Outside the time windows, service is authorized while the cost increases linearly by time. We propose a heuristic approach based on Dantzig-Wolfe decomposition and column generation. The master problem is set partitioning model and the sub-problem is a non elementary shortest path with resource constraints. The sub-problem is solved heuristically and exactly by dynamic programming.

3 - Paradox in Multi-commodity Min Cost Network Flow Problem

Ankit Khandelwal, Consumer Banking Risk Analytics, Standard Chartered Bank, 51 Bras Basah Road #08-04, Plaza by the Park, 189554, Singapore, Singapore, ankit.khandelwal@gmail.com, *Sonia*

Minimum cost multi-commodity flow problem is one of the classical optimization problems that arise when several commodities share arcs in a capacitated network. This type of network has found many practical applications in various diversified fields. In this paper we attempt to extend the concept of More (same) for less paradox in Multi-commodity Min Cost Flow Problem and obtain the conditions for its existence. Some supporting illustrations are also included.

4 - Improving public disabled transportation using a mathematical programming approach

Gizem Ozel, Industrial Engineering, Dokuz Eylül University, Tinaztepe Campus, 35160, İzmir, Turkey, ozelgizem@gmail.com, Alper Unal, Seyda Topaloglu

Public transportation of disabled people in Izmir is not at a desired service quality since specialized buses for disabled people have been allocated to the bus routes without considering disabled population and degree of disability on each route. The aim of this study is to improve disabled transportation. First, weighted scoring method and fuzzy TOPSIS is used to find the need of disabled buses on each route. Then, a mathematical programming model is developed for optimal assignment of these buses. This way, the number of disabled passengers is greatly increased compared to current situation.

■ TD-10

Tuesday, 14:00-15:20

6.2.56

OR in Sports 1

Stream: OR in Sports

Invited session

Chair: Dennis Van den Broeck, MOSI, VUB, P.P. Rubensstraat 9, 1880, Kapelle-op-den-Bos, Belgium, devdbroe@vub.ac.be

1 - Scheduling the play-offs in Belgian football

Dries Goossens, Operations Research and Business Statistics (ORSTAT), Katholieke Universiteit Leuven, Naamsestraat 69, 3000, Leuven, Belgium, Dries.Goossens@econ.kuleuven.be

Since this season, the competition format in the highest division of Belgian football includes play-offs, consisting of 3 double round robin tournaments, with 6 or 4 teams. Apart from the usual scheduling constraints in each of these tournament, a number of constraints linking the 3 tournaments should be taken into account. For instance, two teams playing in different play-off competitions share the same stadium and thus should not play at home in the same round. This presentation shows how a play-off schedule was developed which was actually used to determine the 2009-2010 champion.

2 - Combining the AHP and VIKOR Methodologies for Ranking Basketball Players

Seyhan Sipahi, Quantitative Methods, Istanbul University School of Business, IU Isletme Fakultesi Avclar Kampusu 34320, Avclar, 34320, Istanbul, sipahi@istanbul.edu.tr, Bilge Donuk

The purpose of this study is to provide a hybrid multi-criteria model for ranking basketball players who perform in the first division of the National Basketball league in Turkey. The model combines the Analytic Hierarchy Process (AHP) and the VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Rešenje) methodologies. In the study, players were ranked in accordance with the evaluation criteria such as shooting, free throw, assist, block, steal, turnover and rebound. The findings showed that the novel methodology can be successfully applied by basketball managers to evaluate player performance.

3 - Was Joe Girardi Foolhardy? An Analysis of the New York Yankee Manager's Decision to use only Three Starting Pitchers in the 2009 World Series

James Cochran, Department of Marketing and Analysis, Louisiana Tech University, PO Box 10318, 71272, Ruston, LA, United States, jcochran@cab.latech.edu

The NY Yankees followed baseball convention by using a rotation of 5 starting pitchers in the 2009 regular season, allowing each pitcher 4 days of rest between starts. This is done because most baseball experts believe a pitcher's performance (and his team's probability of winning) deteriorates drastically if he has less than 4 days of rest between starts. However, the team deviated from this strategy in the 2009 World Series, using only its top 3 starting pitchers and allowing each only 3 days of rest between starts. We use classic decision analysis to assess the wisdom of this strategy.

4 - An Inference Approach for Assessing Competitive Balance in Team Sports

Dennis Van den Broeck, MOSI, VUB, P.P. Rubensstraat 9, 1880, Kapelle-op-den-Bos, Belgium, devdbroe@vub.ac.be

Measures of competitive balance aim to assess the equality of playing strengths among teams in a sports tournament. Examples include deviations on win-ratios and the HH-index. These measures are in fact sample statistics and follow a probability distribution. Using concepts of graph theory, this distribution is derived assuming that all teams have equal playing strengths. Given this distribution, the deduction of critical values is straightforward and inferences on team parity are possible. A numerical example discussing a simplified tournament is presented.

■ TD-11

Tuesday, 14:00-15:20

8.2.38

Various New OR Tools and Technologies I

Stream: Emerging Applications of OR

Invited session

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: Tatiana Tchemisova, Departamento of Mathematics, University of Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, tatiana@ua.pt

1 - To develop an e-commerce website template for undergraduates

Özge Nalan Alp, Yildiz Technical University, Turkey, ozgenalan@gmail.com, Nurgül Demirtaş, Hayri Baraçlı

E-commerce is a term meaning buying and selling on internet and its applications are increasing rapidly. To develop e-commerce applications, firstly the scope of the website must be determined. Data mining is a technique which finds important information in data warehouses and data mining helps to make predictions. We aim to analyze undergraduates' purchasing tendency and demands which changes upon their demographic information by using data mining techniques and to prepare a new e-commerce website design template.

2 - Measuring Virtual Experience in 3-D VR Interactive Simulator Environment: A Structural Equation Modeling Approach

Pao-Long Chang, Department of Business Administration, Feng Chia University, 100, Wenhwa Road, Seatwen, Taichung, Taiwan, R.O.C, 407, Taichung, Taiwan, paolong_chang@yahoo.com.tw, Ming-Hua Chieng

The study aims to measure the consumer's virtual experience in the formation of flow in a 3-D VR environment via a 3-D interactive motion simulator. Study findings revealed that stages in the formation of flow encompass the intrinsic characteristic manifestation of the mediated environment; the premise and perception prior to entering the flow state; the stage of entering a flow state; and lastly the consequences of the formation of flow.

3 - Exploring the Evolutional Life of White LED Lighting Technology with Technology Prediction

Yuanchau Liour, Logistics Management, Takming University of Science and Technology, 11451, Taipei, Taiwan, ycliour@takming.edu.tw, Po-Liang Chao, Chie-bein Chen

This study bases on patents of white LED lighting technology from the US open patent database, it imports the logistic and Gompertz technology forecasting models to explore the life cycle of white LED lighting technology and further investigates the strength and weakness in the global level of white LED lighting industry in Taiwan. The result shows that the number of patents doubled in 2003-2008. Through the analysis by Logistic and Gompertz models, the white LED lighting technology is growing to the mature stage of long-term life cycle.

4 - Models and Techniques of Recourse Allocation in Controlling the Semi-structured Social and Economic Objects

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, Dmitry Makarenko

In controlling the complex socio-economic systems (territories, branches) one of the key problems is the optimal resource allocation. This problem is solved under incomplete awareness of decision makers, and the object of control is semi-structured in terms of correlation between the impact of separate activities and their contribution to the whole object's development goals. To solve this problem the paper suggests the combination of the following techniques: cognitive mapping, comprehensive evaluation, network programming, constructing of non-manipulable mechanisms for resource allocation.

■ TD-12

Tuesday, 14:00-15:20

8.2.39

ANP 04

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Mei-Chen Lo*, National United University, Taiwan, meichen_lo@nuu.edu.tw

1 - A model for equipment selection: An integrated approach with DEMATEL and ANP

Metin Dagdeviren, Department of Industrial Engineering, Engineering and Architecture Faculty, Celal Bayar Bulvar, Gazi Univ. MMF, Endustri Muh., 06570, Ankara, Turkey, metindag@gazi.edu.tr, *Erdem Aksakal*, *Ihsan Yüksel*

With the affect of the globalization and competition, selecting proper equipment becomes a very important activity due to the fact that improper equipment selection can negatively affect the overall performance and productivity of the manufacturing systems. Selecting the proper equipment includes many alternatives on the behalf of the manufacturing systems and makes the equipment selection process as a multicriteria decision making problem. In this study, a hybrid model which employs DEMATEL and Analytic Network Process together, is proposed for the equipment selection problem.

2 - Improving the assessment of railway projects through new performance indicators

Stefano Strami, DICA - Dept of Civil and Environmental Engineering, University of Trieste, Piazzale Europa 1, 34127, Trieste, Italy, stefano.strami@phd.units.it, *Giovanni Longo*, *Elio Padoano*

In the railway field, multi-criteria decision-making methods are commonly applied in order to assess and compare alternative projects. In this work, some useful indicators are proposed to quantify the performances and positive effects of different interventions. These can be used together with the well-known parameters related to the negative drawbacks (which mainly explain the reasons not to intervene), aiming at a thorough description of each considered project. The new indicators were applied to a real case study in Italy that is described in the paper.

3 - Decision-making by "Minor ANP" for Selecting the Best Business Partner

Mei-Chen Lo, National United University, Taiwan, meichen_lo@nuu.edu.tw, *Ozaki Toshimasa*, *Gwo-Hshiang Tzeng*

The ANP is a network structure with alternatives and criteria for clarifying complex decision-making problems. It is important to obtain the consent from both criteria and alternatives because the evaluation is relative and reciprocal. From our study, the evaluation with only the alternatives consists of the missing values or the non-square matrix, these irregular alternatives is defined as "Minor ANP" which describes these methods of making the priority of only the alternative's matrix values by using the ANP. An empirical case of the best business partner selection is illustrated.

■ TD-13

Tuesday, 14:00-15:20

2.2.21

Emergency facilities location

Stream: Location Analysis

Invited session

Chair: *Sibel Salman*, Industrial Engineering, Koc University, Sariyer, 34450, Istanbul, Turkey, ssalman@ku.edu.tr

1 - Emergency Response Facility Location in Istanbul for Effective Distribution of Relief Aid

Selin Ozdinc, industrial engineering, koc university, koc university, rumelifeneri yolu, sariyer, 34450, istanbul, Turkey, selinozdinc@gmail.com

We model the Emergency Response Facility location problem for the Disaster Coordination Center of Istanbul Municipality by a two-stage stochastic program that maximizes the expected post-disaster demand coverage in a network whose links may fail. We develop a Tabu Search algorithm that uses sampling to evaluate the expected coverage. We analyze the solutions under various cases and provide guidelines for earthquake-preparedness.

2 - Pre-Positioning of Emergency Items Worldwide for CARE International

Serhan Duran, Industrial Engineering, Middle East Technical University, Orta Dogu Teknik Universitesi, Endustri Muh. Bolumu, 06531, Ankara, Turkey, sduran@ie.metu.edu.tr, *Marco Gutierrez*, *Pinar Keskinocak*

The most vital issues in responding to such disasters are the agility in mobilizing the supplies and the effectiveness in distributing them. In an effort to improve disaster response, a research group from Georgia Tech, in collaboration with CARE, developed a model to evaluate the effect of relief items pre-positioning on CARE's average emergency response time to provide relief aid to people affected by natural disasters. The model's results helped CARE's managers to determine a desired configuration of three facilities around the world for the pre-positioning network.

3 - A humanitarian relief logistics model and Lagrangean-based solution approach

Alper Döyem, Industrial Engineering, Boğaziçi University, Department of Industrial Engineering, Boğaziçi University, Bebek, 34342, İstanbul, Turkey, alper.doyem@boun.edu.tr, *Necati Aras*, *Gülşay Barbarosoglu*

We develop a two-stage stochastic programming model for a humanitarian relief logistics problem where decisions are made for pre- and post-disaster rescue centers, the amount of relief items to be stocked and the flow amounts at each echelon. The objective is to minimize the total cost of facility location, inventory holding, transportation and unsatisfied demand. The deterministic equivalent of the model is formulated as an MIP for which a Lagrangean relaxation based algorithm is proposed. Test results show that proposed algorithm shows good performance for a wide range of problem instances.

4 - Locating Emergency Response Facilities on a Network with a Linear Reliability Order of Links

Sibel Salman, Industrial Engineering, Koc University, Sariyer, 34450, Istanbul, Turkey, ssalman@ku.edu.tr, *Refael Hassin*, *R. Ravi*

We study the problem of locating emergency response facilities to maximize the expected demand serviced in a network with unreliable links. Under a linear reliability ordering of links, that models dependencies among link failures in a disaster situation, we give two polynomial time exact algorithms by a greedy approach and by dynamic programming. When two disaster scenarios with different linear orderings are given, we prove the total unimodularity of a linear programming formulation and NP-hardness for three orderings. When a demand point can be covered only if a facility exists within a distance limit, we show that the problem is NP-hard even for a single ordering.

■ TD-14

Tuesday, 14:00-15:20

2.2.15

Supply Chain Design and Sustainability

Stream: Supply Chain Planning [c]

Contributed 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 - Modeling and Design of Cross-Docking Systems

Georgios Sgoutas, Business Administration, University of Aegean, N. Haviara 14, Evaggelistria, 82100, Chios, Greece, george.chios@gmail.com, *Michael Vidalis*, *Vassilis Angelis*

Cross docks are modelled as queuing network with parallel servers. First station represents strip doors, 2nd station represents stack doors and the intermediate buffer models the width of the dock. Markov processes are used to model random arriving, servicing, repairing times and to calculate Performance measures for different dock configurations. Cross docking system is assumed with and without waiting space and with breakdowns in loading and unloading operations. Structure of transition matrices is examined for each case and computational algorithms are developed for generating them.

2 - Supply Chain Network Design with Sustainability Perspective

Hazal Karaman, Industrial Engineering, Kadir Has University, Zeytinoglu st. Lale C, 33/8 Akatlar, 34335, Istanbul, Turkey, hazalkaraman@gmail.com, *Cagatay Mekiker*, *Sinan Mercan*, *Orhan Feyzioglu*

While supply chains have become globalized, environmental concerns due to global warming and associated security risks have drawn the attention of numerous constituencies. Companies are increasingly being held accountable for their own environmental performance, and also for that of their suppliers, distribution facilities and even for the disposal of their products. We present a supply network design model that aims to locate centers and assign material flow optimally while considering multiple sustainability related objectives, and provide economic insights with an illustrative example.

3 - Carbon footprinting and labeling in a supply chain

Charles Corbett, UCLA Anderson School of Management, 110 westwood plaza, box 951481, 90095-1481, Los Angeles, CA, United States, charles.corbett@anderson.ucla.edu, *Chien-Ming Chen*, *Rob Zuidwijk*

When firms plan to put carbon footprint labels on their products, it is often not unambiguous how those carbon footprints should be determined. Current standards for carbon footprinting also leave room for ambiguity. This gives firms some flexibility in how to allocate carbon emissions to different products. In this paper we examine conditions under which that flexibility in fact helps to reduce the firm's total carbon footprint.

■ TD-15

Tuesday, 14:00-15:20

2.2.12

Routing Optimization

Stream: Vehicle Routing

Invited session

Chair: *Christos Tarantilis*, Department of Management Science & Technology, Athens University of Economics and Business, 28 Hydras st, Athens, Greece, Management Science Laboratory (MSL), 9th Floor, Room 913, 113-62, Athens, Greece, tarantil@aueb.gr

1 - Solving the Weekly Log-Truck Routing and Scheduling Problem

Michel Gendreau, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec,

Canada, michel.gendreau@cirrelt.ca, *Nizar El Hachemi*, *Louis-Martin Rousseau*

We address the problem of routing and scheduling log-trucks over a week in a forestry environment. This problem includes features such as multiple products, inventories, and lunch breaks for drivers. The objective is to minimize the overall cost including waiting times, loaded travel and empty driven distance. Our solution approach is based on solving in sequence two integer linear programs that determine respectively the destinations of full truckloads and the routing and scheduling of trucks at a minimum cost. Results of computational experiments using CPLEX 11 will be reported.

2 - A branch-and-price algorithm for the capacitated team orienteering problem

M. Grazia Speranza, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, speranza@eco.unibs.it, *Claudia Archetti*, *Nicola Bianchessi*, *Nicola Bianchessi*

The capacitated team orienteering problem (CTOP) is the problem to select a subset of customers among a set of potential customers with the objective to maximize the total profit collected. Each customer has an associated demand and profit. A fleet of capacitated vehicles is available. In this paper we present a column generation approach for the solution of the CTOP that solves to optimality many previously unsolved benchmark instances.

3 - Partial Path Column Generation for the Elementary Shortest Path Problem with Resource Constraints

Mads Kehlet Jepsen, Management Engineering, Technical University of Denmark, Produktionstorvet, bygn. 424, 2800, Kgs lyngby, Denmark, makj@man.dtu.dk, *Bjørn Petersen*

This paper introduces a decomposition of the Elementary Shortest Path Problem with Resource Constraints, where the path is combined by smaller sub paths. The approach can be seen as an idea to extend the bidirectional labeling. We present a Danzig-Wolfe Decomposition algorithm for the problem and compare the dicuess the computational results by comparing different approaches for the decomposition. Finally we compare the algorithmh with existing algorithms.

4 - Towards an Exact Approach for the Capacitated Vehicle Routing Problem

Panagiotis Repoussis, Management Science & Technology, Athens University of Economics & Business, Evelpidon 47A, 11362, Athens, Greece, prepousi@aueb.gr, *Chrysanthos Gounaris*, *Christos Tarantilis*, *Christodoulos Floudas*

In this presentation we propose advances towards a two-level exact solution framework for the Capacitated Vehicle Routing Problem. During the first level, a soft branching decomposition scheme based on Hamming distances is iteratively applied to confine and partition the solution space. At the second level, each solution subspace is solved via a new branch-and-cut algorithm that uses an adaptive memory programming metaheuristic to inform branching decisions and accelerate the search process. Computational experiments on benchmark data sets illustrate the performance of the proposed approach.

■ TD-16

Tuesday, 14:00-15:20

2.2.14

Strategic decisions and infrastructure

Stream: Public Transport

Invited session

Chair: *Konstantinos Gkoumas*, DITS (Dipartimento di Idraulica Trasporti e Strade), Sapienza Universita' di Roma, Via Eudossiana 18, 00184, Rome, Italy, konstantinos.gkoumas@uniroma1.it

Chair: *Federico Perea*, Matemática Aplicada 2, Universidad de Sevilla, 41092, Seville, Spain, perea@us.es

1 - Exact algorithms for Location Routing Problems

Claudio Contardo, Département d' informatique et de r.o., University of Montreal, 2920 chemin de la tour, bureau 3484, H3T 1J4, Montreal, Québec, Canada, ccontard@crt.umontreal.ca

Location routing problems usually occur whenever strategic decisions must be taken considering operational consequences. We review the state of the art of exact algorithms for solving Location Routing Problems. We describe algorithms based on cutting planes strategies as well as decomposition methods solved by means of Lagrangean relaxation or column generation. We present computational results and discuss the strengths of every approach as well as directions of future research

■ TD-17

Tuesday, 14:00-15:20

1.3.14

Container Terminal Planning II

Stream: Transportation Planning

Invited session

Chair: *Frank Meisel*, Martin-Luther-University Halle-Wittenberg, Gr. Steinstr. 73, 06108, Halle, Germany, frank.meisel@wiwi.uni-halle.de

Chair: *Christian Bierwirth*, Martin-Luther-University Halle-Wittenberg, 06108, Halle, Germany, christian.bierwirth@wiwi.uni-halle.de

1 - Effect of Resource Allocation Rules in Different Layout Types of Seaport Container Terminals

Olcay Polat, Industrial Engineering, Pamukkale University, Pamukkale Üniversitesi Endüstri Mühendisliği Bölümü No:437, Kinikli Kampusu, 20100, Denizli, Turkey, olcaay@gmail.com, *Osman Kulak*, *Mustafa Egemen Taner*, *Hans-Otto Guenther*

Due to the long-lasting increase in global trade worldwide until the recent economic crisis container traffic has grown dramatically. As a result, new terminals have opened and existing terminals face a much higher container turnover than before. The goal of this study is to propose strategies for allocating resources in different layout alternatives and evaluating impact of these strategies rules in these layout types. With the help of the simulation model potential layout and allocation alternatives can be evaluated for the container terminals.

2 - Terminal planning and optimising via distributed emulation

Holger Schuett, Optimisation and Simulation, ISL - Institute of Shipping Economics and Logistics, Barkhausenstrasse 2, 27568, Bremerhaven, Germany, schuett@isl.org

The paper presents an emulation system based on a worldwide accepted simulation tool for container terminals. By combining the Terminal Operating System to models of the terminal devices (emulators) the TOS may be tested before going alive. Moreover emulation will allow the terminal operator to fine-tune the strategies and historical data may be imported to train the staff. The emulation system is based on a distributed communication network, which allows the integration of external emulators. This will be shown in an example, where a Java based emulator connects to the C# based network.

3 - An integrated simulation model for quay and yard operations at gioia tauro terminal

Roberto Trunfio, Dipartimento di Elettronica, Informatica e Sistemistica, Università della Calabria, Via P. Bucci, 41C, 87036, Rende, Cosenza, Italy, rtrunfio@deis.unical.it, *Pasquale Legato*

Discrete-event simulation (DES) models are powerful tools for representing maritime container terminals in a stochastic-dynamic context. They are able of giving a valuable contribution in estimation of entire terminal performance by considering all the logistical processes involved in system dynamics. Hence, container terminal companies recognize that simulation cover a lead role in supporting the decisional process. For this reason, the MCT company at Gioia Tauro terminal, asked us for an integrated DES model focused on quay and yard operations. The model depicts in detail both vessel and container life cycles. Moreover, quay crane allocation and yard block policies are considered.

4 - Analysis and Simulation of a Port Container Terminal Operating in Naples (Italy) Harbor

Gennaro Improta, Dipartimento di Ingegneria Economico-Gestionale, Università Federico II di Napoli, Via Claudio, 21, 80125, Napoli, Italy, improta@unina.it, *Francesco Gargano*, *Giuseppe Bruno*, *Andrea Genovese*, *Cinzia Vinti*, *Pietro Averaimo*

We implemented, in Arena environment, a Discrete Event Simulation model of the Co.Na.Te.Co. Container Terminal operating in Naples, Italy, harbor. In a first phase we reproduced its current situation. Obtained results showed a good correspondence between real and simulated data. Then, in order to evaluate possible performance improvements, we have experimented different decision rules for the Berth Allocation phase considering it as a dynamic parallel machines scheduling problem. First simulated results seems to be promising.

■ TD-18

Tuesday, 14:00-15:20

1.3.15

Decision Analysis in Marketing and Financial Modeling

Stream: Stochastic Modeling and Simulation

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: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Applying Rough Set Theory Constructing Customer Relationship Model for Pharmaceutical Agents

Tsau-Tang Yang, Graduate Institute of Management Sciences, Tamkang University, 8F, No.43, Lane 115, Sec.2, Chung Shan N.Rd. Taipei, Taiwan(R.O.C), 10448, Taipei, Taiwan, giddi.john@msa.hinet.net, *Hsu-Hua Lee*, *Chie-Bein Chen*, *Mei-Hsiu Huang*, *Wei Ting Cho*, *Chung-Chang Lien*

Business need take targeted marketing to capture the customers in promotion activity, since modern marketing paradigm rapidly shifting. Recently, pharmaceutical agents face challenges, such as foreign pharmaceutical companies authorizing the rights to the agents' pharmaceutical divisions or hospitals taking a total payment system. Therefore, pharmaceutical agents should adjust their marketing strategy to keep long-relationship with existed channels. It plays an important role for finding unobvious but valuable promotion knowledge to support making marketing related decisions in customer relationship management. This study use rough set theory to analyze actually the transaction records between a specific pharmaceutical agent company and its channels, and then build customer relationship model. The result of this study can provide the decision maker of pharmaceutical agent company as a reference for making marketing strategy.

Keywords: pharmaceutical agents, customer relationship management, rough set theory

2 - Strategic investment timing under asymmetric access charge regulation in telecommunications

Takashi Shibata, Graduate School of Social Sciences, Tokyo Metropolitan University, 1-1, Minami-osawa, Hachioji, 192-0397, Hachioji, Tokyo, Japan, tshibata@tmu.ac.jp

In a liberalized telecommunications market, an incumbent has several advantages over any entrant. An asymmetric access charge regulation for two such asymmetric firms stimulates competitive investment. We show that an entrant with a cost disadvantage has an incentive to invest as a leader under an asymmetric access charge regulation. These results fit well with the findings of previous empirical work. Moreover, we also investigate the effects of an asymmetric access charge regulation on competitive investment strategies.

3 - Combination strategies in predictive-prescriptive setups

Paulo Freitas, CIO and University of Madeira, Centro de Ciências Exactas e da Engenharia, Campus Universitário da Ganteada, 9000-390, Funchal, Portugal, paulo@uma.pt, *Antonio Rodrigues*

In decision problems involving asymmetric loss functions, the optimal decision should be based on a quantile of a density forecast, rather than simply given by an expected-value forecast. Also, the combination of forecasts produced by different models may improve forecasting accuracy, as much as the combination of decision proposals from different sources may reduce the expected regret. We thus investigate and compare two possible approaches: either inferring decisions from combined predictive estimates, or combining prescriptive solutions derived from different forecasting models.

4 - Classification by Archipelago Subgraph

Bela Vizvari, Industrial Engineering, Eastern Mediterranean University, Gazimagusa, Mersin 10, Turkey, vizvaribela@gmail.com

An ideal clustering of stocks is that there are positively correlated ones in each cluster and among stocks of different clusters the correlation is negative. This state can be achieved only if correlations close to zero are neglected. The ideal case is an archipelago. Clustering is done by deleting edges from a signed graph to get an archipelago. Algorithms are provided to determine that how high weights must be deleted and to find an archipelago subgraph with maximal total weight. Joint work with P. L. Hammer, P. Majlender, and B. Simeone

■ TD-19

Tuesday, 14:00-15:20
1.3.20

Dynamical Systems

Stream: Dynamical Systems and Game Theory

Invited session

Chair: *João Almeida*, Instituto Politécnico de Bragança, 5301-857, Bragança, jpa@ipb.pt

Chair: *Flávio Ferreira*, Mathematics, ESEIG - Instituto Politécnico do Porto, R. D. Sancho I, 981, 4480-876, Vila do Conde, Portugal, flavioferreira@eu.ipp.pt

1 - Pinto's Golden Tilings

João Almeida, Instituto Politécnico de Bragança, 5301-857, Bragança, jpa@ipb.pt

We present the definition of a golden sequence. These golden sequences are Fibonacci quasi-periodic and determine a tiling of the real line. We prove the existence of a natural one-to-one correspondence between: (i) Golden sequences; (ii) Smooth conjugacy classes of circle diffeomorphisms with golden rotation number that are smooth fixed points of renormalization, and (iii) Smooth conjugacy classes of Anosov diffeomorphisms that are topologically conjugate to the toral automorphism $G_A=(x+y,x)$. The Pinto-Sullivan tilings of the real line relate smooth conjugacy classes of expanding circle maps with 2-adic sequences.

2 - Dynamic Thresholds in Biology

Alberto A. Pinto, Departamento de Matematica, University of Minho, Escola de Ciências, Universidade do Minho, 4710-057, Braga, Portugal, aapinto1@gmail.com

3 - Leadership in a differentiated and uncertain market

Flávio Ferreira, Mathematics, ESEIG - Instituto Politécnico do Porto, R. D. Sancho I, 981, 4480-876, Vila do Conde, Portugal, flavioferreira@eu.ipp.pt, *Fernanda A. Ferreira*, *Alberto A. Pinto*

We present a brief study of the effects of product differentiation in a Stackelberg model with demand uncertainty. We do an ex-ante and ex-post analysis, in terms of product differentiation and of the demand uncertainty, of the profits of the leader and of the follower firms. We show that even with small uncertainty about the demand, the follower firm can achieve greater profits than the leader, if their products are sufficiently differentiated.

4 - Effects of Individual Dynamic Complexity Elements on the Overall Complexity of a Simulation Game

Onur Ozgün, Department of Industrial Engineering, Bogazici University, Bebek, 34342, Istanbul, Turkey, onur.ozgun@boun.edu.tr

System dynamics based simulation games are commonly used to assist learning about complex systems. Though, it's unclear whether players can acquire transferrable learning by playing games. The main goal of this research is to assess the extent of learning under different game complexity levels. As the first part of this research, this paper focuses on explaining the overall game complexity in terms of dynamic complexity factors: delay, nonlinearity, stock and feedback. Using a two-stage experimental procedure, a complexity measure is sought, based on player performances and their assessments

■ TD-20

Tuesday, 14:00-15:20
1.3.33A

Cutting and Packing 8

Stream: Cutting and Packing

Invited session

Chair: *J. M. Valério de Carvalho*, Departamento de Produção e Sistemas, Universidade do Minho, 4710 053, Braga, Portugal, vc@dps.uminho.pt

1 - A constructive Heuristic for the Minimization of Open Stacks Problem

Marco Carvalho, Computer Science Department, Technological Institute of Aeronautics, Praça Marechal Eduardo Gomes, 50, Vila das Acácias, CEP 12.228, São José dos Campos, São Paulo, Brazil, mamc@ita.br, *Nei Yoshihiro Soma*

We present a constructive heuristic for the minimization of open stacks, a sequencing problem related to cutting stock. The method uses a quantity of techniques: breadth-first search, permutations generation and an anticipatory closing stack heuristic rule. Computational experiments encompassed a benchmark and a random set of instances. The gap to the first set is of 1.82% over almost six thousand instances, and a comparison with two other heuristics from the literature using the second set shows that the constructive heuristic has a better performance, opening far fewer stacks on average.

2 - Sequencing bidimensional guillotine cutting operations considering lateness and raw material utilization

Felipe Lemos, Production Engineering Department, Universidade de São Paulo, Av. Prof. Almeida Prado, Travessa 2, Nº 128, Cidade Universitária, 05508-070, São Paulo, São Paulo, Brazil, felipeklemos@gmail.com, *Miguel Cezar Santoro*

The paper analyses sequencing on guillotine cutting aiming to improve lateness and raw material utilization. It studies the unexplored intersection of 2 classic themes, cutting & packing and sequencing. Ten constructive heuristics were tested on different conditions of items sizes, lateness intensity and decision criteria weighs. The results showed the advantage of probabilistic heuristics; the importance of the chosen bias; and also of coherency between initial order and the weights of the objectives aimed. The implantation on an aircraft factory resulted better raw material utilization.

3 - Pattern Cutting and Sequencing in a Multi-Stage Production System

Rifat Gürçan Özdemir, Industrial Engineering Department, Istanbul Kültür University, Atakoy Campus, Atakoy-Bakirkoy, 34156, Istanbul, Turkey, rg.ozdemir@iku.edu.tr, *Tülin Aktin*

In this study, an integrated mathematical approach is proposed for the pattern cutting and sequencing problem in a multi-stage production system. The completion times of final products are dependent upon the cutting and sequencing of patterns based on which raw materials are cut in the first stage. The developed ILP model with the objective of minimizing WIP and tardiness costs, determines the number of hardboards that will be cut and obtains the sequence of these cutting patterns simultaneously. The model is then implemented in a furniture manufacturer operating on a make-to-order basis.

4 - Sequencing cutting patterns in order to minimize the stack occupation

Isabel Cristina Lopes, Dep. Matematica, ESEIG - Instituto Politecnico do Porto, Rua D.Sancho I, 981, 4480-876, Vila do Conde, Portugal, tulicreme@netcabo.pt, *J. M. Valério de Carvalho*

We address a situation where machines process one cutting pattern at a time and equal pieces cut from the patterns are piled in stacks in the work area. The sequence in which preset cutting patterns are processed can affect the flow and total completion time, so it is desirable to optimize the occupation of the stacks to eliminate unnecessary dispersion. A solution can be modelled by an interval graph exhibiting a set of intervals that match the duration of stacks. We propose an IP model that reduces the occupation of the stacks, by adding the least number of edges to the graph.

■ TD-21

Tuesday, 14:00-15:20

6.2.47

Software for OR/MS II - Open Source

Stream: Software for OR/MS

Invited session

Chair: *Vinicius Armentano*, Faculdade de Engenharia Elétrica e de Computação, Universidade de Campinas, FEEC-UNICAMP- CP 6101, Av. Albert Einstein 400, 13083-970, Campinas, São Paulo, Brazil, vinicius@densis.fee.unicamp.br

1 - Open-Source Software in OR Education

Jorge Santos, Matemática, Univ Evora, Rua Romão Ramalho, 59, 7000-671 Évora, 7000-671, Évora, Portugal, jmas@uevora.pt, *Luís Cavique*, *Armando Mendes*

This contribution will focus on Computational Tools of Open-Source Software in OR Education. Some educational experiences in the area of Forecasting; Simulation; Graphs and Networks; Decision Theory and Linear Programming based on: R 2.10.0, Scilab 5.1.1 and an Open Source Spreadsheet will be illustrated, with a brief reference to the acceptance of pupils and colleagues.

2 - Parallel Machine Scheduling Using Free Software: an Application

António Duarte, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Apartado 1038, 5301-854, Bragança, Portugal, aduarte@ipb.pt, *J. M. Valério de Carvalho*

We will show how to implement large scale optimization by only using freely available software tools. We solve exactly a parallel machine scheduling problem with identical parallel machines and malleable tasks, subject to arbitrary release dates and due dates. The objective is to minimize a function of late work and setup costs. We use the COIN-OR BCP framework to implement column generation to solve a model that results from a Dantzig-Wolfe decomposition, and also CRIFOR MCFZIB to solve an equivalent network flow model. Computational results are presented.

3 - Consumers and Suppliers Decision Process in Information System Markets

João Rosário, Marketing, Escola Superior de Comunicação Social-Instituto Politécnico de Lisboa, Portugal, jrosario@escs.ipl.pt, *António Palma dos Reis*

The objective of this presentation is to discuss the consumer decision process in the Information Systems markets and how these markets evolve influenced by these consumer decisions and the suppliers' decisions and business models. Will be discussed the factors that have influence on the consumers buying process decision and the option between Proprietary Software and Open Source Software in the Operating Systems and Office Suites categories; the gratuity degree of Open Source Software; and also on the supply side the advantages and disadvantages regarding innovation, software developing organization and market survival of Open Source Software versus Proprietary Software business models.

4 - Fleet Deployment Optimization for Tramp Shipping

Vinicius Armentano, Faculdade de Engenharia Elétrica e de Computação, Universidade de Campinas, FEEC-UNICAMP- CP 6101, Av. Albert Einstein 400, 13083-970, Campinas, São Paulo, Brazil, vinicius@densis.fee.unicamp.br, *Rodrigo Branchini*

We address a tactical planning problem faced by many tramp shipping companies that have cargo contracts which they are committed to carry, while trying to serve optional spot cargoes to increase their revenue over medium-term horizon. 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. This problem is modeled as a mixed integer programming which is solved using COIN-OR open source platform. Computational results are reported.

■ TD-22

Tuesday, 14:00-15:20

3.1.10

Health Care Policy Making II

Stream: Health Care Management [c]

Contributed session

Chair: *Jose Luis Andrade*, Industrial Management, School of Engineering, University of Seville, Camino de los Descubrimientos s/n, 41092, Seville, Spain, jlandrade@esi.us.es

1 - Innovative Approach to Design Decisions on a Regional Network of Clinical Laboratories

Jose Luis Andrade, Industrial Management, School of Engineering, University of Seville, Camino de los Descubrimientos s/n, 41092, Seville, Spain, jlandrade@esi.us.es

We present a model supporting design and operation decisions on a regional network of clinical laboratories (able to reassign resources, redistribute workloads and reorganize flows), modelled as a multicommodity flow problem which conducts to a MIP formulation. We build a prototype tool for Health Care Managers to analyse scenarios and select the best options to improve the behaviour of the whole network. It is a graphical tool that launches an optimization process and supports: zoom, iconographical presentation of solutions and on-click access to input data or output solution, among others.

2 - A Case-based Reasoning System for Radiotherapy Treatment Planning in Brain Cancer

Rupa Jagannathan, Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, Nottinghamshire, United Kingdom, rxj@cs.nott.ac.uk, *Sanja Petrovic*, *Angela Mckenna*, *Louise Newton*

A decision support system for brain cancer radiotherapy treatment planning is presented. The aim of treatment planning is to attain a uniform tumouricidal dose for the tumour cells while minimizing the damage caused to adjacent healthy tissue and organs. This is a complex decision-making process that relies on subjective experience and expert clinical domain knowledge. We develop a case-based reasoning system that generates treatment plans for new patients based on the plans for previous similar patients. Our experiments, which use real brain cancer patient cases, show promising results.

3 - Decision Support System for Warfarin Therapy Management

Barbaros Yet, Technology Management and Economics, Chalmers University of Technology, Sweden, barbaros@student.chalmers.se, *Kaveh Bastani*, *Hendry Raharjo*, *Svante Lifvergren*, *Bo Bergman*

Warfarin therapy is known as a complex process due to variation in the patients' response. Failure to deal with such variation may lead to thrombosis or bleeding. There have been studies done on investigating the sources of variation, such as alcohol consumption and interacting drugs. However, this knowledge is, unfortunately, often used loosely by the physicians. This paper proposes a decision support system to integrate experts' knowledge in a systematic way using Bayesian Network. The model is built upon literature review in medical fields and interviews with doctors in a Swedish hospital.

■ TD-23

Tuesday, 14:00-15:20

6.2.49

MOO: Nonlinear Multi-Objective Optimization Techniques in Action

Stream: Multi-Objective Optimization

Invited session

Chair: *Jussi Hakanen*, Dept. of Mathematical Information Technology, University of Jyväskylä, P.O. Box 35 (Agora), FI-40014, University of Jyväskylä, Finland, jussi.hakanen@jyu.fi

Chair: *Kaisa Miettinen*, Dept. of Mathematical Information Technology, University of Jyväskylä, P.O. Box 35 (Agora), FI-40014, University of Jyväskylä, Finland, kaisa.miettinen@jyu.fi

1 - A synchronous Reference Point scheme for Stochastic Multiobjective Problems

Mariano Luque, Applied Economics (Mathematics), University of Malaga, Ejido, 6, 29071, Malaga, Spain, mluque@uma.es, Jose Manuel Cabello, Ana Belen Ruiz, Francisco Ruiz

In this work, we propose an interactive synchronous approach for stochastic multiobjective programming, which is based on the achievement scalarizing function approach, and where the reference point philosophy is adapted to the nature stochastic in several ways. At each iteration, the DM must provide a reference level for each objective and the risk level (probability) that he is prepared to assume for each objective. We show that three different scalarizing functions can be used for each iteration, depending on which information is regarded as reference point. Theoretical results are given which prove the efficiency of the optimal solutions obtained in the three cases.

2 - Gemstone cutting - a tradeoff between beauty and volume

Karl-Heinz Küfer, Optimization, Fraunhofer ITWM, Fraunhofer-Platz 1, 67663, Kaiserslautern, Germany, kuefer@itwm.fhg.de, Anton Winterfeld

Production of gemstones has in all times been a compromise between best possible volume exploitation of expensive rough materials and producing a beautiful jewel. Fraunhofer ITWM has devised a mathematical model for decision support of this multicriteria problem for the gemindustry. The code based on a semiinfinite programming approach is working in daily business. The talk will survey mathematical models used and will demonstrate the functionality of the system with screen shots.

3 - An interactive multi-objective approach to heat exchanger network synthesis

Timo Laukkanen, Energy Technology, Aalto University School of Science and Technology, PO Box 14400, FI-00076 Aalto, PO Box 14400, FI-00076 Aalto, Finland, timo.laukkanen@tkk.fi, Tor-Martin Tveit, Vesa Ojalehto, Kaisa Miettinen, Carl-Johan Fogelholm

The heat exchanger network synthesis problem is a very important problem for designing energy-efficient industrial processes. One approach in solving this synthesis problem has been to use single-objective MINLP models where the objective is to design a heat exchanger network that minimises total annualised cost, i.e. investment and energy costs. In this work we use a multi-objective approach to heat exchanger network synthesis. The approach solves a modified version of a known MINLP model using an interactive multi-objective optimisation method, NIMBUS, which is partly implemented in GAMS.

4 - Interactive Wastewater Treatment Plant (WWTP) Design by Using Pareto Navigator

Jussi Hakanen, Dept. of Mathematical Information Technology, University of Jyväskylä, P.O. Box 35 (Agora), FI-40014, University of Jyväskylä, Finland, jussi.hakanen@jyu.fi, Kaisa Miettinen

In WWTP design, conflicting objectives need to be considered simultaneously, e.g. operational requirements and economical efficiency. Finding the most preferred design involves solving a multiobjective optimization (MO) problem where objective values are obtained via computationally costly numerical simulation. We apply an interactive MO method Pareto Navigator utilizing an approximation of the Pareto optimal set instead of costly simulation when searching for the best compromise design. The benefits include a reduced computational time and interactive design process enabling learning.

TD-24

Tuesday, 14:00-15:20

6.2.50

Bioinformatics V

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

1 - Cancer classification using hyper-box enclosure method

Onur Dagliyan, Chemical and Biological Engineering, Koc University, Rumelifeneri yolu, Sariyer, 34450, Istanbul, Turkey, odagliyan@ku.edu.tr, Halil Kavakli, Metin Turkay

One of the applications of microarray experiments is the classification of tumor types with respect to their gene profiles. In this work, we employed a mixed integer programming based "hyper-box enclosure method" for the classification of some cancer types such as leukemia, prostate cancer, lymphoma, small round blue cell tumors with a minimal set of predictor genes. Due to its non-parametric structure and accurate prediction rate, hyper-box enclosure method is a robust and convenient tool for tumor prediction with a small number of gene markers.

2 - Epidemic modeling by mixtures of binomial distributions with susceptible/exposure/infection dependence

Eva Maria Ortega, CIO, University Miguel Hndez, Spain, evamaria@umh.es, Isabel Ortega

Stochastic SIR (susceptible-infective-removed) models for the mathematical modelling of the spread of an infectious disease, have received considerable attention. To incorporate individual heterogeneity, or structure mixing patterns and randomness for some parameters constitute key issues. Uncertainties are due to either environmental, clinical and exposure or social, geographical and personal features. Correlations arise from several factors influencing the epidemics in the heterogeneous populations. The impact of these dependencies has been studied by different approaches, mainly from simulation and semi-parametric modelling. Recently, Ortega and Alonso (2010) provided a general framework and analytical results to study the dependence for several epidemic models. We provide stochastic ordering results for the analysis of some epidemics where the number of infectives (susceptibles) is a mixture of a binomially distributed population conditioning upon certain amounts. Some measures for the risk assessment are compared. We consider a general stochastic model for the population of interest, with some random parameters, that leads to analyze some models in recent literature: randomized carrier-borne epidemics, infector or/and exposure dependent severity models, branching-type representations.

3 - Assignment problems for medical image registration

Michael Stiglmayr, Institute of Mathematics, University of Wuppertal, Gaußstr. 20, 42119, Wuppertal, Germany, stiglmayr@math.uni-wuppertal.de, Kathrin Klamroth

Image registration has become an indispensable tool for diagnosis and operation planning. Combinatorial, feature-based registration approach have the advantage that global optima can be determined by applying well-researched Branch and Bound algorithms, however, at a potentially high cost. The application of a generalized, mixed-integer linear and a quadratic assignment problem is discussed in the context of feature-based image registration. Computational results as well as a multicriteria parameter analysis of the model are presented.

4 - Protein domain networks: analysis of error and attack tolerance under different circumstances

Saziye Deniz Oguz, Institute of Applied Mathematics, Scientific Computing Program, Middle East Technical University, Orta Dogu Teknik Universitesi, Inonu Bulvari, Cankaya, 06531, Ankara, Turkey, doguz@metu.edu.tr, Hakan Oktom

The stability or survivability of some complex networks under different circumstances has received a growing interest among scientists. In this work we study the protein domain networks generated with data from the ProDom and Pfam domain databases with an essential interest in both error and attack tolerance. The topology of a complex network can be characterized by distribution of the connectivity. We first find out whether networks of same connectivity distribution have same robustness to error and attack. Secondly we explore whether there are evolutionary means to create such networks.

■ TD-25

Tuesday, 14:00-15:20

6.2.48

Risk Management and Portfolio Optimization III

Stream: Financial Mathematics and OR

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Fuzzy portfolio selection using a genetic algorithm

Enriqueta Vercher, Spain, enriqueta.vercher@uv.es, *José D. Bermúdez*, *José Vicente Segura*

We consider the problem of finding the efficient frontier associated with the fuzzy mean-downside risk portfolio selection model. The return and risk of the portfolio are measured through the value and ambiguity of the fuzzy number that represents the uncertainty of the return. The feasible set includes the diversification and cardinality constraints. We develop a strategy for fuzzy ordering the portfolios using a genetic algorithm that provides a set of acceptable portfolios. Illustrative examples are provided for the historical returns of a set of assets.

2 - Maxentropic Estimation of the Failure Probability Function

Alin Rusu, Faculty of Mathematics and Computer Science, University of Bucharest, Academiei Street, no. 14, sector 1, 010014, Bucuresti, Romania, rusualinmarian@yahoo.com

In this paper we will describe the failure probability function and its properties and we will estimate the failure probability function. The failure probability function is a function that depends on the design variables. The maximum entropy principle will be used in estimating the failure function. Also the confidence interval of the failure probability function will be found.

3 - S&P 500 Stocks Screening Using Multiple Criteria

Mohsen Bahramgiri, Graduate School of Management and Economics, Sharif University of Technology, Azadi St., Tehran, Iran, Islamic Republic Of, bahramgiri@sharif.edu

In this work, an optimizing method based on the multiple criterion decision making for ranking the firms' stocks with the most correlation between past performance and future success of the firms have been proposed. Ten financial ratios of the firms were treated as: "past performance" and the second one "future success" has been built based on the two concepts: the maximum lost due to both buying and selling of the stocks of a single firm, and the maximum revenue. Finally three aggregation modes have been used to bring out two general criteria.

4 - Possibilities of Calibrating Low-Default Portfolios with Parametric Approaches

Vesna Bogojevic Arsic, management, Faculty of organizational sciences, Jove Ilica 154, 11000, Belgrade, Serbia, bogojevic@fon.rs

Development of internal rating based models is very difficult for banks because of insufficient data of low-default portfolios that are used for backtesting these models. The paper considers possibilities of calibrating low-default portfolios using parametric approaches. One approach is to calibrate these portfolios using so called power curve, while the second uses receiver operating characteristic. Both approaches provide statistical measures to assess the discriminatory power of various rating models and can be used for rating model comparison.

■ TD-26

Tuesday, 14:00-15:20

3.1.11

Dynamics, statistical inference and algorithms of 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 - Bayesian inference for weighted voting games

Pierpaolo Brutti, Department of Economics and Business, LUISS Guido Carli, Viale Romania 32, 00157, Roma, Italy, pierpaolo.brutti@gmail.com, *Marco Scarsini*

Weighted voting games are ubiquitous models which are used in many fields ranging from economics and political science to bioinformatics and machine learning. They model scenarios where agents with associated a non-negative weight, vote in favour or against a decision. The decision is made if and only if the total weight of those voting in favour of the decision is equal to or greater than a given quota. In this work we consider a pre-electoral setup, so to speak, where the weight configuration has to be learnt from sampling data. Tackling this statistical problem from a Bayesian viewpoint, we place a Dirichlet prior over the weight vector to obtain – by conjugacy – a Dirichlet posterior distribution that can then be used to make inference on various solution concepts of interest. In particular we consider the posterior behaviour of the Shapley value, a key index used to quantify the "political" power of each agent, and show how useful some tools from computational and discrete geometry are in this respect. Finally we briefly touch upon an extension of our framework where also the co-operation structure is modeled as a random (weighted) graph with connectivity estimated from (historical) data.

2 - Financial games with external opportunities

Camilla Di Luca, Scienze, University "G. D'Annunzio" Chieti-Pescara, Viale Pindaro 42, 65127, Pescara, Italy, love_saved@hotmail.it, *Carles Rafels*, *Josep M Izquierdo*

In financial games, from the point of view of cooperative game theory, the proportional distribution arises as the most prominent allocation method and the core of the associated cooperative game shrinks into it if and only if there are no decisive investors. We consider the possibility of an external investor and discuss the problem within the framework of coalition structures. Generally, the core of the game turns out to be empty, so we focus on the bargaining set and give a sufficient condition to guarantee that the bargaining set only includes the proportional distribution.

3 - Algorithms in Cooperative Fair Division

Marco Dall'Aglio, Dept of Economics and Business, LUISS University, Viale Romania 32, Rome, Italy, mdallaglio@luiss.it, *Camilla Di Luca*

We consider the situation in which several agents attend the apportionment of a completely divisible good (such as a piece of land, or a cake) and are willing to cooperate to achieve a better division. We provide algorithms for finding values of the cooperative games associated to the division. These algorithms are based on a geometric model for fair division as well as on duality considerations over the same model.

■ TD-27

Tuesday, 14:00-15:20

8.2.06

URBAN TRAFFIC CONTROL

Stream: Transportation and Logistics

Invited session

Chair: *Tobias Pohlmann*, Institut für Verkehr und Stadtbauwesen, Technische Universität Braunschweig, Rebenring 31, 38106, Braunschweig, Germany, t.pohlmann@tu-braunschweig.de

1 - Online Offset Optimization of Traffic Lights using Vehicle-to-Infrastructure Communication

Daniel Schmidt, Technical University Braunschweig, Institut of Transportation and Urban Engineering, Rebenring 31, 38106, Braunschweig, Germany, dan.schmidt@tu-braunschweig.de, *Tchouankem Hugues*

Optimization of traffic lights increases road capacity and traffic flow, and can prevent traffic congestions in urban areas. Through the dynamic exchange of messages between vehicles and infrastructure online offset optimization for constructing a progressive signal system is possible. Within the project PLANETS we study methods for the offset optimization using realistic V2I-communications. To validate our research, we connect the traffic simulator AIMSUN with a model that implements the traffic light control algorithm as well as the communication between vehicles and traffic lights.

2 - Decentralized Decision Support and Coordination of Autonomous Vehicles Based on Online Data Mining Techniques

Maksims Fiosins, Department of Informatics, Clausthal University of Technology, Julius-Albert-Strasse 4, D-38678, Clausthal-Zellerfeld, Germany, maksims.fiosins@tu-clausthal.de, *Jana Görmer, Jan Fabian Ehmke*

We present an approach for decision making and coordination of vehicles in urban traffic systems. Our concept is based on the application of multiagent systems by representing vehicles as agents in a centrally controlled environment. They gain recommendations based on reinforcement learning methods, represented in the form of (decentralized) Markov Decision Processes. In order to reduce the complexity of joint learning, we organize agents in groups of limited size. Methods from the field of online data mining provide a consistent information models for learning and group formation processes.

3 - Optimisation of signal change intervals from a capacity point of view

Axel Wolfermann, Transport Planning and Traffic Engineering, Technische Universität Darmstadt, Petersenstr. 30, 64287, Darmstadt, Germany, wolfermann@verkehr.tu-darmstadt.de

To improve the efficiency of signal change intervals at signalised intersections it is important to connect the safety evaluation with a capacity evaluation. The capacity impact of signal change intervals is determined by the traffic flow characteristics, traffic volumes, and intersection design. A methodology is presented to comprehensively analyse the factors leading to capacity reductions by signal change intervals. This methodology is the basis for an optimisation of signal change intervals from a capacity point of view.

4 - Model-based Adaptive Traffic Control employing Genetic Algorithms

Tobias Pohlmann, Institut für Verkehr und Stadtbauwesen, Technische Universität Braunschweig, Rebenring 31, 38106, Braunschweig, Germany, t.pohlmann@tu-braunschweig.de, *Bernhard Friedrich*

A new adaptive traffic control strategy for urban networks with several signalized intersections has been developed. It optimizes signal plans for consecutive time intervals of 15 minutes based on forecasted traffic demands. Its main feature is a heuristic model-based offset optimization. Three different algorithms are proposed: Parallel and Serial Genetic Algorithm and Sequential Enumeration. An extended Cell Transmission Model is used to calculate the fitness in terms of delay of possible solutions. A comprehensive microsimulation study has been conducted to assess the new strategy.

■ TD-28

Tuesday, 14:00-15:20
8.2.10

Scheduling in Health Care

Stream: Scheduling

Invited session

Chair: *Dobrila Petrovic*, Faculty of Engineering and Computing, Coventry University, Priory Street, CV1 5FB, Coventry, United Kingdom, D.Petrovic@coventry.ac.uk

1 - Scheduling Treatment at a Rehabilitation Hospital

Richard M Wood, School of Mathematics, Cardiff University, Senghennydd Road, Cardiff, United Kingdom, woodrm@cardiff.ac.uk, *Jeff Griffiths, Janet Williams*

A multi-objective hierarchical scheduling problem will be presented with application to a major UK rehabilitation hospital. The project will investigate the weekly allocation of physiotherapy treatment slots to patients. The aims are to reduce the time spent on timetable production and to improve the timetable quality. An automated program is therefore developed comprising a series of greedy heuristics and steepest descent based local search algorithms. The terminating criterion will also be addressed.

2 - Heuristics for planning elective surgeries

Inês Marques, DEIO - CIO, Faculdade de Ciências da Universidade de Lisboa, Campo Grande - Ed. C6 - 4º Piso,

1749-016, Lisbon, Portugal, ines.marques@fc.ul.pt, *Maria Eugénia Captivo, Margarida Pato*

Resources rationalization is an imperative of our times, also present in health care services. In Portugal, the hospital surgery suite also has the important objective of reducing waiting lists for surgery. Both objectives are outlined in the National Health Plan for 2004-2010. Heuristics developed to address those objectives in the elective surgeries planning, as well as results obtained from their application to real data from a hospital in Lisbon, are presented. These results are also compared with results obtained through an integer linear programming model approach.

3 - Heuristics for radiotherapy scheduling

Dobrila Petrovic, Faculty of Engineering and Computing, Coventry University, Priory Street, CV1 5FB, Coventry, United Kingdom, D.Petrovic@coventry.ac.uk, *Truword Kapamara*

Novel scheduling heuristics for booking appointments for radiotherapy patients in Arden Cancer Centre, UK were developed. The heuristics involved the following parameters: a) maximum allowed breach of the patients' waiting time targets, b) number of reserved slots on treatment machines for different types of treatments, and c) number of overtime slots. Various tests were carried out to analyse the impact of these parameters on the schedule performance.

4 - Operating room planning and scheduling: a multi-objective model solved via a genetic algorithm

Rosita Guido, of Electronics, Computer Science and Systems, University of Calabria, Ponte Pietro Bucci, Arcavacata di Rende (CS), 87036, Rende, Italy, rguido@deis.unical.it, *Domenico Conforti, Francesca Guerriero*

In recent years, an increasing interest of Operations Research is on the domain of operating room (OR) planning and scheduling. In this complex context, known the conflicting nature of several goals, we have developed a multi-objective model whose aim is to assign surgeries of different surgical specialties to multiple operating rooms in a block scheduling system. The set of efficient solutions have been determined on several scenarios (real-life and randomly generated data) by adopting a genetic algorithm. Preliminary results confirm the importance of multiobjective model in OR management.

■ TD-29

Tuesday, 14:00-15:20
8.2.11

Preference Learning I

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 - Learning of rule preference models for a mixture of non-ordinal and ordinal attributes

Jerzy Blaszczynski, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, jerzy.blaszczynski@cs.put.poznan.pl, *Salvatore Greco, Roman Slowinski*

We induce from data decision rule models that represent preferences in terms of logical statements. In case of multi-attribute classification their syntax is: "if performance of action a is better (or worse) than given values of some attributes, then a belongs to at least (at most) given class", and in case of multi-attribute ranking: "if action a is preferred to action b in at least (at most) given degrees with respect to some attributes, then a is preferred to b in at least (at most) given degree". The input data are examples of classification or ranking decisions described by a mixture of non-ordinal and ordinal attributes. The above rules are induced within the Dominance-based Rough Set Approach (DRSA). While the syntax of DRSA rules involves dominance relation in the condition part, such rules are also useful when non-ordinal attributes are considered, because they provide comprehensible pros and cons arguments for a decision. Moreover, they permit to avoid discretization of numerical attributes prior to induction of rules. We give examples of induction of rule preference models and we prove their usefulness in a comparative experiment.

2 - Conditional Ranking on Relational Data

Willem Waegeman, Department of Applied Mathematics, Biometrics and Process Control, Ghent University, Coupure links 653, 9000, Ghent, willem.waegeman@ugent.be, *Tapio Pahikkala, Antti Airola, Tapio Salakoski, Bernard De Baets*

In domains like bioinformatics, information retrieval and social networks analysis, one can find learning tasks where the goal consists of inferring a ranking of objects, conditioned on a target object. We present a general kernel framework for learning conditional rankings from various types of relational data, where rankings can be conditioned on unseen data objects. Symmetric and reciprocal relations can in this framework be treated as two important special cases, for which the task simplifies to a traditional ranking task when the relations satisfy certain restrictive properties.

3 - How to establish a mathematical relationship between temperament and competences ? From a classification problem to a label ranking problem.

Massimo Gurrieri, University of Mons, Rue du Houdain 9, 7000, Mons, Belgium, Massimo.Gurrieri@umons.ac.be, *Philippe Fortemps*

In the context of recruitment, the recruiter is often interested in establishing a ranking among competences profiles of the candidates. But such a ranking of the different competences (e.g. soft skills) of one candidate is hard to establish. We are looking for rules of the following kind: "if candidate is more temperament T1 than T2, then his competence C1 is better than competence C2". Rules are generated by means of DRSA for pair-wise comparisons of competences, and then more general rules are induced by merging previous ones on a logical basis.

4 - Evolutionary Fuzzy Rules for Binary Classification Problems with Preferences

Christian Moewes, Faculty of Computer Science, University of Magdeburg, Universitaetsplatz 2, 39114, Magdeburg, Germany, cmoewes@ovgu.de, *Roman Slowinski, Izabela Szczepczak, Rudolf Kruse*

We present an approach to learn fuzzy binary classifiers from ordinal data. We assume that one class is preferred to the other, e.g., it must not be misclassified. Hence we use Dominance-based Rough Set Approach to select relevant fuzzy rules. Fuzzy partitions are tuned by an evolutionary algorithm trying to minimize classification accuracy of the current rule base. The model complexity in terms of number of rules is controlled by fuzzy confirmation measures. We discuss similarities to interval-based fuzzy classifiers and compare their performances to our approach on benchmark data sets.

■ TD-30

Tuesday, 14:00-15:20
8.2.13

MCDM 1

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues [c]

Contributed session

Chair: *Denis Yannacopoulos*, Department of Business Administration, Technological Educational Institute of Piraeus, 12244, Egaleo, Greece, dgian@teipir.gr

1 - Predictive Maintenance Program Audit by means of a multicriteria decision support methodology

Maria Carmen Carnero, Technical School of Industrial Engineering, University of Castilla-La Mancha, Avda. Camilo José Cela s/n, 13071, Ciudad Real, Ciudad Real, Spain, Carmen.Carnero@uclm.es, *Mónica Oliveira, Carlos Bana e Costa*

Auditing tools have a key role in promoting continuous improvement in a predictive maintenance program (PMP). This study proposes (and applies) a framework for auditing a PMP based on a multicriteria decision support methodology that consists on: a hierarchical model identifying and describing the auditing criteria in which the performance of the PMP should be appraised; an additive value model based on the MACBETH methodology to evaluate the level of accomplishment of the PMP; and a classification procedure to identify the dimensions and areas that demand for higher managerial attention.

2 - A Multicriteria Ordinal Measurement Method to Customer Satisfaction Evaluation: MOMENTS

Isabel M. Joao, DEQ-ISEL, CEG-IST, R. Conselheiro Emidio Navarro., 1959-007, Lisbon, Portugal, ijoao@deq.isel.ipl.pt, *Carlos Bana e Costa*

Understanding interactions between customer and the provided service, the crucial moments that lead to customer satisfaction (CS), is the key to improve the service. CS surveys ask questions about several criteria and typically use ordinal scales. To deal with the ordinal property we propose a multicriteria ordinal measurement method based on the additive value model. The value functions and criteria weights proposed by MOMENTS are obtained by an ordinal regression method with constraints. MOMENTS is illustrated with a real application in the hotel industry for guests satisfaction evaluation

3 - Citizens' Satisfaction from the Public Services: A Multicriteria Approach

Denis Yannacopoulos, Department of Business Administration, Technological Educational Institute of Piraeus, 12244, Egaleo, Greece, dgian@teipir.gr, *Panagiotis Manolitzas, Nikos Tsotsolas, Dimitrios Drosos*

Studying the administrative reforms that have taken place the last twenty years in the European Union we can assume that the basic principle of these reforms led to major changes in citizens' expectations, organizational structures and working processes. With the byway of years in the public sector many practices have been adopted like Total Quality Management, and the replanning of business procedures. These practices have been adopted in order to help the public sector to work more effectively and efficiently. In this paper we measure the citizen's satisfaction using an ordinal regression model based on the principles of multicriteria decision analysis.

■ TD-31

Tuesday, 14:00-15:20
8.2.15

OR based Decision Support by Fraunhofer Society

Stream: OR Applications in Industry

Invited session

Chair: *Sascha Herrmann*, Decision Support Systems, Fraunhofer SCS, Nordostpark 93, 90411, Nuremberg, Germany, sascha.herrmann@scs.fraunhofer.de

1 - System-Assisted Cooperation of Independent Freight Forwarding Offices

Jens Wollenweber, Decision Support Systems, Fraunhofer SCS, Nordostpark 93, 90411, Nürnberg, Germany, jens.wollenweber@scs.fraunhofer.de

The talk gives an overview of the central ideas and the preliminary findings of a publicly funded research project in the road transport sector. The project deals with non-specialized partial and full truckload (FTL) tramp transports by non-specialized less-than-truckload (LTL) forwarders. This business sector is characterized by individual and manual planning processes, the lack of computer-aided dispatching, and virtually no information interchange between local offices. The purpose of the project is the improvement of the planning of FTL road transports in independent, decentral forwarding offices by means of a decision support system (DSS) for collaborative planning. The two main challenging research issues in the development such a DSS were (i) to find a practically viable process of collaboration, i.e., a scheme for trading transport requests and vehicles, and (ii) to devise a heuristic algorithm capable of solving large instances of multi-period, multi-depot pickup and delivery problems with heterogeneous fleet, time windows and driver rules. The central aspects of the solution approaches developed in the project are presented and discussed, and some new research issues that have arisen during this work are pointed out.

2 - A Decision Support System for waste management organizations

Sascha Herrmann, Decision Support Systems, Fraunhofer SCS, Nordostpark 93, 90411, Nuremberg, Germany, sascha.herrmann@scs.fraunhofer.de

By directive of the EU existing substances like plastics or glass waste have to be collected, recycled and commercialized as secondary raw materials. While the value of these substances is small, the expenses for recycling and transportation are considerable. Therefore waste management organizations are interested in minimizing their expenses for this process. In this talk we present a generalized two-stage assignment and transportation model for this real-world problem, which can be solved within seconds. The model is integrated into a custom-made DSS, and generates substantial savings.

3 - Optimal Scheduling of Transports with Interdependent Resources for the Advanced Truckload Concept

Bettina Berning, Decision Support Systems, Fraunhofer SCS, Nordostpark 93, 90411, Nürnberg, Germany, bettina.berning@scs.fraunhofer.de

The Advanced Truckload Concept is a new business model for the truckload transport market where drivers and vehicles should operate decoupled in an area wide network of driver stations and cargo occurrence. This enables more flexibility in scheduling. Particularly with regard to smart driver changes this may result in less operating time and cost. However the economic benefit is in contrast to the mathematical complexity this problem causes. As proof of the mathematical feasibility this talk will provide a mathematical formulation as well as optimal results for small instances.

4 - CARP of Urban Municipal Solid Waste Collection

Volker Engels, Fraunhofer IML, 44227, Dortmund, Germany, volker.engels@iml.fraunhofer.de

This Article tackles a specification of real world urban Capacitated Arc Routing Problems (CARP). It deals with the collection of solid household waste in heterogeneous containers (bins, bags) with different service frequencies which belong to directed arcs of streets considering area structures and service levels. We face the challenge to find daily tours starting at depots traveling over arcs to be serviced and ending at waste plants. We consider real heterogeneous collection vehicles with fixed teams and some special constraints. Following the description of this specific problem this article proposes a multi-stage solution idea.

■ TD-32

Tuesday, 14:00-15:20

8.2.17

OR in Forest Management

Stream: OR in Agriculture and Forest Management [c]
Contributed session

Chair: *Raul Brás*, Matemática, ISEG/UTL - CEMAPRE, Rua Miguel Lupi, 20, Lisboa, 1249-078, Lisbon, Portugal, rbras@iseg.utl.pt

1 - Dynamic log yard designs for an improved coordination of sawmill and log yard operations

Luc LeBel, Sciences du bois et de la foret, université laval, 2405 de la terrasse, g1v 0a6, Quebec, Quebec, Canada, luc.lebel@sbf.ulaval.ca

Sawmills have traditionally kept high level of inventory in their yards for seasonal considerations. We attempt to find the optimal assortments to store through a Forward-Reserve Problem (FRP). The classical FRP was extended to a multi-period FRP in the context of a divergent process industry. The multi-period context allows for changes in assignments to the forward area as market conditions change. In order to account for the divergent nature of the industry, the FRP formulation has been extended to anticipate production at the mill based on known demands and market anticipation functions.

2 - On the validation of an occurrence forest fire index on a Mediterranean region

Fortunato Crespo Abril, Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Camino de Vera, s/n, 46022, Valencia, Spain, fcrespo@eio.upv.es, *Javier de Vicente*

This paper describes the methodology used to assess the capabilities of a new fire danger rating system. This index is used to map the wildland fire occurrence and risk on a Mediterranean area in Spain. A generalized estimating equations (GEE) model, which takes into account the correlated nature of responses is used to validate the occurrence fire index and to obtain a different mapping representation.

3 - Two variable selection methods for fuzzy regression model

Barbara Gladysz, Institute of Organization and Management, Wrocław University of Technology, Wybrzeże Wyspińskiego 27, 50-370, Wrocław, Poland, barbara.gladysz@pwr.wroc.pl, *Dorota Kuchta*

In the paper we propose two variable selection methods for a fuzzy regression model. The first one is a graph method and the second one is a backward selection technique. The main criterion of both methods is the significance of the regression coefficients. In the paper we also propose a criterion of fuzzy regression coincidence. In all the proposed techniques the possibility theory is applied. An example of an energy load model construction is presented. The set of a priori plausible variables consists of past levels of energy load variables and weather data.

4 - A modified Steiner forest problem with applications in conservation biology

Raul Brás, Matemática, ISEG/UTL - CEMAPRE, Rua Miguel Lupi, 20, Lisboa, 1249-078, Lisbon, Portugal, rbras@iseg.utl.pt, *J. Orestes Cerdeira*, *Diogo Alagador*, *Maria Triviño*, *Mar Cabeza*, *Miguel Araújo*

The Steiner forest problem is a generalization of the Steiner tree problem where sets of terminal vertices have to be connected at minimum cost. We consider the connection of different types of environmental similar protected areas (PA), to allow free flow of species between PA of the same type. The paths should not include sites which are environmental too different from those of the PA they are linking. We designed an algorithm to deal with very large graphs, and applied it to all the PA of the Iberian Peninsula clustered in four different types. Computational outcomes are reported.

■ TD-33

Tuesday, 14:00-15:20

8.2.19

Modelling of uncertainties in the energy sector (short-term planning)

Stream: Energy, Environment and Climate

Invited session

Chair: *Christoph Weber*, Universität Essen, Universitätsstr. 11, 45117, Essen, Germany, Christoph_Weber@uni-duisburg-essen.de

1 - Efficient treatment of the Stochastic Unit Commitment problem for long-term planning studies

Alexander Sturt, Electrical and Electronic Engineering, Imperial College, London, SW7 2AZ, London, United Kingdom, alexander.sturt07@imperial.ac.uk, *Goran Strbac*

We describe a new tool for simulating simplified, large-scale power systems with a significant renewables component. It solves the stochastic unit commitment problem at each timestep using a MILP solver. We attack the computational problem using a multi-pronged approach, including parallelisation, efficient modelling of many identical units, parsimonious construction of scenario trees, and importance sampling. These techniques reduce the computational burden to tolerable levels while still allowing us to draw meaningful, quantitative assessments of potential future power systems.

2 - Spot-based storage valuation using a multi-factor price process

Alexander Boogert, KYOS Energy Consulting / Birkbeck College, University of London, Netherlands, boogert@kyos.com, *Cyriel de Jong*

In this talk we discuss a popular valuation method for gas storage. Our starting point is the spot-based approach as introduced in Boogert & De Jong (Journal of Derivatives, 2008). In this talk we extend the approach to multi-factor price processes. Such price processes can capture more realistically the actual price behavior. First, we compare two ways to incorporate multi-factor price process into the optimization. Next, we study the impact of using multi-factor price processes on different aspects of the valuation such as convergence, average storage value and distribution of storage values

3 - Modelling Electricity Prices in the Selected Regions: Linear vs Non-linear Auto-Regressive Models

Jiri Valecky, Finance, VSB-TUO, Sokolska tr. 33, 701 21, Ostrava, Czech Republic, jiri.valecky@vsb.cz, Miroslav Culik

Because of the features occurring in the time series of electricity prices, we focused on more sophisticated models for the purposes of their modelling. We aim to the proposing the empirical models for modelling daily electricity prices in three selected regions (California, North Europe and Austria). We place the emphasis on the application of non-linear regime switching models and we also verify whether the proposed non-linear models give better results then the linear AR models and whether these results are satisfactory in the sense of data fitting and diagnostic checks.

4 - Evaluation of energy technologies based on stochastic price simulations

Dogan Keles, Institute for Industrial Production (IIP), Karlsruhe Institute for Technology (KIT), Germany, dogan.keles@kit.edu, Dominik Möst, Wolf Fichtner

The liberalisation of the energy market requires new methods for the assessment of energy technologies. Therefore a new modelling approach based on stochastic methods is introduced, considering different market parameters, such as price expectations on the spot or reserve power markets. The electricity spot prices are simulated with appropriate time-series models and a regime-switching approach. Based on these simulations a specific energy technology investment is analysed. A main outcome is that the regime-switching approach delivers well-fitting price paths for the investment evaluation.

TD-34

Tuesday, 14:00-15:20

8.2.23

Generalized Convexity II

Stream: Convex Optimization

Invited session

Chair: Zsolt Pales, Institute of Mathematics, University of Debrecen, Egyetem tér 1, 4032, Debrecen, Hungary, pales@math.klte.hu

1 - Geometric approach to approximating the solution of a class of generalized convex optimization problems

Gabriela Cristescu, Department of Mathematics and Computer Science, Aurel Vlaicu University of Arad, Aurel Vlaicu University of Arad, Department of Mathematics and Computer Science, Str. Revolutiei, No. 77., 310130, Arad, Arad, Romania, gcristescu@inext.ro, Mihail Găianu

The classes of g -convex sets and g -convex functions are described from the shape point of view. The g -convexity is a particular type of invexity, which brings useful properties in connection with approaching the vectorial optimization problems with g -convex objective functions on g -convex domain. A procedure of geometrical representation of the objective function by maps leads to a sequential approximation of the solution. A method of estimating the error is given. The paper is supported by the Education and Research Ministry of Romania, within the research project ID-1239 PN II 2007 CNC SIS.

2 - Sufficient efficiency conditions for multiobjective fractional programming with generalized type-I-univexity

Andreea Madalina Stancu, Institute of Mathematical Statistics and Applied Mathematics, The Romanian Academy, Calea 13 Septembrie, nr 13, RO-050711, Bucharest, andreea_madalina_s@yahoo.com, Ioan Stancu-Minasian

In the last time, important results in multiobjective programming involving type-I functions were obtained. In this paper, we consider the n -set functions multiobjective fractional programming problem (Problem (P)). The problem is to find the collection of (properly) efficient sets. We present a few global semiparametric sufficient efficiency conditions under various generalized type-I univexity hypotheses for Problem (P).

3 - New method of Homotopy Approximation for Solving Linear and Nonlinear problems

Mohamad Hosein Kafash, Mechanical Engineering, Islamic Azad University, No.23-12 daneshjoo-daneshjoo Blv.-vakilabad Blv., No.23-12 daneshjoo-daneshjoo Blv.-vakilabad Blv.,

+98511, Mashhad, Iran, Islamic Republic Of, m_h_k2001@yahoo.com

The homotopy perturbation method is a powerful device for solving functional equations. This method was introduced by He in the year 1998. In this method, the solution is considered as the summation of an infinite series that converges rapidly. This technique is used for many other subjects such as optimization of linear and nonlinear systems, nonlinear oscillators with discontinuities, nonlinear wave equations, boundary value problems. In this article, an analytic approximation to the solution of Blasius equation is obtained by using a new modification of homotopy perturbation method. The Blasius equation is a nonlinear ordinary differential equation which arises in the boundary layer flow. The comparison with Howarth's numerical solution shows that the new homotopy perturbation method is an effective mathematical method with high accuracy.

TD-35

Tuesday, 14:00-15:20

6.2.46

Facilitated Discrete-Event Simulation

Stream: Facilitated Modelling in OR

Invited session

Chair: Stewart Robinson, University of Warwick, Warwick Business School, Coventry, United Kingdom, stewart.robinson@warwick.ac.uk

1 - Challenges for Discrete-Event Simulation as a Facilitative Modelling Tool

Stewart Robinson, University of Warwick, Warwick Business School, Coventry, United Kingdom, stewart.robinson@warwick.ac.uk

Modelling studies involving discrete-event simulation (DES) typically require detailed models and associated with them protracted periods of model building, data collection, data analysis and experimentation. Much of this work is carried out in the back office by expert modellers with occasional client interaction. This presents a challenge to using DES for facilitative modelling which by nature requires rapid turnaround and involvement of the clients in group modelling sessions. This paper explores these challenges for DES as a facilitative modelling tool and suggests some ways in which it might be possible to use DES for this purpose. The ideas will be illustrated by two example projects.

2 - A participative modelling framework for health care simulation studies

Antuela Tako, Warwick Business School, University of Warwick, CV4 7AL, Coventry, United Kingdom, antuela.tako@wbs.ac.uk, Kathy Kotiadis, Christos Vasilakis

This study sets out a framework and accompanying tools for developing models and conducting health care simulation studies with the active involvement of the project stakeholders. So far discrete-event simulation studies in health care have not engaged stakeholders in a structured and participative mode in the development of models. In this paper we propose a framework called PartiSim that aims to engage the stakeholders of simulation studies by using a set of tools as part of a series of facilitated workshops. The PartiSim framework is illustrated by an example drawn from our experience in conducting a simulation study of a bariatric care system with healthcare professionals.

3 - Participative simulation as a pragmatic tool to facilitate problem solving

Tillal Eldabi, Brunel University, UB8 3PH, Uxbridge, United Kingdom, Tillal.Eldabi@brunel.ac.uk

The traditional approach to modelling and simulation modelling has been criticised as too rigid and irrelevant to the complexity and fluctuating dynamism of business and public sectors. In this presentation we explore the use of modelling and simulation as a facilitative tool to support problem understanding in a more pragmatic way with less emphasis on the scientific rigour of unnecessary outputs. We propose a modelling approach that sheds more light on the intangible outcomes of the modelling process. A number of examples are presented to examine the proposed approach and lay out some opportunities for further work.

■ TD-36

Tuesday, 14:00-15:20

3.1.05

Fuzzy Decision Making

Stream: Fuzzy Systems, Neural Networks & Artificial Intelligence [c]

Contributed session

Chair: *Miroslav Hudec*, Information Systems and Applications, Infostat, Dubravská cesta 3, 845 24, Bratislava, Slovakia, hudec@infostat.sk

1 - Paraconsistent Annotated Evidencial Logic Et and Decision Making Method in Fuzzy Set Theory

Fábio Romeu de Carvalho, Paulista University, Rua Dr Bacelar 1212, 04026-002, São Paulo, SP, Brazil, fabioromeu@unip.br, *Jair Minoro Abe*

Decision making is a matter of attention by experts since long time ago. Fuzzy set theory has provides a satisfactory application mainly in control systems, but it lacks some details mainly involving conflicting situations. On the other hand, Paraconsistent logic supplies the concept of inconsistency in a non-trivial way. This work presents a first attempt to cope ideas developed with paraconsistent annotated logic Et and apply them to a decision making technique for Fuzzy set theory.

2 - Introducing and Managing Uncertainty in Performance Measurement Systems

Sergio Sousa, Production and Systems, University of Minho, Campus de Gualtar, 4710-057, Braga, Portugal, sds@dps.uminho.pt, *Eusebio Nunes*

Many Performance Measurement Systems (PMSs) are available nowadays. Some Performance Measures (PMs) have intrinsic uncertainty, such as customer satisfaction that is usually expressed through natural language. Most PMSs use 'crisp' numbers that have limitations to deal with such uncertainty. The authors, inspired by the 'measurement system analysis', present an alternative approach based on the definition of a scale of uncertainty and its propagation through the PMS. The testing of such method is currently being performed to ascertain its feasibility, usability and utility.

3 - Decision Makers Weighting in Fuzzy Multiple Attributes Group Decision Making

Mohsen Rostamy-Malkhalifeh, Mathematics, Science and Research Branch, Islamic Azad University (IAU), Hesarak, poonak, 1477893855, Tehran, Iran, Islamic Republic Of, rostamy@srbiau.ac.ir, *Fateme Ghaemi Nasab*, *Razieh Mehrjoo*

In this paper we introduce a method for modifying data in Fuzzy multiple attributes group decision making problems with respect to the weight (reliability) of decision makers based on trapezoidal interval type-2 Fuzzy sets. A modified decision making method is introduced by combining our proposed algorithm with the method which was proposed by Shyi-Ming Chen.

4 - A fuzzy model for single-period inventory problem with pre-season extension

Hülya Behret, Industrial Engineering Dept., Istanbul Technical University, I.T.U. Faculty of Management, Industrial Engineering Dept., Macka., Istanbul, Turkey, hulbeh@yahoo.com

In this study a fuzzy model for an extended single-period inventory problem is proposed. The problem is extended with multiple pre-season periods. As the selling season becomes closer, the production cost increases and demand fuzziness decreases. The demand is believed to be a discrete normal fuzzy number, the holding and shortage cost parameters are considered as imprecise and represented by triangular fuzzy numbers. The optimum order period and optimum order quantity minimize the fuzzy total cost. The model is experimented with an illustrative example and supported by sensitivity analyses.

■ TD-37

Tuesday, 14:00-15:20

3.1.09

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 - Survey forest fire detection systems via multicriteria disaggregation — aggregation approach: the case of Lycabettus Hill

Athanasios Spyridakos, Mathematics, TEI of Piraeus, P. Ralli and Thivon 250, 12244, Aigaleo, Athens, Greece, tspyr@teipir.gr, *Yannis Psaromiligkos*, *Lazaros Vryzidis*, *Maria Litsardaki*, *Ioannis Salmon*

Allocation of fire detection units in forests is influenced by a set of conflicting parameters representing effectiveness (degree of screening, degree of plating), cost of installing and maintenance, reliability and security. This research work proposes a multicriteria methodological frame based on disaggregation — aggregation UTA II method and MIIDAS system, in order to support the selection of positions and the arrangement of the fire detection units in the forest. The methodological frame was utilized for the design of Lycabettus Hill fire detection system.

2 - The PROBE Decision Support System and Capital Budgeting: an application to the electricity sector

João Carlos Lourenço, Centre for Management Studies of IST (CEG-IST), Instituto Superior Técnico / Technical University of Lisbon, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, joao.lourenco@ist.utl.pt, *Carlos Bana e Costa*, *João Oliveira Soares*

Every year EDPD, the main electricity distribution company in Portugal, selects a portfolio of projects to expand and modernize its electricity network infrastructures. The portfolio must comply with budget and dependence constraints concerning different types of projects and organizational units. We present how the decision support system PROBE (Portfólio Robustness Evaluation) may be used to help the portfolio decision analysis process when in presence of uncertainty in the benefits and in the costs of the projects.

3 - Search Analysis to Locate a Sustainable Data Center in Portugal using Geographic Information Systems

Luis C. Dias, Faculdade de Economia / INESC Coimbra, University of Coimbra, Av Dias da Silva 165, 3004-512, Coimbra, Portugal, lmcddias@fe.uc.pt, *Miguel Covas*, *Carlos Santos Silva*

Data Centers (DC) are buildings constructed primarily to house, power and cool computer equipment, consuming as much energy as 25.000 households on average. The increasing demand for computer resources has led to a growth of DC's over the world along with the increase of energy used by these servers and the power and cooling infrastructure to support them. A search analysis to locate a sustainable data center in Portugal is performed using Geographic Information Systems, explicitly taking into account multiple criteria.

4 - How does the EURO Working Group on DSS interact? A social-academic network analysis 1989-2008

Fatima Dargam, SimTech Simulation Technology, Ries Strasse 120, 8010, Graz, Austria, F.Dargam@SimTechnology.com, *Rita Ribeiro*, *Pascale Zaraté*

This work reports the advances on the analysis of the social-academic network, created for the EURO Working Group on Decision Support Systems (EWG-DSS), representing the various relationships that link academically its 105 members; as well as its collaboration dynamics' evolution since 1989 up to 2008. The EWG-DSS social-academic network has already shown to encourage new research and promote further collaboration among its members in common projects and joint-publications. In this paper further network analysis is presented, to better explain some concluding factors about the group.

■ TD-38

Tuesday, 14:00-15:20

6.2.44

Stochastic Valuation of Energy Prices and Derivatives

Stream: Stochastic Valuation for Financial Markets

Invited session

Chair: *Nadia Maïzi*, Center for Applied mathematics, MINES ParisTech, Rue C. Daunesse, BP 207, 06904, Sophia-Antipolis, France, nadia.maizi@mines-paristech.fr

Chair: *Pourtallier Odile*, Sophia Antipolis, INRIA, 2004 rte des lucioles, 06902, Sophia Antipolis, odile.pourtallier@sophia.inria.fr

Chair: *Martin Rainer*, Inst. Applied Mathematics, METU Ankara, ENAMEC Inst., Glockengasse 15, D-97070 Würzburg, 97070, Würzburg, Germany, martin.rainer@enamec.de

1 - Robust pricing in electricity markets with a variable demand

Eugene Zak, Areva T&D Inc., 10865 Willows Road NE, 98052, Redmond, WA, United States, eugene.zak@areva-td.com, *Kwok Cheung*, *Ricardo Rios-Zalapa*

Clearing prices in a linear dispatch problem come from a dual solution. The situation is getting more complicated when a power demand is not constant but depends on current prices. Following Bulavskii [Soviet Math. Dokl., Vol 23 (1981), No. 2] a corresponding primal-dual model incorporates both primal and dual variables. Under a linearity assumption for the demand-price function with a semi-definite matrix a resultant quadratic program yields stable prices and optimal levels of the demand.

2 - Determining market clearing prices for coupled day-ahead energy markets

Johannes Müller, Discrete Optimization, TU Darmstadt, Dolivostr 15, 64293, Darmstadt, Germany, jmueller@mathematik.tu-darmstadt.de, *Alexander Martin*, *Sebastian Pokutta*

The European power grid can be divided into several market areas where the prices of electricity are determined in a day-ahead auction. These market areas are connected by power lines whose transmission capacity is restricted. Hence supply and demand of the different areas can not be balanced in all cases. The goal of the auction is to determine prices and cross border flow, so that the social welfare gets maximized and the electricity is transmitted in general from a low price area to an high price area. Therefore a MIQP has to be solved.

3 - Indifference price for emission permits

Olivier Davidau, Center for Applied Mathematics, Mines Paristech, Rue Claude Daunesse - B.P. 207, 06904, Sophia Antipolis Cedex, France, olivier.davidau@cma.ensmp.fr, *Mireille Bossy*, *Nadia Maïzi*, *Pourtallier Odile*

Agents on the emission markets have to assess their subjective value for emission permits. This value depends on expected emissions and thus on production. We focus on the case of an electricity producer and use a stochastic control framework, taking into account the electricity market uncertainties. Solving this stochastic control problem gives the price the agent is ready to pay for emission permits. This so called indifference price gives information on opportunity to reduce emission or invest in clean technology.

■ TD-39

Tuesday, 14:00-15:20

6.2.45

Optimal Control: Recent Advances II

Stream: Optimal Control

Invited session

Chair: *Gustav Feichtinger*, Institute for Mathematical Methods in Economics, Vienna University of Technology, Argentinierstr. 8/105-4, 1040, Vienna, Austria, gustav@eos.tuwien.ac.at

1 - Local ramp metering control based on a coupling of continuum traffic flow models with reinforcement learning

Salissou Moutari, Applied Mathematics and Theoretical Physics, Queen's University Belfast, David Bates Building, Queen's University Belfast, University Road, BT7 1NN, Belfast, United Kingdom, s.moutari@qub.ac.uk, *Barry McCollum*

In order to increase the operational efficiency of transportation systems, nowadays, freeway networks are equipped with ramp metering systems which aim to regulate, in an appropriate way, the inflow from on-ramps to main carriageways. The effectiveness of a ramp metering system in improving traffic conditions, e.g. by minimizing traffic congestion, depends highly upon the efficiency of its operational strategy. In this work, we introduce a new strategy of addressing the issue of coordinating local ramp metering actions by coupling the continuum traffic flow model with reinforcement learning.

2 - Optimal Control for Spacecraft Orbital Transfer Manuever

M. Navabi, Shahid Beheshti University, Iran, Islamic Republic Of, civil.space.edu@gmail.com, *M. Sanatifar*

The spacecraft orbital transfer is significant in view of time or energy optimality. In this paper, the optimal control for spacecraft orbital transfer using impulsive thrust is studied. Impulsive maneuvers could be categorized based on the geometry of initial and final orbits, number of impulses, etc.. Our paper is a comprehensive investigation of existing approaches and also to propose a numerical method based on minimization of total delta V for problem of optimal transfer maneuver. Some numerical examples are presented to demonstrate the accuracy of the method.

3 - A new Branch and Bound based method dedicated to minimize the energy consumption of an electric vehicle.

Merakeb Abdelkader, IRT-ENSEEIH, 2, rue Camichel, 31000, toulouse, France, abdelkader.merakeb@n7.fr, *Frederic Messine*

This work consists to elaborate a strategy of control in fixed time of an electric vehicle which must perform a given displacement. Moreover, a constraint about a state variable has to be taken into account. The minimization of the energy consumption with a fixed time makes it possible to use a mesh of time and control. According to assumptions about the terminal constraints imposed on the trajectories, an algorithm based on Branch and Bound techniques is proposed. This one is dedicated to solve the studied problem but this approach is sufficiently general for some extensions.

■ TD-40

Tuesday, 14:00-15:20

6.2.52

Port Simulation and Optimization

Stream: Container Terminal Operations

Invited session

Chair: *Yue Wu*, School of Management, University of Southampton, University Road., SO17 1BJ, Southampton, United Kingdom, Y.Wu@soton.ac.uk

Chair: *Jing-An Li*, MADIS, Institute of Systems Science, Academy of Mathematics and Systems Science, No. 55, Zhongguancun East Road, Haidian District, 100190, Beijing, China, ajli@amss.ac.cn

1 - Modeling of vehicle scheduling and storage problems for import containers

Jiabin Luo, School of Management, University of Southampton, School of Management, University of Southampton, University Road, Highfield, SO17 1BJ, Southampton, United Kingdom, j.luo@soton.ac.uk, *Yue Wu*, *Dali Zhang*

This paper discusses optimization problems for unloading import containers. A mixed integer programming model is presented for scheduling different types of container handling equipments and selecting storage locations in an integrated way. The objective is to minimize the container handling time at quay side and yard side as well as the transportation time by vehicles. Several constraints are considered as well, such as the block size, the sequence of vehicles and the handling time of cranes. A series of numerical experiments has been carried out to test the efficiency of the proposed model.

2 - Optimal pricing strategies for empty container management

Jing-An Li, MADIS, Institute of Systems Science, Academy of Mathematics and Systems Science, No. 55, Zhongguancun East Road, Haidian District, 100190, Beijing, China, ajli@amss.ac.cn

One assumption in most research about empty container management is that, the demand should be satisfied by companies' owned containers or leased containers, where empty containers are always available for the lease. However, it is not true in the real world. And companies always face the shortage of empty containers to such an extent that more and more excess demand are delayed. In this paper, we analyze the pricing strategies for empty container management. Especially, we analyze the strategy 'high price for short delivery time while low price for long delivery time'. It is shown that, this strategy can partially relax the tension of the limited empty containers. On the basis of ensuring the regular profit, this strategy also provides one flexible mechanism for empty container management.

3 - Simulation based evaluation of container terminal yard layouts

Jörg Wiese, DS&OR Lab, University of Paderborn, Warburgerstr. 100, 33098, Paderborn, Germany, wiesej@upb.de, Leena Suhl, Natalia Kliewer

The structure of a container terminal yard layout is significantly influenced by the equipment type used for stacking operations. Based on these equipment types different yard layout categories can be distinguished, such as parallel rubber tired gantry crane based layouts or perpendicular rail mounted gantry crane based layouts. We present a simulation study in which we evaluate if these yard layout categories (respectively different yard layouts) are adequate for several possible scenarios, e.g. for scenarios with varying ratios of transshipment and import/export containers.

4 - Generic Port Operations Simulator

Rui Carlos Botter, Logistics Systems, University of São Paulo, Av. Prof. Mello Moraes, no. 2231, 05356000, São Paulo, SP, Brazil, rcbotter@usp.br, Afonso Celso Medina

The research presents a generic simulator for iron ore port operations that allow the analysis of current and future operations of bulk terminals, aiming identification of bottlenecks, operational alternatives and needs for infrastructure, as well as estimating the equipments required annual productivity rates, the storage capacity requirements of all different products handled, according to the operational restrictions; evaluation of the nominal capacity and operational efficiency of the handling equipments and the selection of the export plans in the short, medium and long time horizon.

■ TD-41

Tuesday, 14:00-15:20

3.1.06

Applications of System Dynamics Modeling III

Stream: System Dynamics Modeling

Invited session

Chair: Gisele Bosso de Freitas, Department of Physics, Sao Paulo State University, Brazil, freitas_gb@yahoo.com.br

1 - Diffusion equation, growth and diagnosis of tumor aggressiveness

Gisele Bosso de Freitas, Department of Physics, Sao Paulo State University, Brazil, freitas_gb@yahoo.com.br, Elso Drigo Filho

In this work we study a model for growth of tumor cells based on a diffusion equation, which uses a 2D model on the growth of cells "in vitro". The solutions obtained can be compared to the ways that tumor cells take during growth, which may indicate tumor aggressiveness. Thus, comparing the solutions obtained through the model to the tumor forms "in vitro" could be inferred, the solutions obtained through the model, which more aggressive tumors. We suggest that this identification is related to the number of basis functions required to simulate the contour of the tumor.

2 - Optimization of resources for a behavior controlled of Petri nets with multipliers in dioid algebra

Samir Hamaci, Productique, EPMI, 13, boulevard de l'Hautail, 95092, Cergy, France, S.HAMACI@EPMI.FR, Rahim Benfkir

We are particularly interested to the problem of allocating an initial marking in a Timed Event Graphs with Multipliers for a desired cycle time. For this, for define the marking of some places, we proceed by linearization of the mathematical model reflecting the behavior of a TEGM in order to obtain a (min, +) linear model. From the latter, we determine the marking which satisfies the desired cycle time.

3 - Collective animal manure management simulation and environmental impact assessment

Francois Guerrin, CA, Inra/Cirad, Station de la Bretagne - BP 20, 97408, Saint-Denis, France, francois.guerrin@cirad.fr

This contribution deals with simulation modeling to help manage agricultural production systems. It describes the use of a Systems Dynamics complex model to simulating the functioning of pig slurry collective spreading plans in Brittany (Northwestern France), where intensive livestock farming has a well-known harmful environmental impact, namely on groundwater and coastal waters. The model dynamically simulates the slurry stock evolutions at pig farms and the spreading fluxes on crops, both at the pig farms and the remote crop farms.

■ TD-42

Tuesday, 14:00-15:20

3.1.07

Decison Making 1

Stream: Decision Making

Contributed session

Chair: Alan French, The Business School, Loughborough University, Ashby Road, LE11 3UT, Loughborough, United Kingdom, A.P.French@lboro.ac.uk

1 - Tail Restricted Stochastic Dominance (TRSD): A Class for Quasi Stochastic Dominance

Edgar Elias Osuna, Centro de Finanzas, Instituto de Estudios Superiores de Administracion (IESA), Av. IESA, San Bernardino, 1010, Caracas, DC, Venezuela, eosuna@iesa.edu.ve

We introduce a class for quasi stochastic dominance between probability distributions. It will be concerned with a dominance restricted to a range of values of the random variables which disregards very unlikely outcomes; specifically those in the tail(s) of the distributions. We have named the class Tail Restricted Stochastic Dominance (TRSD) to differentiate it from two similar concepts: the almost stochastic dominance for investment decisions (ASD) introduced by Leshno and Levy (2002) and the restricted stochastic dominance used by Davidson and Duclos (2000) for poverty studies. We illustrate the concept for the case of two empirical distributions and apply it to decision making under risk.

2 - The effects of emotions on decision making

Mohammad Emambocus, Business, London South Bank University, 103 Borough Road, SE1 0AA, London, United Kingdom, emambocm@lsbu.ac.uk

Decision making occurs in the light of uncertainty between different alternatives depending on the expected outcomes. These rational decisions are taken through the application of conditional probability as elaborated by Bayes' Theorem. However, there are lots of evidences that have proven that investors violate the Bayes rules and this is mainly due to the effects of emotions which affects the rational decision-making process. This paper investigates at this issue and analyses whether emotions are harmful to decision making or is it enhancing the process.

3 - Measuring Changes in Brand Knowledge/Perception Using Brand Concept Mapping

Alan French, The Business School, Loughborough University, Ashby Road, LE11 3UT, Loughborough, United Kingdom, A.P.French@lboro.ac.uk, Gareth Smith

The brand is an associative network of interconnected information about an object, held in memory and accessible when stimulated from the memory of a consumer. This network is dynamic and subject to change. We show how Brand Concept Mapping can be used to capture individual maps of consumers perception of brands at a point in time, which are then aggregated to produce one consensus map. In this way, changes in perception of a brand can be tracked over time. We treat the leaders of the main political parties in the UK as brands and illustrate the approach in the run-up to the general election.

■ TD-43

Tuesday, 14:00-15:20

8.2.02

Global Optimization 2

Stream: Global Optimization

Invited session

Chair: *Mirjam Duer*, Johann Bernoulli Institute of Mathematics and Computer Science, Rijksuniversiteit Groningen, P.O. Box 407, 9700 AK, Groningen, Netherlands, M.E.Dur@rug.nl

1 - An approach to constrained global optimization based on exact penalty functions

Francesco Rinaldi, Dipartimento Informatica e Sistemistica, Sapienza, via Ariosto, 25 Roma, 00185, Rome, Italy, rinaldi@dis.uniroma1.it, *Gianni Di Pillo*, *Stefano Lucidi*

In the field of global optimization many efforts have been devoted to solve unconstrained global optimization problems. The aim of this paper is to show that unconstrained global optimization methods can be used also for solving constrained optimization problems, by resorting to an exact penalty approach. In particular, we make use of a non-differentiable exact penalty function. We show that, under weak assumptions, there exists a threshold value of the penalty parameter such that any global minimizer of the penalty function is a global solution of the related constrained problem and conversely. On these bases, we describe an algorithm that, by combining an unconstrained global minimization technique for minimizing the penalty function and an automatic updating of the penalty parameter that occurs only a finite number of times, produces a sequence of solutions such that any limit point of the sequence is a global solution of the related constrained problem. In the algorithm any efficient unconstrained global minimization technique can be used. In particular, we adopt an improved version of the DIRECT algorithm. Some numerical experimentation confirms the effectiveness of the approach.

2 - Test-Problem Generator for Unconstrained Global Optimization

Chi-Kong Ng, Systems Engineering & Engineering Management, Chinese University of Hong Kong, Shatin, N.T, Hong Kong, ckng@se.cuhk.edu.hk, *Duan Li*

A novel test-problem generator for benchmarking unconstrained GO algorithms is discussed. By combining n sophisticated univariate problems and applying linear transformation of variables, a class of inseparable test-problems with $2n$ local minima is obtained. The generator is realized by a set of MATLAB programs, and is capable of generating test-problems in MATLAB and GAMS. A standard set of test problems is produced. Computational experiments have demonstrated the stability of the generating process and the controllability of assigning the difficulty level to the test problems.

3 - Certificates for copositive programming

Immanuel Bomze, ISDS, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, immanuel.bomze@univie.ac.at

Many global and some combinatorial optimization problems have a copositive reformulation, shifting complexity entirely to the question whether a given matrix is copositive, i.e. generates a quadratic form taking no negative values over the positive orthant. Either an affirmative answer or a negative certificate (a violating vector) is required. The dual involves completely positive matrices, so-called because they are symmetric-factorizable with a nonnegative rectangular matrix. Knowledge of this factor gives the explicit solution of the given problem, which is a positive certificate.

4 - Some new results on Copositive Programming

Mirjam Duer, Johann Bernoulli Institute of Mathematics and Computer Science, Rijksuniversiteit Groningen, P.O. Box 407, 9700 AK, Groningen, Netherlands, M.E.Dur@rug.nl

We present some new results on copositive programming. Copositive programs are optimization problems over the cone of copositive matrices, or its dual cone of completely positive matrices. Copositive programs are of interest because they model both quadratic and binary problems and hence provide a unified framework for certain mixed-integer nonlinear problems.

■ TD-44

Tuesday, 14:00-15:20

8.2.03

Business Process Modelling and Simulation

Stream: Simulation Based Decision Support

Invited session

Chair: *Miro Gradisar*, Univ. of Ljubljana, Faculty for economy, Kardeljeva ploscad 17, 1000, Ljubljana, Slovenia, miro.gradisar@ef.uni-lj.si

1 - Probability of default simulation: managing predictive analytics processes in a multi-model system

Igor Perko, Faculty of Economics and Business, Razlagova 14, 2000, Maribor, Slovenia, igor.perko@uni-mb.si, *Miro Gradisar*, *Samo Bobek*

For the probability of default simulation to be successful it needs to include all customers in the credit portfolio and continually deliver accurate results. To resolve these issues we propose a multi-model evaluation system using transparent selection logic and an active predictive analytics (PA) processes management. The multi-model system knowledge is stored in reasoning capable knowledge management structures while the involved PA processes are actively managed using a multi agent system. The proposed solution is applied in a scenario, based on a commercial bank customer portfolio data.

2 - Business process simulation for solving large cutting problems

Mihael Cesar, Business Informatics, Faculty of Economics, Kardeljeva pl. 17, 1000, Ljubljana, mcesar@gmail.com, *Jure Erjavec*, *Miro Gradisar*

Reasons for solving large one-dimensional cutting stock problems (CSPs) in the context of business process as a whole are outlined. The solution considers characteristics of different units (logistic, production). Large CSPs are solved through optimization on two levels. Individual order lengths are cut from the best suiting stock lengths. The whole order is divided into groups consisting of certain amount of different order lengths, which can appear only in one group. Groups enable better handling of material during the logistic process and make entire business process more effective.

3 - Cutting stock problem as a part of a business process

Jure Erjavec, Informatics, Faculty of Economics, Kardeljeva ploscad 17, 1000, Ljubljana, jure.erjavec@ef.uni-lj.si, *Miro Gradisar*

Renovation of business processes leads to shorter lead times and lower inventory levels. The size of inventory is one of the key factors when addressing the cutting stock problem. Low inventory size with regard to order size means less cutting possibilities which can lead to higher trim loss. Therefore the company has to optimize its inventory size when seeking balance between inventory costs and costs of trim loss. A simulation model for determining the optimal inventory size is developed.

4 - Cash flow modeling and optimization in road network building

Marko Šetinc, Geopolis, d.o.o., 1000, Ljubljana, marko.setinc@guest.arnes.si, *Miro Gradisar*

An efficient system was made that allows the cash flow simulation and optimization in the road building process. In the simulation a model for the calculation of cash flows was created, which is based on the National program for the construction of motorways in Slovenia. The optimization of cash flows was carried out with a genetic algorithm. It is presented, analyzed, and used several criteria for optimization as maximization of net present value and minimization of time deviation from the original plan. The obtained result is an optimal value of selected financial and time parameters.

■ TD-45

Tuesday, 14:00-15:20

8.2.12

OR in Military II

Stream: OR in Military

Invited session

Chair: *Ana Isabel Barros*, Information & Operations, TNO - Defense, Security and Safety, POBox 96864, 2509 JG, The Hague, Netherlands, ana.barros@tno.nl

1 - A Robust Approach to the Missile Defence Location Problem

Lanah Evers, Defence, Security and Safety, TNO, P.O. Box 96864, 2509 JG, The Hague, Netherlands, lanah.evers@tno.nl,
Axel Bloemen, Ana Isabel Barros, Herman Monsuur, Albert Wagelmans

This paper proposes a model for determining a robust defence strategy against ballistic missile threat. Two problem variants are formulated. In the first one, the number of ballistic missile interceptor systems is minimised, such that a predetermined defence level is achieved. In the second variant, the defence level is maximised for a given number of available interceptor systems. To solve these problems we applied both a heuristic and an exact solution method. We used a fictive, but realistic data set to illustrate the differences between both variants and their use in practice.

2 - Development of a Joint Picture for Domestic Domain Awareness

Mark Gammon, DRDC Atlantic, Defence R&D Canada, 9 Grove Street, PO Box 1012, B2Y 3Z7, Dartmouth, Nova Scotia, Canada, mark.gammon@drdc-rddc.gc.ca

Canada Command requires a Joint Picture that can combine maritime, air, and land pictures on one system to enhance their Domestic Domain Awareness in their Area of Responsibility. The development of a Joint Picture is a stated objective of Canada Command that requires more definition in order to progress from the conceptual stage to a Joint Picture that is relevant in the context of Domestic Domain Awareness. This document proposes an approach based on examination of Canada Command exercises that will produce requirements for a Joint Picture. These requirements should be consistent with and relevant to the Canada Command mission and evolve over the life of the project to accommodate changes in the CF/DND. This approach will allow the Joint Picture to progress from the conceptual stage to a Joint Picture that is relevant for Domestic Domain Awareness. The initial analysis performed and reported here shows that there is sufficient information available to support the proposed methodology.

3 - UAV's MISSION OPERATION SIMULATION

Dusan Starcevic, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Serbia, starcevc@fon.rs

Unmanned Aerial Vehicles (UAV) system require complex hardware and software components and highly time constrained coordination between these components. The software component consists of three grouped concurrent tasks (hard real-time tasks, soft real-time tasks and non-real-time tasks). Given the high cost of fielding physical UAVs, computer simulation has been used extensively to test the solutions that incorporate aforementioned challenges for UAVs. In this paper we present a simulation environment for visualizing, controlling and simulating UAVs data acquisition operations.

4 - A search game with incomplete information on a searcher's detection capability

Hideki Higuchi, Dep. of Computer Science, National Defense Academy, Japan, g48037@nda.ac.jp, *Ryusuke Hohzaki, Toru Komiya, Emiko Fukuda*

This presentation deals with a search game, in which a stationary hider selects a cell in a discrete search space to hide himself/herself, and a searcher that distributes his/hers search resources in the space to detect the hider. The searcher's detection capability usually depends on the searcher's or the hider's property which is unknown to the other. We model two search games with asymmetric information in which the searcher or the hider has private information affecting the detection capability, and show how their private information change their optimal strategies and the value of the game.

■ TD-46

Tuesday, 14:00-15:20

8.2.14

Agent-based Modeling II

Stream: Agent-Based Modeling [c]

Contributed session

Chair: *Massimo Genoese*, Institute for Industrial Production, University of Karlsruhe, Hertzstraße 16, 76187, Karlsruhe, Germany, massimo.genoese@kit.edu

1 - An agent-based electricity demand model for the distribution grid. Case study PREMIO-Capenergies project

Enrique Kremers, EIFER, Universität Karlsruhe, Emmy-Noether-Strasse 11, 76131, Karlsruhe, Germany, kremers@eifer.org, *Alvaro Gómez Ibañez, Pablo Viejo, Sophie Chartres*

To analyze demand at substation level, static, top-down based methods (load profiles or statistical analysis) are the state-of-art. The model presented here has been developed in the PREMIO-Capenergies project (dynamic load management at local scale). A three level, bottom-up approach is presented. Agents representing customers at the lowest level generate the demand based on stochastic models. Groups of customers are modelled by different agent classes. Transformers represent the aggregation points for the intermediate level and the global aggregation point stands for the substation.

2 - Stable Distributions in Agent-based Model and Asset Liability Management

Vadym Omelchenko, Faculty of Mathematics and Physics, Charles University in Prague and Institute of Information Theory and Automation, Ke Karlovu 3, 121 16 Praha 2, Prague, Czech Republic, so8859@mail.ru, *Vladimir Gurzhiy*

Stable distributions can serve as the best candidate to replace the normal distribution due to the fact that they possess most of the properties of the normal distributions representing a flexible family capable of adjusting to many constraints and fitting larger classes of data. In my research I am going to use them for modeling asset prices for the agent-based model and for Asset Liability management. The latter will be conducted in cooperation with Vladimir Gurzhiy.

3 - Supply Chains and Multiple Marginalization: A Study Using Multi-Agent Simulation

Jan Zouhar, Department of Econometrics, University of Economics, nám. W. Churchilla 4, Prague 3, 13067, 12000, Prague 2, zouharj@vse.cz

As described by multiple marginalization models, with a lack of cooperation the prices within a supply chain tend to spiral up to an inefficient level (equilibrium prices) where both the consumer surplus and the SC's profit are diminished. The focus of our recent research was the process of convergence of prices inside the SC to their equilibrium levels. The analysis was carried out using computer experiments with a multi-agent simulation model of a SC with limited information. Two different types of supply chain architecture were studied — the serial and the parallel type.

4 - A generic agent-based framework for cooperative hybrid meta-heuristic search

Simon Martin, Mathematics, University of Portsmouth, Lion Building, Lion Gate, PO1 3HE, Portsmouth, Hampshire, United Kingdom, simon.martin@port.ac.uk, *Djamila Ouelhadj, Patrick Beullens, Ender Ozcan*

Different (meta/hyper-)heuristics have strengths and weaknesses. This study aims to build a framework where different agents performing different (meta/hyper-)heuristics cooperate and investigate its performance over some OR problems. We have implemented an island model in which the agents run different (meta/hyper-)heuristics. The agents cooperate through asynchronous communication by exchanging solutions during the search process. Preliminary experiments have been conducted on TSP. We plan to apply this agent based cooperative approach to other OR problems.

■ TD-47

Tuesday, 14:00-15:20

8.2.16

Optimization in Water Systems I

Stream: OR in Water Management

Invited session

Chair: *Mathias Höfer*, Heidelberg University, 69120, Heidelberg, hoef_m@web.de

Chair: *Halil Önder*, Civil Engineering, Middle East Technical University, Middle East Technical University, Department of Civil Engineering, 06531, Ankara, Turkey, onde@metu.edu.tr

1 - Optimization of Booster Disinfection Station Scheduling

Caglayan Sert, Civil Engineering, T.C. Atılım University, İncek/Ankara, 06836, Ankara, Turkey, caglayansert@gmail.com, *Ayşe Burcu Altan Sakarya*

Chlorine is mostly used as disinfectant in water systems. Since disinfectants are reactive and decay in the system, in order to satisfy bounds on residual concentration required for water quality, chlorine added at source may not be enough. Hence booster stations are also needed. The optimization problem is formulated as having an objective to minimize the injected mass dosage rate subjected to the provision of adequate and more uniform residual concentration. A C++ code interfacing with EPANET is developed to find optimum scheduling and injection rates of the booster disinfection stations.

2 - Optimum Design of Slurry Pipelines

Burhan Yıldız, Civil Engineering, Middle East Technical University, Ankara, Turkey, burhan@metu.edu.tr, *Ayşe Burcu Altan Sakarya, Metin Ger*

There exist various applications of slurry transportation through pipelines. This transportation problem is solved to determine the pipe diameters and the transported slurry amounts from the demand points to the processing points. The minimization of the pipe and energy costs is considered as the objective function. The optimization method used is Genetic Algorithms. The proposed methodology to solve this nonlinear programming problem is applied to a transportation system and it is seen that the methodology made the complex, labor intensive equation solution process very convenient to use.

3 - Online Pressure Optimization in Water Distribution Networks

Frederik Blank, ABB Corporate Research, Germany, frederik.blank@de.abb.com, *Mathias Höfer, Rüdiger Franke, Markus Gauder*

In this presentation we provide an insight into how to improve energy efficiency and to reduce the leakage flows in water distribution networks by calculating optimal pressure set-points of the main pressure reduction valves and thus to minimize the pressure levels and along with it the leakage rate. In a first step, we present a methodology to reduce the number of model equations and constraints of a large hydraulic nonlinear water distribution network simulation model to an online suitable optimization model. In a second step the formulation of the NLP problem and results are presented.

4 - Optimal Management of Coastal Aquifers by Using Genetic Algorithm

Korkut Demirbaş, Middle East Technical University, Turkey, korkut.demirbas@tubitak.gov.tr, *Ayşe Burcu Altan Sakarya, Halil Önder*

Overexploitation of groundwater in coastal aquifers results in extraction of salt water from wells near the coast. In this work, optimal management of a coastal aquifer is studied where groundwater flow is modeled with single potential formulation of Strack (1976). Genetic algorithm (GA) is used to optimize the pumping scheme. Different seawater prevention methods such as injection wells are added to the model to further test the optimal management.

■ TD-48

Tuesday, 14:00-15:20

8.2.04

Multi-Objective Optimization

Stream: Nonlinear Programming [c]

Contributed session

Chair: *Lino Costa*, Dept. Production and Systems, University of Minho, School of Engineering, Campus de Gualtar, 4710-057, Braga, Portugal, lac@dps.uminho.pt

1 - Nonlinear Multi-Objective Integer Programming: A General Approach For Optimization

Melih Özlen, School of Mathematical and Geospatial Sciences, RMIT University, 3000, Melbourne, Australia, melih.ozlen@rmit.edu.au, *Meral Azizođlu*

In this study we develop a general approach to solve Nonlinear Multi-Objective Integer Programming problems. Our approach is based on identifying the objective efficiency and nonlinear optimality ranges. The objective efficiency ranges are found by solving Multi-Objective Integer Programming problems with fewer objectives. To find the nonlinear objective optimality ranges, we use a set of already known nondominated solutions and defined nonlinear objective function.

2 - Multiobjective optimization based on the cone of efficient directions and multiobjective golden section algorithm

Douglas Vieira, ENACOM, Brazil, douglas.vieira@enacom.com.br, *Adriano Lisboa, Rodney Saldanha*

This work introduces a method to solve nonlinear multiobjective optimization problems based on the cone of efficient directions and on a multiobjective line search. The cone of efficient directions is derived from the KKT conditions. Any direction in it guarantees a dominating point (at least in the vicinity of the evaluation point). A multiobjective golden section was formulated in to find such a point in a finite number of iterations. The resulting method inherits an asymptotical convergence to a point with necessary optimality conditions, which is a notable property in real world problems.

3 - Integrating Taylor's expansion on the lexicographic approach for unconstrained optimization

Christina D. Nikolakakou, Department of Mathematics, Patras University, Greece, University Campus, 26504, Rio, Greece, christina.nikolakakou@gmail.com, *Theodoula N. Grapsa, George S. Androulakis*

Recently, we proposed a novel technique for transforming the unconstrained optimization problem to an equivalent lexicographic optimization one. This was achieved by constructing objective functions using appropriate partition of the original objective function. In this paper we propose objective functions, via Taylor expansions, to constitute the corresponding partition of the objective function. The proposed methodology is tested in optimization problems using different order of Taylor expansions with promising results.

4 - Optimality in multiobjective programming under generalized invexity

Hachem Slimani, Laboratory of Modeling and Optimization of Systems LAMOS, Operational Research Department, University of Bejaia, 06000, Bejaia, Algeria, haslimani@gmail.com, *Mohammed Said Radjef*

We introduce new classes of invex and weakly pseudo-invex vector functions, where every component is considered with respect to its own function etc. A new Kuhn-Tucker type necessary condition is established, for differentiable multiobjective problems, without using any constraint qualification and any alternative theorem. Sufficient conditions for a feasible point to be weakly or properly efficient are obtained under weak invexity assumptions. The obtained optimality conditions allow to prove that a feasible point is weakly or properly efficient even if it is not a vector Kuhn-Tucker point.

Tuesday, 15:40-17:00**■ TE-01**

Tuesday, 15:40-17:00

Aula Magna

Plenary Talk 2

Stream: Keynote Speakers

*Invited session*Chair: *Silvano Martello*, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, silvano.martello@unibo.it**1 - A Tale of Three Eras: The Discovery and Rediscovery of the Hungarian Method***Harold W. Kuhn*, Department of Mathematics, Princeton University, Fine Hall, Washington Road, NJ 08544-1000, Princeton, United States, kuhn@math.Princeton.EDU

In the Fall of 1953, a translation of a paper of Jenő Egervary from Hungarian into English combined with a result of Denes König provided the basis of a good algorithm for the linear assignment problem. To honor the Hungarian mathematicians whose ideas had been used, it was called the Hungarian Method. In 2005, François Ollivier discovered that the posthumous papers of Carl G. J. Jacobi contain an algorithm that, when examined carefully, is essentially identical to the Hungarian Method. Since Jacobi died in 1851, this work was done over a hundred years prior to the publication of the Hungarian Method in 1955. This lecture will provide an account of the mathematical, academic, social and political worlds of Jacobi, König/Egervary, and Kuhn. As sharply different as they were (Prussian monarchy, Hungary under the Nazis and the Communists, and the post-war USA), they produced the same mathematical result. The lecture will be self-contained, assuming little beyond the duality theory of linear programming. The Hungarian Method and Jacobi's algorithm will be explained at an elementary level and will be illustrated by several examples.

Tuesday, 17:20-18:40**■ TF-03**

Tuesday, 17:20-18:40

3.2.15

Location problems

Stream: Metaheuristics

*Invited session*Chair: *Manuel Laguna*, Leeds School of Business, University of Colorado at Boulder, 80309-0419, Boulder, Colorado, United States, laguna@colorado.eduChair: *Javier Alcaraz*, Dept. Estadística, Matemáticas e Informática, Universidad Miguel Hernández de Elche, Av. Universidad s/n, 03202, Elche, Alicante, Spain, jalcaraz@umh.es**1 - Approximation Algorithms for the Competitive Facility Location Problem***Vladimir Beresnev*, Operation Research, Sobolev Institute of Mathematics, pr.Academica Koptuyuga,4, 630090, Novosibirsk, Russian Federation, beresnev@math.nsc.ru

We consider the competitive facility location problem, where two rival firms (Leader and Follower) open facilities sequentially and each client selects one of the open facilities according to his preferences. The problem is to find a facility location for the Leader which maximized his profit taking into account the best answer of the Follower. We formulate model as bilevel integer programming problem. The way of construction of an upper bound for optimal values of the Leader's profit is proposed. Together we obtain an initial approximation solution of the problem. We present local search algorithms for improving the initial solution. Our computation results illustrate the good quality of the obtained solutions.

2 - Solving a location problem with advanced metaheuristics*Javier Alcaraz*, Dept. Estadística, Matemáticas e Informática, Universidad Miguel Hernández de Elche, Av. Universidad s/n, 03202, Elche, Alicante, Spain, jalcaraz@umh.es, *Mercedes Landete*, *Juan Francisco Monge*

In this work we propose two new advanced hybrid metaheuristics to solve the Reliability P-Median Problem (RPMP) in which the objective is to minimize the operation costs but also hedging against cost failures within the system. The algorithms we have designed, a scatter search technique and a genetic algorithm, have been hybridized with procedures which incorporate problem specific knowledge in order to improve the efficiency of the techniques and the quality of the solutions found. The computational experiment carried out shows the excellent performance of these metaheuristics.

3 - A grouping genetic algorithm for the capacitated facility location problem*Diptesh Ghosh*, Production and Quantitative Methods, Indian Institute of Management, Ahmedabad, Vastrapur, Ahmedabad, Gujarat, India, diptesh@iimahd.ernet.in, *Megha Sharma*

We present a grouping genetic algorithm for the capacitated facility location problem (CFLP). We first use Monte Carlo simulations to ascertain a group of facilities with a high probability of being opened in a good solution along with another group of facilities with a low probability of being opened in such a solution. We also find groups of facilities which co-exist in a good solution, and other groups which do not co-exist in such a solution. We use these two groupings to develop a genetic algorithm for the CFLP. We present our computational experience on benchmark CFLP instances.

■ TF-04

Tuesday, 17:20-18:40

3.2.13

Airline applications

Stream: Metaheuristics

Invited session

Chair: *Elaine Wong*, Innovation Works, European Aeronautic Defence and Space Company, 41 Science Park Road #01-30, The Gemini, Science Park II, 117610, Singapore, -, Singapore, elaine.wong.kl@eads.net

Chair: *Pasu Ratprasert*, aeronautics, NCKU, NCKU Department of Aero neutics & Astroneutics, university Road, 701, tainan, Taiwan, cessa-skyline@hotmail.com

1 - Ant colony optimization applied on weekly fleet assignment with time window model

Pasu Ratprasert, aeronautics, NCKU, NCKU Department of Aero neutics & Astroneutics, university Road, 701, tainan, Taiwan, cessa-skyline@hotmail.com

Fleet assignment consists of deciding on the type of aircraft that will operate each specific flight. The objective is to maximize the total profit. The inherent complexity of fleet assignment problem has normally resulted in development of integer programming based model and various heuristic procedures. This paper we introduce the Max-Min Ant System to solve weekly fleet assignment with time window. Using data from major airlines, the result from the implementation and evaluation confirm that the proposed ACO is suitable for the airline fleet assignment problem with good performance.

2 - Exploiting metaheuristics to optimize performance-based logistics contracts for MRO services

Elaine Wong, Innovation Works, European Aeronautic Defence and Space Company, 41 Science Park Road #01-30, The Gemini, Science Park II, 117610, Singapore, -, Singapore, elaine.wong.kl@eads.net, *Zhichao Zheng*, *Arnd Schirrmann*

A key challenge of using Performance-Based Logistics contracts for aircraft MRO services is pricing competitively and profitably in face of operational uncertainties. Previous work to solve this contracting problem adopted the principal-agent model. This work extends existing models by incorporating integrality constraints. Using Simulated Annealing, we show how the MIP problem can be solved efficiently by appropriate (a)initial solution derivation, (b)neighbour generation, and (c)solution acceptance. Graphical representations of results from a real test case will be provided and analyzed.

3 - Stochastic Airport Gate Assignment Problem

Merve Şeker, Manufacturing Systems/Industrial Engineering, Sabanci University, Sabanci University, Orhanli, Tuzla, 34956, istanbul, Turkey, merveseker@su.sabanciuniv.edu, *Nilay Noyan*

We consider the flight-gate assignment problem in the presence of uncertainty in arrival and departure times of the flights. We develop stochastic programming models incorporating alternate robustness measures to obtain assignments that would perform well under potential random disruptions. In particular, we focus on the buffer and idle times, and the number of conflicting flights as robustness measures. The proposed problems are formulated as computationally expensive large-scale mixed-integer LPs. In order to find good feasible solutions in short CPU times, we employ tabu-search algorithms.

■ TF-05

Tuesday, 17:20-18:40

3.2.16

Meet the Editors of EJOR

Stream: EJOR

Invited session

Chair: *Gerard Wanrooy*, Economics and Decision sciences, Elsevier Science, P O Box 1991, Amsterdam, Netherlands, g.wanrooy@elsevier.nl

1 - Meet the Editors of 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, *Jesus Artalejo*, *Jean-Charles Billaut*, *Robert Dyson*, *Lorenzo Peccati*

During this session, the editors of the European Journal of Operational Research, Jesus Artalejo, Jean-Charles Billaut, Robert Dyson, Lorenzo Peccati and Roman Slowinski, will present the editorial policy (increase of selectivity, invited reviews, special issues, plagiarism problems, etc.) and production report of the journal (bibliometry, rejection rate, geographical breakdown, ScienceDirect downloads, etc.). They will also explain their approach to evaluation and selection of articles, and will point out topics in which methodological papers, invited reviews and application papers are particularly welcome. Some general questions will be welcome during this session, but it is not the intention to discuss individual articles (published, rejected or in process). A drink offered by Elsevier will be served to the participants.

■ TF-06

Tuesday, 17:20-18:40

8.2.30

DEA Application IV — Quality of Life and development

Stream: DEA and Performance Measurement

Invited session

Chair: *Juan Ventura*, Administración de Empresas, University of Oviedo, Av. Cristo s/n, 33071, Oviedo, Spain, ventura@uniovi.es

1 - Evaluation of performance of european cities with the aim to promote quality of life improvements

Paulo Morais, Engenharia Industrial e Gestão, Faculdade de Engenharia da Universidade do Porto, Rua Roberto Frias, 4200-465, Porto, Portugal, pauloteixeiramorais@gmail.com, *Ana Camanho*

This paper explores the possibilities presented by DEA to assess quality of life and evaluate performance of city managers in the promotion of urban quality of life. Using the data provided by the Urban Audit program from the EU we defined the profile for 206 cities. Two approaches are presented: a composite indicator of quality of life and the performance of local management, contextualised by the GDP per capita to take into account national economic conditions. The results identify the cities with urban best practices and present a model of intervention for the cities considered inefficient

2 - Efficiency of public expenditure: a two-stage dea approach

Janaina Tenorio, of Economics, Federal University of Pernambuco, R. Prof. Marculino Botelho, 835, ap 401, 53130-150, Olinda, Pernambuco, Brazil, janainaratis@gmail.com, *Francisco Ramos*

The importance of public expenditure policies for economic development is widely recognized. It is argued that the local government has superior advantage in providing such services because its proximity to users facilitates the identification of the social needs. This paper aims to measure the efficiency of the expenditures made by the local governments in a Brazilian state using two-stages DEA estimators. The results showed that, in general, the smaller is the municipal the lower is its efficient index, characterizing the existence of economies of scale.

3 - Optimal National Resource Allocation for Multi-Factor Development: Cross-Country Analysis Based on DEA

Abdel Latif Anouze, Busienss School, American University of Beirut, Bliss Street, 1107 2020, Beirut, Lebanon, aamajed2001@hotmail.com, *Neil Yorke-Smith*

Development, economic and other, depends on prudent allocation of national resources. Recent works that rank countries using DEA approaches, taking Human Development Factors as the primary model input and outputs, offer classification of countries but fail to provide strategies to improve a country's rank. We propose such strategies, combining DEA with Classification and Regression, in order to suggest rules that indicate the most effective allocation of resources. By considering a wider range of national performance indicators, we aim toward applicability and acceptability of the results.

4 - Assessment of quality of life using value efficiency analysis: the importance of the geographic level of analysis

Eduardo Gonzalez, Business Administration, University of Oviedo, Av Cristo s(n. 33071, Oviedo, Asturias, Spain, efidalgo@uniovi.es, *Ana Cárcaba*, *Juan Ventura*

Here we attempt to quantify the relative importance of three different geographic levels of analysis in assessing the quality of life (QoL) of the Spanish population. We evaluate how much QoL is explained by the province and region in which the municipality is located. We first construct a composite indicator of QoL for the 643 largest municipalities of Spain using 19 variables which are weighted by means of VEA, a refinement of DEA. The results show that the municipal level is the most important accounting for a 52% of the variance in QoL.

■ TF-07

Tuesday, 17:20-18:40

8.2.47

Scheduling Applications

Stream: Project Management and 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 - Scheduling MapReduce Computations

Maciej Drozdowski, Dept. of Computer Science and Management, Institute of Computing Science, Poznan Univeristy of Technology, Piotrowo 2, 60-965, Poznan, Poland, Maciej.Drozdowski@cs.put.poznan.pl, *Joanna Berlinska*

We analyze MapReduce distributed computations. MapReduce can be understood as two divisible applications with precedence constraints. This poses a scheduling problem of transferring load between two parallel applications using network with limited bandwidth. Schedule dominance properties are analyzed. We investigate performance limits of MapReduce computations. To our best knowledge this is the first time that processing divisible loads with precedence constraints is considered on the grounds of divisible load theory.

2 - Scheduling re-entrant jobs in the car factory paint shop

Grzegorz Pawlak, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, Poland, grzegorz.pawlak@cs.put.poznan.pl

The car factory paint shop production system was considered in the paper. Low cost and efficient production are always the car makers' goals. The scheduling jobs problem for the practical car factory paint shop was considered. The planned car sequence is disturbed by the repainted cars. The reduction of the negative impact of that process is the purpose of the work. Proposed mathematical models take into account the real production system and real data constraints. For these models the solution algorithms are developed and computational experiments are performed.

3 - Balancing and Equalizing Problem of Assembly Lines

Waldemar Grzechca, Faculty of Automatic Control, Electronics and Computer Science, The Silesian University of Technology, Akademicka 2A, 44100, Gliwice, Poland, waldemar.grzechca@polsl.pl

Assembly lines became one of the most popular production structures in manufacturing systems. The problem of balancing is connected with assigning all tasks to the workstations. The optimal solution is characterized by total zero idle time in whole system and 100% line efficiency. Mostly only feasible solutions are possible to obtain using heuristics methods. Some quality measures (line efficiency, station efficiency, smoothness index and time of line) allow us to estimate the final result. Very often instead of balancing problem the equalizing problem is considered. Equalizing allows us to avoid situation where one of the workstation is clearly loaded with low station time in comparison with other workstations.

4 - Reflecting Scheduling Goals with Due Date Involving Criteria

Malgorzata Sterna, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Malgorzata.Sterna@cs.put.poznan.pl

The performance measure is an important component of every scheduling problem. It allows for modeling different goals which should be achieved in constructed solutions. We collect some results obtained for a few criteria involving due dates and deadlines such as minimizing late work or maximizing revenue. Slight changes in the definitions of objective functions make it possible to cover different application fields. We present definitions of several scheduling problems with some results obtained for them.

■ TF-08

Tuesday, 17:20-18:40

6.1.36

Scheduling with Uncertainties

Stream: Project Management and Scheduling

Invited session

Chair: *Andreas Ernst*, Mathematics, Informatics and Statistics, CSIRO, Gate 5, Normanby Road, 3168, Clayton, Vic, Australia, Andreas.Ernst@csiro.au

1 - Algebra of uncertain variables applied to task scheduling

Maciej Hojda, Computer Science and Management, Wrocław University of Technology, Wybrzeże Wyspiańskiego 27, 50-370, Wrocław, Dolnoslaskie, Poland, maciej.hojda@pwr.wroc.pl

Uncertain variables, as introduced by Bubnicki, are a useful tool for dealing with non-determinism in operation complexes. Proposed is an approach that simplifies problem solving for a class of uncertain variables with (non-symmetric) triangular certainty distributions. It is shown that uncertain variables form a linear algebra and an expression for a linear combination of a set of uncertain variables is derived. Application of the proposed approach is shown on a simple task scheduling problem with uncertain execution times.

2 - Dynamic programming approximations for a stochastic machine scheduling problem

Débora Ronconi, Production Engineering, University of Sao Paulo, Av. Prof. Almeida Prado, 128, 05508070, Sao Paulo, Sao Paulo, Brazil, dronconi@usp.br, *Warren Powell*

In this work we examine a scheduling environment where jobs arrive to the system at random times. Jobs have to be scheduled without knowing what jobs will come afterwards. We investigate the application of approximate dynamic programming in order to help decide whether a job should be scheduled for today or some day in the future to minimize the total tardiness. Computational experiments are presented in a set of 750 problems and the proposed approach was found to be superior to known myopic policies.

3 - An exact solution algorithm for parallel machine scheduling with stochastic release dates

Andreas Ernst, Mathematics, Informatics and Statistics, CSIRO, Gate 5, Normanby Road, 3168, Clayton, Vic, Australia, Andreas.Ernst@csiro.au, *Gaurav Singh*

Consider a static stochastic machine scheduling problem where jobs with fixed duration and stochastic release dates are to be scheduled on parallel machines, subject to precedence constraints. Here a solution specifies both the order in which jobs are to be processed on each machine and a due date (or advertised completion time) for each job. The aim is to minimise the sum of expected completion times and expected tardiness. We develop a branch and bound algorithm that can solve these kinds of problems exactly and demonstrate the computational effectiveness of the scheme.

■ TF-09

Tuesday, 17:20-18:40

6.2.53

Various Aspects of Modern 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: *Armin Fügenschuh*, Optimierung, Zuse Institut Berlin, Takustraße 7, 14195, Berlin, Germany, fuegenschuh@zib.de

1 - A New Disaggregated Formulation of the Generalized Assignment Problem and Its Associated Inequalities

Ishwar Murthy, QMIS, Indian Institute of Management Bangalore, NF103, IIM Campus, Bannerghatta Road, 560076, Bangalore, Karnataka, India, ishwar@iimb.ernet.in

We present a new disaggregated formulation of the Generalized Assignment Problem, consisting of $O(mn^2)$ variables and constraints, where n denotes the number of jobs and m the number of agents. We show this formulation to be stronger than the traditional formulation. We then present generalizations of the Cover and (1,k)-Configuration inequalities whose presence in this disaggregated formulation is a lot more ubiquitous than their counterparts in the traditional formulation. Finally, we present inequalities that involve multiple agents that are specific to this formulation.

2 - Feasibility of Integer Knapsacks and Lattice Problems

Iskander Aliev, School of Mathematics, Cardiff University, Senghennydd Road, CF24 4AG, Cardiff, alievi@cf.ac.uk

We will discuss recent results on feasibility of integer knapsacks, obtained by applying lattice techniques. The feasibility problem appears to be related to the geometric structure of a certain feasible set which, apart from a few special cases, remains unexplored. Known results suggest that the set may be decomposed into the set of all integer points in the interior of a certain translated feasible cone and a complementary set with complex combinatorial structure. We give an optimal estimate for the position of the feasible cone and show that a much stronger estimate holds on average.

3 - Complexity of a Particular Class of 0-1 Linear Multiplicative Fractional Programming Problems

Simranjit Kaur, Mathematics, University of Delhi, 100 Dr. Mukherjee Nagar, Delhi, 110001, Delhi, India, simran_1209@rediffmail.com

The paper deals with hardness of 0-1 Linear Fractional Multiplicative Programming Problem considered under the assumptions: each factor in numerator and denominator is positive; each decision variable in every factor in the denominator has a non zero coefficient. We have also discussed the complexity of checking whether the problem has a unique solution or not, hardness of solving the problem even in case of unique solution, complexity of local search and global verification and complexity of the problem with cardinality constraint.

4 - Finding all the vertices of a convex polyhedral set

Israfil Roshdi, Department of Mathematics, Science and Research Branch, Islamic Azad University, Tehran, Iran, Rajaei Aveune, Eslamabad alley. No 47. Marand, Iran, 5417733737, Marand, East-azerbaijan, Iran, Islamic Republic Of, i.roshdi@gmail.com, *Mostafa Davtalab Olyaei*

A system of linear inequality constraints determines a convex polyhedral set of feasible solutions S . We consider the problem of finding all the extreme points, pay attention to redundancy and adjacency. We will construct a mixed integer programming problem and will give some structural theorems. By converting the main problem into two small sub problems; we will present an efficient algorithm for finding all extreme points of S . Our approach is totally different with the other methods in theory and practice. We will illustrate our algorithm by numerical examples.

■ TF-10

Tuesday, 17:20-18:40

6.2.56

OR in Sports 2

Stream: OR in Sports

Invited session

Chair: *Anastasios Oikonomidis*, management, university of southampton, United Kingdom, taso33bc@yahoo.co.uk

1 - Subjective Judgment vs Market Idiosyncrasies; Exploring Influences on the Favourite Longshot Bias in European Betting Markets

Anastasios Oikonomidis, management, university of southampton, United Kingdom, taso33bc@yahoo.co.uk, *Johnnie Johnson*

A dataset of 55,880 football events is analyzed to explore the favourite longshot bias in the bookmaker betting market. Limited dependent variable modelling of game outcomes is employed to identify sources of variation in the observed bias. It is concluded that it is consistently expressed through time, but varies significantly across leagues. It is shown that the bias is caused by bookmakers offering better odds for popular bets in order to increase their customer basis. Finally, it is proved that league specific fundamental information causes variation in the magnitude of the bias.

■ TF-11

Tuesday, 17:20-18:40

8.2.38

Structural Equation Modelling Approach in User Acceptance of Information Technology II

Stream: Emerging Applications of OR

Invited session

Chair: *Sevgi Ozkan*, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, Ismet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr

1 - An investigation into the acceptance of mobile banking by turkish consumers

Gülgin Afacan, Information Systems, METU, METU Information Systems, 06531, Ankara, Ankara, Turkey, e157093@metu.edu.tr, *Sevgi Ozkan*

Carrying out banking operations via mobile terminals is defined as mobile banking. Although number of mobile users is increasing throughout the world, this figure has not been observed in rate of mobile banking transactions. In this regard, major purpose of this study is to explore acceptance and adoption of mobile banking services by Turkish consumers. Theoretical framework of the study is based on Technology Acceptance Model (TAM) and also integrate trust, system quality, financial cost and self-efficacy constructs to fit the research model in mobile banking field.

2 - Factors Influencing Users' Adoption of Technology: Empirical Investigations in Different Contexts using Structural Equation Modeling Approach

Sevgi Ozkan, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, Ismet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr, *Irfan Emrah Kanat*, *Emre Sezgin*, *Yasemin Çetin*, *Duygu Findik*, *Oguzhan Alasehir*, *Nurcan Alkiş*

The factors that affect the user acceptance of technology related products and practices have attracted the attention of researchers. In this study, a technology acceptance model will be developed via Structural Equation Modeling approach. Technology Acceptance Model (TAM) will be extended in four different contexts, i.e. e-government, e-health, e-learning and e-commerce. The factors that affect the attitudes of users in each context will be investigated. The study will be implemented by collecting data within practices. This research is funded by TUBITAK project no: 109K394

3 - What is available about technology acceptance of e-learning software and systems? A review and comprehension study

Mustafa Degerli, Information Systems, Middle East Technical University, Informatics Institute, Dept. of IS, METU, Cankaya, Ankara, 06531, Ankara, Turkey, md.mustafadegerli@gmail.com, *Sevgi Ozkan*

Applying technology by means of e-learning software and systems (e-LSS) to facilitate and support learning is an important and interested in application area recently. Yet, another important concern meant for this context is surely the technology acceptance of these e-LSS by the people. Although there are studies, but not many, conducted in this subject with respect to various contexts, there is lacking a study that reviews and summarizes previous studies and provides a comprehensive guide to let people know about the technology acceptance of e-LSS. This study aims to compensate this lack.

4 - Evaluating User Acceptance of Internet Banking Service in Turkey

Mustafa Aydin, Information Management, Banking Regulation and Supervision Agency, Ataturk Bulvari, No:191/B, Kavaklıdere Çankaya, 06680, Ankara, Turkey, maydin@bddk.org.tr, *Sevgi Ozkan*, *Arif Yilmaz*

Online banking systems are beneficial both for banks as well as for users. Banks make an investment in internet based online banking systems to improve their operations and to reduce cost. The more users use online banking systems, the more they improve banks' performance. Therefore banks require a better understanding of how users accept and use online banking services. The purpose of this study is to examine factors, especially perceived usefulness and perceived ease of use, that affect users to accept online banking based on Technology Acceptance Model (TAM) in Turkey.

■ TF-12

Tuesday, 17:20-18:40

8.2.39

ANP 05

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Yi-Chun Chen*, Department of Leisure Management, Taiwan Hospitality & Tourism College, No 268 Chung-Hsing ST., Feng-Shan Village, Shou-Feng County, 974, Hualien, Taiwan, chen.vivien@gmail.com

1 - Improving the Career-Change Tendency for Hot-Spring Hotels Using Dominance-base Rough Set Approach

Yi-Chun Chen, Department of Leisure Management, Taiwan Hospitality & Tourism College, No 268 Chung-Hsing ST., Feng-Shan Village, Shou-Feng County, 974, Hualien, Taiwan, chen.vivien@gmail.com, *Gwo-Hshiung Tzeng*

The stability of hotel employees is essential to overall management of a hotel. Yet it is reported that high turnover rate is found common in hotels and causes an increasing impact on hospitality industry. Given this, the study adopts Dominance-based Rough Set Approach (DRSA) to find a strategy helpful to improve the high career-change tendency in hot spring hotels. The model was implemented with survey data from a large sample of employees of the hot spring hotels in central Taiwan.

2 - A decision Rules Approach for Marketing Improvement of European Art Tour Participants from Taiwan

Yi-Chun Chen, Department of Leisure Management, Taiwan Hospitality & Tourism College, No 268 Chung-Hsing ST., Feng-Shan Village, Shou-Feng County, 974, Hualien, Taiwan, chen.vivien@gmail.com, *Gwo-Hshiung Tzeng*

The goal of the research is to investigate the tour market of European Art-tour participants from Taiwan and learn how to improve this market for satisfying tourists' needs of mental feeling-well in art enjoyment. This study is using a brand new method of rough set-based logics. It is Dominance-based Rough Set Approach (DRSA), a set of decision rules "if-then rule" use in the preference model. The proposed method can provide practical information supposed helpful for tourism industry to develop the improvement strategies.

3 - Constructing the Learning Criteria of Basic System for Community Industry Development Based on DEMATEL technique with MCDM Model

Yi-Chun Chen, Department of Leisure Management, Taiwan Hospitality & Tourism College, No 268 Chung-Hsing ST., Feng-Shan Village, Shou-Feng County, 974, Hualien, Taiwan, chen.vivien@gmail.com, *Gwo-Hshiung Tzeng*

This research aims to explore and establish the learning criteria of basic system for community industries development to prosper the core-values and happiness. To achieve such research purposes, the methodology includes Delphi technique, and then combined DEMATEL technique with new hybrid MCDM model to construct the learning criteria of basic system for community industry development. Most importantly, what learning criteria context of this study develops could be adopted as important references; then the best core-values and happiness of community industries can be achieved.

4 - A Hybrid MCDM Model Combing DEMATEL-Based ANP with VIKOR for Establishing the Best Management Systems of Transformation-Learning Community Industry

Yi-Chun Chen, Department of Leisure Management, Taiwan Hospitality & Tourism College, No 268 Chung-Hsing ST., Feng-Shan Village, Shou-Feng County, 974, Hualien, Taiwan, chen.vivien@gmail.com, *Gwo-Hshiung Tzeng*

The purpose of this paper is to explore and establish the best management systems for transformation-learning community industries. To achieve such research purposes, a hybrid MCDM model combing DEMATEL-Based ANP (DANP) with VIKOR method is used to construct the learning criteria of the best management system for community industry transformation. Therefore, the best management systems of transformation-learning community constituted in this study could be adopted as important citation, and the best transformation criteria can be achieved.

■ TF-13

Tuesday, 17:20-18:40

2.2.21

Competitive Location

Stream: Location Analysis

Invited session

Chair: *Dolores R. Santos-Peñate*, Métodos Cuantitativos en Economía y Gestión, University of Las Palmas de Gran Canaria, Campus de Taira. Edificio Dptal de Ciencias Económicas y Empresariales D-4-22, 35017, Las Palmas de Gran Canaria, Canarias, Spain, drsantos@dmc.ulpgc.es

1 - A Competitive Location Model with Demand Uncertainty

Tolga Seyhan, Industrial and Systems Engineering, Lehigh University, 8 Duh Drive Apt. 222, 18015, Bethlehem, PA, United States, ths207@lehigh.edu, *Lawrence Snyder*

We consider a facility location problem under Stackelberg competition where two players sequentially locate their facilities in order to capture the maximum customer demand. We propose a model where the follower is assumed to employ a greedy add heuristic as his response, and formulate a mixed integer programming model that solves the leader's problem under this assumption. Later, we bring demand uncertainty into the scene such that it exists as the leader makes her decision but is resolved when the follower makes his. We extend our first model into a two stage stochastic programming model.

2 - Incorporating inventory decisions in competitive location models

Francisco Silva, Economics and Business, University of the Azores, Rua da Mae Deus, Ponta Delgada, 9500, Ponta Delgada, Portugal, fsilva@uac.pt, *Helena Ramalhinho Lourenço*

Competitive Location Models seek positions and prices which maximize the market captured by an entrant firm from previously positioned competitors. Nevertheless, strategic location decisions may have a significant impact on future inventory and shipment costs thus affecting the firm's competitive advantages. In this paper we introduce a heuristic algorithm which considers both market capture and replenishment costs in order to choose the firm's locations. Viswanathan's (1996) algorithm is used to solve the replenishment problem whereas a Greedy Randomized Adaptive Search Procedure is used to solve the location problem.

3 - A new method for the location and design of multiple new facilities in the competitive market

Nasreddine Saidani, ICD, CNRS 2848 Université de Technologie de Troyes, France, 12, rue Marie Curie - BP 2060, 10010, TROYES, France, nasreddine.saidani@utt.fr, *Feng Chu, Chen Haoxun*

This work investigates the location of multiple new facilities in a competitive market. The objective is to set up new facilities in a planar area, where similar facilities of competitors are already present. In EURO 2009 we proposed a new method with two stages for the location of a single facility in the market with a single facility of competitors. Different from the existing methods, our method takes in consideration of the reaction of competitors. In this work we generalize our method to the problem of locating multiple facilities with multiple facilities already presented in the market.

4 - An LP-PSO matheuristic to solve the leader-follower problem

Dolores R. Santos-Peñate, Métodos Cuantitativos en Economía y Gestión, University of Las Palmas de Gran Canaria, Campus de Tafira. Edificio Dptal de Ciencias Económicas y Empresariales D-4-22, 35017, Las Palmas de Gran Canaria, Canarias, Spain, drsantos@dmc.ulpgc.es, *Clara M. Campos, José A. Moreno-Pérez, Rafael Suarez-Vega*

The leader-follower problem consists of determining optimal strategies for two competing firms, the leader and the follower. The follower maximizes its market share, given the locations chosen by the leader. The leader minimizes the maximum market share that the follower can get. We propose a resolution approach in which the leader strategies are represented by particles position in a swarm optimization procedure. Given the facility locations for the leader, the follower problem is solved using linear programming.

■ TF-15

Tuesday, 17:20-18:40

2.2.12

Vehicle Routing Applications I

Stream: Vehicle Routing

Invited session

Chair: *M. Grazia Speranza*, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, speranza@eco.unibs.it

1 - Periodic Vehicle Routing and Scheduling for End-of-Life Product Collection

Yeliz Akca, Industrial Engineering, Koc University, Koc Universitesi, Rumeli Feneri Yolu., Sariyer/Istanbul - Turkey, 34450, Istanbul, Sariyer, Turkey, yakca@ku.edu.tr, *Sibel Salman, Onur Kaya, Deniz Aksen*

We address the collection of end-of-life products to be used in a production process, such as used vegetable oil for bio-diesel production. We develop a MIP model to optimize the integrated production and periodic routing schedule for collection while satisfying operational constraints. The aim is to minimize the sum of transportation, inventory and outsourcing costs. We develop a Lagrangian Relaxation method to generate both lower bounds and feasible solutions. We also develop heuristics and compare their performance with the bounds found by Lagrangian Relaxation and MIP solutions.

2 - Collection and recycling of WEEE facilities location

Jorge Pereira, Production and Systems Department, University of Minho, Portugal, Universidade do Minho, Campus de Gualtar, 4710-057, Braga, Portugal, jamilcar@gmail.com, *Simão Ribeiro, Joel Carvalho, José Oliveira, Manuel Figueiredo, José Telhada, Luis Dias*

This project focuses on a network optimization for collecting waste of electrical and electronic equipment (WEEE). Waste recovery is part of the environmental policies, regulated by European Directives promoting the collection and recycling of such equipment (Directive 2002/96/EC) which has been in force since February 2003. This project addresses the facilities location issues and the related routing problems. It is expected that relevant economic and environmental benefits will be achieved, including increases in the quantities of WEEE collected and the reduction of operational costs.

3 - An Exact Algorithm for the Vehicle Routing Problem with Stochastic Demands

Michel Gendreau, MAGI and CIRRELT, École Polytechnique, C.P. 6079, succ. Centre-ville, H3C 3A7, Montreal, Quebec, Canada, michel.gendreau@cirrelt.ca, *Walter Rei*

The Vehicle Routing Problem with Stochastic Demands (SVRPSD) consists in finding routes for a fleet of capacitated vehicles delivering goods to customers with stochastic demands. When the cumulative demand of the customers assigned to a vehicle exceeds its capacity, the vehicle goes back to the depot to replenish its stock. The objective is to find the routes that yield the lowest expected total travel cost. We present an exact solution method which relies heavily on concepts of the local branching approach for mixed integer programs. Computational results will be reported.

■ TF-16

Tuesday, 17:20-18:40

2.2.14

Optimization Methods for Railway Freight Transportation

Stream: Public Transport

Invited session

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

1 - A branch and generate heuristic (BANG) to solve large-scale train timetabling problems

Thomas Schlechte, Optimization, Zuse-Institute-Berlin, Takustrasse 7, 14195, Berlin, Berlin, Germany, schlechte@zib.de, *Ralf Borndörfer, Steffen Weider*

We present a branch and generate heuristic to solve very large-scale instances of the macroscopic train timetabling problem (TTP). The TTP consists in finding a conflict free set of train routes of maximum value in a given railway network. We model the TTP as a large scale integer program and solve it by a column generation procedure using the bundle method. We show how our branch and generate heuristic performs in comparison to standard branch and bound approaches. Computational results are shown for a part of German network (available at ttplib.zib.de) and the Simplon corridor.

2 - Modeling and Optimizing the Simplon Railway Corridor

Elmar Swarat, Optimization, Zuse Institute Berlin, Takustr. 7, 14195, Berlin-Dahlem, Germany, swarat@zib.de, *Ralf Borndörfer, Thomas Schlechte*

We present a bottom-up approach of automatic network aggregation with application to the Simplon corridor, an important line in the European railway network. Our method reduces detailed microscopic infrastructure data from a simulation kernel to an aggregated, macroscopic level. We prove error estimates for the proposed transformation, which allows for an exact optimization of train schedules using integer programming.

3 - Single Car Routing in Rail Freight Transport

Armin Fügenschuh, Optimierung, Zuse Institut Berlin, Takustraße 7, 14195, Berlin, Germany, fuegenschuh@zib.de, *Henning Homfeld, Alexander Martin, Hanno Schülldorf*

Cars in rail freight service follow prescribed routes from their origin via intermediate shunting yards to their destination. The goal in designing such routes is to reduce the number of trains and their travel distances. Various real-world hard constraints make the problem difficult to formulate and also to solve. We present mixed-integer linear and nonlinear programming formulations for this car routing problem arising at Deutsche Bahn, one of the largest European railway companies, and computational results using test- and real-world data.

4 - Optimized fleet management of ballast supply railcars

François Ramond, Innovation & Research, SNCF, 45 rue de Londres, 75008, Paris, France, francoisramond@gmail.com, *Francis Sourd, Lionel Lagarde, Pierrick Vallat*

We propose a model of railcar fleet management. The railcars, used to deliver ballast to track renewal sites, follow the cycle: empty move, ballast loading within ballast quarry, loaded move towards a customer site, unloading of ballast, empty move towards a quarry, and so on. The objective is, given a fixed fleet size, to maximize demand satisfaction while minimizing the travelled distance and encouraging railcar reuse by the same customer. Demand is satisfied if ballast is delivered during a given time range, and quarries have capacity constraints on the number of in / out moves each day.

■ TF-17

Tuesday, 17:20-18:40

1.3.14

Technologies for Collaborative Planning

Stream: Transportation Planning

Invited session

Chair: *Melanie Bloos*, Chair of Logistics, Bremen University, Wilhelm Herbst Str.5, 28359, Bremen, Germany, bloos@uni-bremen.de

1 - A Survey of Electronic Transportation Marketplaces in Germany: How can IT-Innovation promote Collaborative Transportation Planning

Michael Schwind, IT-based Logistics, Goethe University Frankfurt, Grueneburgplatz 1, 60323, Frankfurt, Germany, schwind@wiwi.uni-frankfurt.de, *Susanne Aponte*, *Andreas Stenger*

Electronic transportation marketplaces (ETM) provide a platform for the exchange of logistics services between shippers, carriers, and freight forwarders. ETMs are essential to foster collaborative transportation, but most ETMs have not reached a significant influence in logistics until now. In a survey of German logistics platforms, we identify and analyze success factors and shortcomings of the current ETMs. Finally, we propose functionalities such as integrated tour planning, tracking-and-tracing and route pricing based on combinatorial auctions in order to make the ETMs more appealing.

2 - A proposal of autonomous agents' implementation for the maritime logistics of manufactured products

Vanina Macowski Durski Silva, Production Engineering, Federal University of Santa Catarina, Rua Apeninos n. 38, apto. 303, Bairro: Córrego Grande, 88037620, Florianópolis, Santa Catarina, Brazil, vaninadurski@gmail.com, *Antonio G.N. Novaes*, *Antônio Coelho*

This beginner study aims to identify and analyze major strategic and operational parameters that work in maritime logistics of manufactured products for export. The work will be proceed on two ways, a theoretical and other numerical, in order to research the Collaborative Transportation Management to propose a model for the logistical problem under study. In the sequence, the autonomous agent theory in dynamic systems will be applied to solve the problem. Moreover, attempts to establish a criterion to distribute the costs and benefits among the key players in the transportation chain.

3 - Minimizing CO2-Emissions in Transportation Logistics via Autonomous Cooperation? Insights from a stylized Model

Richard Colmorn, Jacobs University Bremen, 28759, Bremen, r.colmorn@jacobs-university.de, *Olivier Gallay*, *Philip Cordes*, *Max-Olivier Hongler*, *Michael Hülsmann*

Awareness about global warming increases the importance of the concept of Green Logistics for logistics service providers. In that regard and focusing on transportation logistics, using autonomous cooperation technologies (e.g. RFID) might be a promising approach. In this paper, a stylized model is proposed that helps to answer the question whether decentralized or centralized organization of transportation networks should be favoured in order to minimize the CO-2 emissions produced by fuel consumption. Furthermore, possible extensions are introduced that enable to incorporate other potential sources of CO-2 emissions occurring in transportation processes.

4 - Auction-based request re-allocation in large-scale transport cooperations considering cost and quality

Tobias Buer, Dept. of Information Systems, FernUniversität - University of Hagen, Profilst. 8, 58084, Hagen, Germany, tobias.buer@fernuni-hagen.de, *Giselher Pankratz*

We examine the problem of re-allocating a large number of transportation requests among cooperating transportation firms using a combinatorial exchange mechanism. We model the problem as a bi-objective extension to the set covering problem, taking into account both minimization of total transportation cost and maximization of overall transportation service quality. For solving the problem, we propose a 'matheuristic' which applies a problem specific branch-and-bound algorithm to the path relinking phase of a bi-objective GRASP metaheuristic. Numerical results are given.

■ TF-18

Tuesday, 17:20-18:40

1.3.15

Data Mining and Knowledge Representation

Stream: Stochastic Modeling and Simulation

Invited session

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Visualization and Representation of Temporal Knowledge

Jiang-Liang Hou, Dept. of Ind. Eng. & Eng. Mgt., National Tsing Hua Univ., No. 101, Section 2, Kuang-Fu Road, Hsinchu, Taiwan 30013, R.O.C., 30013, Hsinchu, Taiwan, Taiwan, adamhou@ie.nthu.edu.tw, *Shih-Ting Yang*, *Wei-Ning Pi*, *Yuh-Liang Chen*

A model for temporal knowledge visualization is presented to enhance reuse of temporal knowledge. The free-form, text-based temporal knowledge can be converted into visualized illustrations via the proposed visualization approach. The model includes three main modules namely full text tagging (FTT), event sequence analysis (ESA) and temporal knowledge visualization (TKV). The model can improve the efficiency and effectiveness for the knowledge receivers to acquire the temporal knowledge in the text-based documents and can be applied in enterprises for employee training and other activities.

2 - Comparing partitions: visual aids

Margarida Cardoso, Métodos Quantitativos, ISCTE-IUL, Av. Forças Armadas, 1649-026, Lisboa, Portugal, margarida.cardoso@iscte.pt, *Ana Alexandra Martins*

The focus of our analysis is the data of a contingency table depicting the association between two partitions. In the context of clustering evaluation, some authors solve an assignment problem to match the two partitions. In addition, there are several coefficients quantifying agreement between two partitions. We suggest considering the contingency table data as similarities and using Multidimensional Scaling to visualize the relationship between the partitions. The proposed approach simultaneously helps visualizing the match between partitions and the distance between the corresponding groups

3 - On the efficiency of Spectral Clustering : interpretation, parallel computation and results

Sandrine Mouysset, IRIT-ENSEEIH, 2 rue Camichel, 31000, Toulouse, France, sandrine.mouysset@enseeiht.fr, *Joseph Noailles*, *Daniel Ruiz*

Spectral Clustering (SC) is one of the most important method based on dimension reduction space in Data Mining. It consists in defining a low-dimensional data space in which data points are clustered by selecting dominant eigenvectors of a Gaussian affinity matrix. With a reformulation of SC algorithm as an eigenvalues problem, an interpretation on how this method works is given. By exploiting this theoretical material, we propose a domain decomposition strategy for parallel SC. Additionally, with a criterion for determining the number of clusters, this strategy becomes robust and efficient.

4 - WhiBo - A platform for component-based design of partitioning cluster algorithms

Kathrin Kirchner, Faculty of Business and Economics, Friedrich Schiller University Jena, Department of Business Informatics, Carl - Zeiss - Strasse 3, D - 07743, Jena, Germany, kathrin.kirchner@uni-jena.de, *Boris Delibasic*, *Milos Jovanovic*, *Milan Vukicevic*, *Johannes Ruhland*

We suggest a process of designing new cluster algorithms by structuring existing ones as sets of reusable components (RCs). New algorithms can now be created as innovative component combinations. To allow for their evaluation, a RC repository has been created and is integrated into our WhiBo platform for RapidMiner. Very often, it is found that desired properties can literally be engineered into an algorithm through judicious combination of components.

■ TF-20

Tuesday, 17:20-18:40

1.3.33A

Cutting and Packing 9

Stream: Cutting and Packing

Invited session

Chair: *A. Miguel Gomes*, Faculty of Engineering / INESC Porto, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465, Porto, Portugal, agomes@fe.up.pt

1 - Multilevel cutting optimisation with production costs in practice

Helmut Schreck, TietoEnator Deutschland GmbH, 81379, München, Germany, Helmut.Schreck@tietoenator.com

Solving cutting stock problems in industrial environment has to deal with a variety of production and handling costs besides standard goals like trim loss or knife changes. Cutting optimization in paper or steel industry is often one of the key points to reduce overall production costs. In our paper we give 2 examples from steel and paper production and discuss the requirements and solution approaches for cutting stock algorithms.

2 - A Mathematical Programming Approach For Retail Space Planning

Gabriel Tavares, FICO, 551 Openaki Road, 07834, Denville, NJ, United States, gabrieltavares@fico.com

A MIP approach to automatically generate planograms based on presentation, inventory and assortment goals, is presented. The model considers a set of bounded knapsack constraints that restrict the item facings on every planogram fixture. For shelf fixtures, the packing is a 1-dimensional item tiling problem. For peg boards, the problem consists of tiling items (rectangles) into blocks (larger rectangles). Using the solver FICO-Xpress and the modeling environment Xpress-Mosel, this approach has been deployed for a large US retailer and can typically handle hundreds of items per request.

■ TF-21

Tuesday, 17:20-18:40

6.2.47

Software for OR/MS III

Stream: Software for OR/MS

Invited session

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 - SIOPRED Web Platform: a Web Application for automatic forecasting of time series

Francesc Silva, University of Valencia, Valencia, Spain, Francesc.Silva@uv.es, *José D. Bermúdez*, *José Vicente Segura*, *Enriqueta Vercher*, *Ana Corberan*

An automatic forecasting procedure based on exponential smoothing has been implemented as a web application using the kernel of SIOPRED. The procedure uses a multi-objective formulation that allows us to estimate jointly all the unknowns — smoothing parameters and initial conditions — of the forecasting method in a Soft Computing framework. The Web application enables to choose among three fitting measures and different exponential smoothing methods with additive or multiplicative seasonality. The application includes a client management suite and a SVG dynamic graphic generator module.

2 - Software for bound-constraint minimization

Ernesto G. Birgin, Dept. of Computer Science, University of São Paulo, Rua do Matão, 1010, Cidade Universitária, 05508-090, São Paulo, SP, egbirgin@gmail.com

In this talk we present recent advances in the development of a software for bound-constraint minimization. A comparison with some state-of-the-art solvers is presented and analysed. The proposed method, embedded in an augmented Lagrangian framework, is also evaluated for solving nonlinear programming problems.

3 - Optimizing Automated Share Trading Using WinORSe-AI: Cognitive Decision Theory and High Frequency Artificial Neural Networks

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*

Recent technological advances have helped to usher in an era where both automated and algorithmic trading have come to characterize current trends in real-time equity trading. This talk presents The WinORSe-AI stochastic price formation algorithm (WINKS). It is a cognitive decision making system based on twin radial basis function artificial neural networks. WINKS is a high frequency automated trading system for individual equity securities traded on U.S. exchanges. We report and demonstrate effective risk-adjusted trading that equals or exceeds results from a simple buy-hold strategy.

■ TF-22

Tuesday, 17:20-18:40

3.1.10

Health Care Policy Making III

Stream: Health Care Management [c]

Contributed session

Chair: *Amílcar Arantes*, Civil Engineering-DECivil, IST/Technical University of Lisbon, Av. Rovisco Pais, 1049-001, LISBOA, Portugal, amilcar.arantes@civil.ist.utl.pt

1 - Procurement strategies in the health sector — How advanced are procurement processes in Portuguese hospitals?

Stephan Messner, Universidade Nova de Lisboa, Rua Fernando Cabral N12/3e, 1750-329, Lisboa, Portugal, stephan.messner@gmx.at, *Amílcar Arantes*

Applying advanced strategies for procurement can help hospitals to save substantial amounts of money. Group purchasing organisations, the use of consignment stock and supplier performance management are strategies especially suited to improve the procurement process in hospitals. Based on focus interviews with procurement managers of Portuguese hospitals it became clear that there is enormous room to improve the general way how procurement is done but also the application of the three strategies mentioned. Given the overall importance of hospital logistics, the hospitals' performance could improve substantially when advancing the hospitals' procurement processes.

2 - Binary matrix decompositions without tongue-and-groove underdosage for radiation therapy planning

Celine Engelbeen, Department of mathematics, Universite Libre de Bruxelles, Boulevard du Triomphe, CP 216, 1050 Brussels, Brussels, Belgium, cengelbe@ulb.ac.be, *Antje Kiesel*

We consider the problem of decomposing a binary matrix into a nonnegative integer linear combination of some particular binary matrices satisfying the consecutive ones property as well as the tongue-and-groove constraint. We prove that this problem is polynomially solvable and provide an algorithm to solve it. This problem arises in the elaboration of radiation therapy plans.

3 - Lean Healthcare in Portuguese Hospitals — a case study

Luis Ferreira, DEGEI, Universidade de Aveiro, Campus Universitário Santiago, 3810-193, Aveiro, Portugal, lmferrreira@ua.pt, *Filipe Simões*

Nowadays the evolution of concepts and the growing need to present a rational and effective management of resources in an environment filled with difficulties, some of them chronic, has in the healthcare, and obliges to implement new management practices such as Lean Management. The purpose of this study is to present our findings in relation to how lean is being implemented in Portuguese public hospitals. Several hospitals were visited and we describe in detail one lean implementation project and the correspondent impacts in the organization.

■ TF-23

Tuesday, 17:20-18:40

6.2.49

MOO: Multiple Criteria Approaches in Mathematical Finance

Stream: Multi-Objective Optimization

Invited session

Chair: *Frank Heyde*, Institute of Mathematics, MLU Halle-Wittenberg, Theodor-Lieser-Str. 5, D-06099, Halle (Saale), Germany, heyde@mathematik.uni-halle.de

1 - Modelling a private equity fund

Johannes Tannert, Mathematics, Martin-Luther-University-Halle-Wittenberg, Theodor-Lieser-Str. 5, 06120, Halle, Sachsen-Anhalt, Germany, johannes.tannert@mathematik.uni-halle.de

In this talk, the focus is on modelling a private equity fund. Stochastic differential equations describe the draw downs, the return repayments and the investment value of the fund from the investors view. These are the restrictions of a multiobjective Markowitz optimization problem with expected return and variance as objective functions. Furthermore, several objective functions like short- and long-term profits and different risk measures are added. The multiobjective optimization problems are solved with MATLAB.

2 - A set-valued approach to minimizing risks in markets with transaction costs

Andreas Hamel, Operations Research and Financial Engineering, Princeton University, Sherrerd Hall 224, 08544, Princeton, NJ, United States, ahamel@princeton.edu

A main source for incompleteness of a financial market is the presence of transaction costs. Major constructions for such markets (e.g. super-hedging prices, risk measures) are best understood as set-valued functions. We present an approach to set-valued optimization problems involving risk minimization of set-valued risk measures in conical market models: A solution concept is defined, optimality conditions and the construction of dual problems are discussed. As a particular example, a portfolio selection problem is discussed involving a set-valued variant of the average value at risk.

3 - Duality for Bicriteria Portfolio Optimization using Average Value at Risk

Frank Heyde, Institute of Mathematics, MLU Halle-Wittenberg, Theodor-Lieser-Str. 5, D-06099, Halle (Saale), Germany, heyde@mathematik.uni-halle.de, *Andreas Löhne*, *Christiane Tammer*, *Mandy Werfel*

We consider a bicriteria Markowitz type of portfolio optimization problem where the risk is expressed by the Average Value at Risk. This problem can be approximated by a linear vector optimization problem. We introduce a set-valued and a geometric dual problem and give an interpretation of the dual problems for the portfolio problem. Moreover, we present numerical results using a primal and dual variant of the Benson algorithm.

4 - Strong KKT conditions in convex vector optimization

Joydeep Dutta, Math and Stat, Indian Institute of Technology, Office : Room No 575, Faculty Building, Academic Area, 208016, Kanpur, Uttar Pradesh, India, jdutta@iitk.ac.in, *Regina Burachik*

In this paper we provide a simple approach using the recent developments in scalar convex optimization to derive strong KKT conditions for vector optimization problems.

■ TF-24

Tuesday, 17:20-18:40

6.2.50

Workforce Scheduling 1

Stream: Timetabling and Rostering

Invited session

Chair: *Joao Telhada*, Departamento de Estatística e Investigação Operacional / Statistics and Operations Research Department, Centro de Investigação Operacional / Operational Research Centre - Faculdade de Ciências da Universidade de Lisboa / Faculty of Sciences - University of Lisbon, Bloco C6 - Campo Grande, 1749-016, Lisboa, Portugal, joao.telhada@fc.ul.pt

1 - Understanding an Operations Research Customer — Or Not

Kimmo Nurmi, Research and Development, Satakunta University of Applied Sciences, Tiedepuisto 3, 28600, Pori, Finland, cimmo.nurmi@samk.fi, *Jari Kyngas*

Good rosters have many benefits for an organization, such as lower costs, more effective utilization of resources and fairer workloads and shifts. The process of constructing optimized work timetables for the personnel is a demanding task. This paper presents a process of understanding and not understanding a customer. The presented staff scheduling problem can be divided into two separate sub-problems: days-off scheduling and shift scheduling. The algorithm used to solve the problem is a variation of the cooperative local search method. The generated software is currently in use.

2 - Alternative MIP formulations for an integrated shift scheduling and rostering problem

Joao Telhada, Departamento de Estatística e Investigação Operacional / Statistics and Operations Research Department, Centro de Investigação Operacional / Operational Research Centre - Faculdade de Ciências da Universidade de Lisboa / Faculty of Sciences - University of Lisbon, Bloco C6 - Campo Grande, 1749-016, Lisboa, Portugal, joao.telhada@fc.ul.pt, *Ana Godinho*

A problem of personnel scheduling in a multiskilled environment is addressed. This problem is treated in an integrated manner, modeling shift scheduling and rostering as one problem. Additionally, the integrated approach allows also to better model intraday breaks and days-off scheduling. Alternative MIP formulations are presented which lead to optimal shift schedulings and task assignments. Improved models are obtained by deriving new block-indexed variables. Computational results show the improvement obtained by extended formulations.

■ TF-25

Tuesday, 17:20-18:40

6.2.48

ROADEF/EURO challenge junior session 1

Stream: ROADEF/EURO challenge

Invited session

Chair: *Christian Artigues*, LAAS, CNRS, 7 avenue du Colonel Roche, 31077, Toulouse Cedex 4, artigues@laas.fr

1 - An Evolution Based Algorithm for a Large Scale Energy Management Problem

Mustafa Kerim Yilmaz, Industrial Engineering, Kocaeli University, Umuttepe Campus, Engineering Faculty, 41000, Kocaeli, Turkey, m_kerim@hotmail.com, *Mustafa Tacettin Ahmet Cihan*

The large scale energy management problem is decomposed into two parts. First, we construct alternative outage schedules for achieving the maximum number of outages by using an evolutionary algorithm while satisfying the constraints. Then we calculate the production levels of both power plant types for required demand in each time step based on each alternative outage schedule while minimizing the cost by using a heuristic approach.

2 - ROADEF/EURO Challenge 2010: A constructive heuristic for large-scale energy management problem with varied constraints

Murat Firat, Mathematics and Computer Science, Eindhoven University of Technology, Postbus 513, 5600 MB, Eindhoven, Netherlands, m.firat@tue.nl

The main strategy in my approach is to determine "lower" and "upper" bounds of both fuel amounts and starting times of type2 outages and to tighten the starting intervals of outages in order to schedule them with least possible conflicts. A constructive heuristics is designed to schedule the outages. Reducing the search space is achieved by determining the minimum cardinality subsets of outages subjected to the same constraint. The encountered conflicts among outages are resolved applying local search using these subsets.

3 - An ACO/VNS Hybrid Approach for a Large-Scale Energy Management Problem

Roman Steiner, Institute for Computer Graphics and Algorithms, Vienna University of Technology, Favoritenstraße 9-11, 1040, Wien, Austria, e0326433@student.tuwien.ac.at, *Günther Raidl*, *Sandro Pirkwieser*, *Matthias Prandstetter*

We use a combination of two different metaheuristics for solving the ROADEF 2010 energy management problem. First, we search for good solutions with an ant colony optimization (ACO) with an integrated local search component. The best found solution is then passed to a variable neighborhood search (VNS). The available time is split approximately in half for both algorithms. It turned out that the ACO is good in finding some average feasible solution and the VNS is able to further improve it. This sequential collaboration yields better solutions than solely applying one of the metaheuristics.

■ TF-26

Tuesday, 17:20-18:40

3.1.11

Cooperative situations on networks: algorithms and applications

Stream: Cooperative Game Theory

Invited session

Chair: *Stefano Moretti*, UMR7024 - LAMSADE, CNRS - Université Paris-Dauphine., Place du Maréchal de Lattre de Tassigny, F-75016, Paris, France, stefano.moretti@dauphine.fr

1 - The G-Game: A Cooperative Game Approach for Resource Consolidation in Network Dimensioning

Aruna Prem Bianzino, CNRS LTCI UMR 5141, Institut TELECOM, TELECOM ParisTech, 75013, Paris, France, bianzino@telecom-paristech.fr, *Stefano Moretti*, *Dario Rossi*, *Jean-Louis Rougier*

Reduction of energy consumption is a major concern in wired networks, usually referred to as green networking. We propose a two-steps cooperative game to reduce the unnecessary energy consumption due to under-utilized network devices, and we discuss its feasibility and computational issues. As a first step, the importance of network devices is evaluated according to the Shapley value of coalitional games, where traffic and topological constraints are considered. Second, less important devices are switched off, up to the minimal sub-network satisfying the providers constraints.

2 - Cost Sharing in Shortest Path Tree Games (SPTGs)

Nayat Horozoglu, Operational Research Group, London School of Economics and Political Science, Houghton Street, WC2A 2AE, London, United Kingdom, n.horozoglu@lse.ac.uk, *Katerina Papadaki*

The SPTGs are cooperative linear programming games where the set of players are the nodes on an undirected graph. The aim of the players is to connect to a root node at minimum cost either directly or via other players who are willing to cooperate. In the current study, we derive structural properties of the SPTGs and present a polyhedral analysis of the core of the SPTGs which is nonempty. Furthermore, we reduce the number of inequalities needed to describe the core using dominance. Our motivation to define these games is to address the cost allocation problem in Wireless Multihop Networks.

3 - Bargaining games with arbitration committee

Vladimir Mazalov, Karelia Research Center of Russian Academy of Sciences, Institute of Applied Mathematical Research, Karelia Research Center, Pushkinskaya st. 11, 185910, Petrozavodsk, Karelia, Russian Federation, vmazalov@krc.karelia.ru, *Julia Tokareva*

Here we consider two-person bargaining model based on arbitration procedure with jury. There are two players I and II. Player I makes an offer x , and II - an offer y . Offers are arbitrary real numbers. If $x > y$ the players call in the jury which consists of some members. Each member of jury decides which offer must be selected. After that they vote and the majority rule works. The solutions of the arbitrators are presented by random variables with a distribution function. We obtain the equilibrium in this bargaining game and analyze the effect of correlation between the arbitrators.

4 - Coalitional games on biological networks to measure the power of genes

Stefano Moretti, UMR7024 - LAMSADE, CNRS - Université Paris-Dauphine., Place du Maréchal de Lattre de Tassigny, F-75016, Paris, France, stefano.moretti@dauphine.fr, *Vito Fragnelli*, *Fioravante Patrone*, *Stefano Bonassi*

The interpretation of gene interaction in biological networks generates the need for a meaningful ranking of network elements. We introduce a new approach using coalitional games to evaluate the centrality of genes in networks keeping into account genes interactions. The Shapley value for coalitional games is used to express the power of each gene in interaction with the others and to stress the centrality of certain hub genes in the regulation of biological pathways of interest. In addition, the new approach allows for the integration of a priori knowledge about genes.

■ TF-27

Tuesday, 17:20-18:40

8.2.06

LOGISTICS 1

Stream: Transportation and Logistics

Invited session

Chair: *Klaus-Christian Maassen*, Mercator School of Management, University of Duisburg-Essen, Lotharstrasse 65, 47048, Duisburg, Germany, klaus-christian.maassen@uni-due.de

1 - A multi-agent negotiation protocol for freight carrier coordination

Gianluca De Pascale, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Siena, via Roma 56, 53100, sienna, Italy, luca1975@gmail.com, *Alessandro Agnetis*

In our work we address the problem of coordinating several carriers, by different owners, in using limited and shared resources in a logistic network. For such purpose we devised a distributed negotiation protocol based on the autonomous-agent paradigm. Such protocol can be implemented as a supervised, distributed local search algorithm. Our protocol exhibits several desirable properties, such as truth enforcing, reduced information exchange, little computational burden and robustness to real-time changes in problem data and structure.

2 - An Expanded Template for the Hosting of Contemporary Auctions for Freight Services

Dimitrios Emiris, INDUSTRIAL MANAGEMENT & TECHNOLOGY, UNIVERSITY OF PIRAEUS, 80 KARAOLI & DIMITRIOU STREET, 18534, PIRAEUS, emiris@unipi.gr, *Charis Marentakis*

The present article combines findings from previously published decision frameworks (Auctions Classification Ecosystem (ACE) and multi-dimensional auction modelling framework) for the customization of contemporary auctions focusing on suitability in the freight services marketplace, obeying to new types of constraints (temporal, spatial, etc.). The presented scheme is enriched to contain characteristics of auctions conducted electronically or over mobile networks setting the basics for the standardization of auctions in all available platforms beyond classic and the development of a parametric auction design model as an analysis tool for logistics practitioners.

3 - Pattern-Based Evacuation Planning for Urban Areas

Sarah Bretschneider, Mercator School of Management - Fachbereich Betriebswirtschaft, Universität Duisburg-Essen, Lotharstraße 65, Gebäude LB, 47057, Duisburg, Germany, sarah.bretschneider@uni-due.de, *Alf Kimms*

The population of an urban area may be in danger due to disasters like floods or chemical accidents. This requires decisions to protect lives of the affected population. One decision may be to evacuate the affected area. For the exceptional case of an evacuation an approach of the reorganization of the traffic routing of the endangered area is developed. In this paper a two-stage heuristic solution approach for a pattern-based mixed integer dynamic network flow model is presented.

4 - A Fast Heuristic Approach for Large Scale Cell-Transmission-Based Evacuation Planning

Klaus-Christian Maassen, Mercator School of Management, University of Duisburg-Essen, Lotharstrasse 65, 47048, Duisburg, Germany, klaus-christian.maassen@uni-due.de, *Alf Kimms*

The basic ideas of the Cell-Transmission-Model (CTM) by Daganzo (1994) were picked up recently to formulate optimization models for evacuation planning, namely the CTEPM and ExCTEPM. These optimization models were able to generate high quality evacuation plans, but computational effort and requirements, especially in terms of real world applications were very high. In order to extend adaptability to much larger evacuation scenarios, a fast heuristic procedure for solving the ExCTEPM will be presented. In a computational study we will demonstrate the effectiveness of our approach.

■ TF-28

Tuesday, 17:20-18:40
8.2.10

Decentralized scheduling

Stream: Scheduling

Invited session

Chair: *Hoong Chuin Lau*, School of Information Systems, Singapore Management University, 80 Stamford Road, 178902, Singapore, Singapore, hclau@smu.edu.sg

1 - Decentralized Resource Allocation and Scheduling via Walrasian Auctions with Negotiable Agents

Hoong Chuin Lau, School of Information Systems, Singapore Management University, 80 Stamford Road, 178902, Singapore, Singapore, hclau@smu.edu.sg

In this talk, we discuss decentralized resource allocation and scheduling problems. We present an auction approach with negotiable agents by allowing agents to switch their bid generation strategies within the auction process, such that a better system wide performance is achieved on average as compared to the conventional walrasian auction running with agents of fixed bid generation strategy. We propose a negotiation mechanism embedded in auctioneer to solicit bidders' change of strategies in the process of auction. Finally we benchmark our approach against conventional auction subject to the real-time large-scale dynamic resource coordination problem to demonstrate the effectiveness of our approach.

2 - Market-based Scheduling at Container Terminals

Clemens van Dinther, Institute of Information Management and Systems, Karlsruhe Institute of Technology (KIT), Englerstr. 14, 76131, Karlsruhe, Germany, clemens.vandinther@kit.edu, *Andreas Hudelmaier*

This paper presents a distributed market-based scheduling method for a mega-container port. The approach is based on work of Bertsekas (1990) and Lim et al. (2003). The problem is to dispatch transportation vehicles to quay-crane to (un)load vessels. A market-based approach can cope with ad hoc changes/events. We analyze the suggested mechanism and compare it to an alternative dispatching approach. In contrast to a classical scheduling problem, it is assumed that the information and optimization decisions in the container terminal are decentralized.

3 - Operational Transport Planning and Scheduling

Cees Witteveen, Software Technology, Delft University of Technology, Mekelweg 4, 26, Delft, Netherlands, C.Witteveen@tudelft.nl, *Jonne Zutt*

We consider the problem of ensuring efficient operational transport planning and scheduling, where several vehicles share a common road infrastructure with limited capacity. We propose a distributed approach where infrastructural resources act as agents that are capable to locally schedule traffic at that resource, taking into account constraints (priorities) of individual requests of the vehicles. The outcome is a distributed and scalable, context-aware, operational transportation planning that is able to deal with congestion and incidents and outperforms traditional planning techniques.

4 - Scalable decentralised approaches for job shop scheduling

Patrick De Causmaecker, Computerscience/CODEs, Katholieke Universiteit Leuven, Campus Kortrijk, Etienne Sabbelaan 53, BE-8500, Kortrijk, Flanders, Belgium, Patrick.DeCausmaecker@kuleuven-kortrijk.be, *Ann Nowe*, *Katja Verbeeck*, *Tony Wauters*, *Yailen Martinez*

We present two Reinforcement Learning approaches for the Parallel Machines Job Shop Scheduling Problem. The objective used is the minimization of the schedule makespan. We study two approaches, one where resources are modeled as intelligent agents and have to choose what operation to process next, and an other where operations themselves are seen as the agents that have to choose their mutual scheduling order. We use a value iteration method (Q-Learning) and a policy iteration method (Learning Automata). The results of both approaches improve on recently published results from the literature and we argue that they exhibit better scaling behaviour. We validate our approaches by applying them to the flexible job shop scheduling problem where operations can be executed on any of a number of available machines.

■ TF-29

Tuesday, 17:20-18:40
8.2.11

Risk measurement and management

Stream: Financial Modeling

Invited session

Chair: *Umberto Triulzi*, Department of Economic Theory and Quantitative Methods for Political Choices, University of Rome "La Sapienza", P.le Aldo Moro 5, 00185, Rome, Italy, umberto.triulzi@uniroma1.it

1 - Cds signaling

Rita D'Ecclesia, Teoria Economica e Metodi Quantitativi per le Scelte politiche, Università di Roma, Piazza Aldo Moro 5, 00185, Roma, Italy, rita.decclesia@uniroma1.it

This paper studies the reactions of the Credit Default Swap (CDS) to rating announcements. Credit rating agencies make multiple announcements, some of which are intended to reflect the latest information available about a firm and others of which are intended to provide a stable signal of credit quality. Applying event study methodology to data on CDS, we examine whether and to what extent these markets respond to rating announcements. Given CDS quotes represent market price of credit risk. The CDS market behavior provide a crucial tool for risk measurement and management

2 - Nonlinearity in electricity price series: a SETARX approach

Carlo Lucheroni, School of Science and Technologies, University of Camerino, via M. delle Carceri 9, 62032, Camerino (MC), Italy, carlo.lucheroni@unicam.it

Two TARX electricity price models are presented. In power systems, technical constraints introduce a threshold in the price formation mechanism. Below the threshold prices react smoothly to demand variations, above the threshold prices can react in a non-smooth way. A self-excited three or five regimes TARX, with one ARX sector set in the usual stable regime and two other sectors are set in unstable and metastable regimes in a specific sequence allows for nonlinear deviations from the stable regime, generating spikes and antispikes.

3 - Using Euro zone sovereign debt ETFs as portfolio constituents

Mikica Drenovak, Operational research, Statistics and IT, Faculty of Economics, Djure Pucara Starog 3, 34000, Kragujevac, Serbia, Serbia, mikicadrenovak@yahoo.com

Performance of an ETF is dominantly affected by changes in underlying benchmark. European sovereign bond space is covered by wide range of indices. ETFs that track those indices provide very good base for building new type of debt portfolios. However different criteria for constructing underlying indices imply challenging task when attempting to recognize the most efficient solutions. We identify important characteristics of the main index families and also compare equivalent indices. The aim is to provide reference framework for constructing diversified sovereign debt portfolios of ETFs.

4 - The Efficiency of Greek Pension Fund Portfolios. An Empirical Approach

Alexandros Koulis, BUSINESS ADMINISTRATION, TECHNOLOGICAL EDUCATIONAL INSTITUTE OF CHALKIDA, PSAXNA, 34400, CHALKIDA, Greece, koulisa@otenet.gr, *Christina Beneki, Maria Adam, Charalampos Botsaris*

Pension Funds in Greece can invest 23% in risk products in equities and mutual funds and the remaining 77% in fixed-income assets. In recent years, the investment in mutual funds is around 5% of their assets. This study is an empirical assessment of the performance of Greek fund managers based on Treynor-Mazuy model and performance measures, between the years 2000 and 2008. The results revealed evidence that the investment of Greek Pension Funds in mutual funds is not efficient due to the lack of the fund managers' ability to time the market correctly or select undervalued securities.

■ TF-30

Tuesday, 17:20-18:40
8.2.13

MCDM 2

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues [c]

Contributed session

Chair: *Nadia Sami*, Computer Science, Cadi Ayyad University, Faculty of the Sciences Semailia, Marrakech, Morocco, n.sami@ucam.ac.ma

1 - Towards the integration of The Multi Criteria Decision Aid in the OLAP Process

Nadia Sami, Computer Science, Cadi Ayyad University, Faculty of the Sciences Semailia, Marrakech, Morocco, n.sami@ucam.ac.ma, *Abdessadek Tikniouine*

Currently, most of the decision support systems (DSS) are based on models that take into account just one objective function (one criterion) that represents the preferences of the decision maker. The MCDA suggests methods that allow the aggregation of many criteria with the objective to select one or more solutions. In this paper, we suggest an approach which is based on the coupling of MCDA with the OLAP system (On Line Analytical Processing) which is an essential element of DSS analysis.

2 - Multi-criteria decision analysis and optimization methods in supporting sustainable use of natural resources

Tanja Myllyviita, Consumption and Production Centre/Environmental Performance Division, Finnish environment institute, Suksimestarintie 1 A 5, 80140, Joensuu, Finland, tanja.myllyviita@joensuu.fi, *Teppo Hujala, Annika Kangas, Pekka Leskinen*

Various decision aid methods are used to support sustainability in natural resources management (NRM). To assess methods' suitability to foster sustainability, 24 peer-reviewed NRM case-studies were evaluated. In the evaluated case-studies, optimization methods rarely involved stakeholders and social sustainability was less processed. Multi-criteria decision analysis (MCDA) methods included participation of stakeholders, and social sustainability was inherent. It is concluded that mixed-methods MCDA provide advantages in ensuring sustainability of NRM.

3 - Lessons from Two Recent Major MCDA Projects

David Collier, Decision Science, Golder Associates, 113 York Road, Montpelier, BS6 5QG, Bristol, United Kingdom, dcollier@golder.com

The paper contrasts two recent projects involving substantial specialist teams. One was based on a conventional scored and weighted multi-attribute decision analysis. In the other, the MADA framework was used largely without quantification to structure the problem and understand the main decision drivers. The aim was to make the best decision, transparently and with stakeholder involvement.

We will discuss the lessons for the use of MCDA frameworks and stakeholder involvement. We will draw conclusions about the appropriate use of quantification, the structured integration of MCDA outputs with other strands of information and management insight, and the role of decision specialists.

4 - The effect of customer satisfaction on financial performance: The case of mobile companies in Greece

Dimitrios Drosos, Department of Business Administration, Graduate Technological Education Institute of Pireaus, 250, Thivon ave., 12244, Aigaleo, Greece, drososd@in.teipir.gr, *Nikos Tsotsolas, Panagiotis Manolizias, Denis Yannacopoulos*

In this paper the relationship between the customer satisfaction from the three mobile companies in Greece and the financial performance of these companies is examined. Specifically, data regarding customer satisfaction were collected from customers of the three service providers using a web survey which were analysed using MUSA methodology. Then the correlation between MUSA indices for each company and their corresponding financial performance ratios was examined by using multivariate statistics and multicriteria analysis approaches.

■ TF-31

Tuesday, 17:20-18:40
8.2.15

Communication Network Design

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 - Models for FTTx network planning

Axel Werner, Optimization, Zuse Institut Berlin (ZIB), Takustr. 7, D-14195, Berlin-Dahlem, Germany, werner@zib.de

Telecommunication access networks of the future are based on fiber technology. The rollout of the infrastructure comprises large investments and therefore requires thorough planning, taking economic, technical and strategic considerations into account.

We present integer programming models trying to incorporate as many aspects of this problem as possible and show how they work together to plan cost-efficient rollout of FTTx networks. Real-world application of the approaches (in joint work with atesio GmbH) are discussed as well as the mathematical context for solving the problems.

2 - Solving A Robust Network Loading Problem - Models, Inequalities and Computations

Christian Raack, Optimization, ZIB, Takustr. 7, D-14195, Berlin, Germany, raack@zib.de

In this talk we consider network loading under demand uncertainty, adapting the robust optimization approach of Bertsimas and Sim [2004]. The corresponding polyhedral demand uncertainty set provides a reasonable alternative to the well-known hose model. We present different ways to solve the corresponding robust counterpart. To enhance the performance of the MIP solver we use cutset inequalities and arc-residual capacity inequalities that generalize their deterministic counterparts. Comprehensive computational studies are provided based on realistic networks and live traffic measurements.

3 - Self-Organization within LTE networks: Soft integration of new base

Andreas Eisenblätter, Konrad-Zuse-Zentrum für Informationstechnik Berlin (ZIB), D-14195, Berlin, eisenblaetter@atesio.de

Self-organization is a key requirement in the design of the 4th generation of mobile communication networks. Self-configuration, self-optimization, and self-healing shall reduce the need for manual intervention. LTE is being standardized as an evolution of UMTS, and first networks are already operational. The European FP7 project SOCRATES develops methods for self-organization in the radio part of LTE networks. We present the novel concept of soft-integration for new base stations, which combines classical off-line planning with on-line adjustments once live measurements become available.

4 - The Robust Network Loading Problem with Dynamic Routing

Sara Mattia, DIS, Università di Roma, via Buonarroti 12, 00185, Roma, Italy, mattia@dis.uniroma1.it

Given a graph and a set of traffic matrices, the Robust Network Loading Problem (RNL) consists of choosing minimum cost integer capacities for the edges, such that all the matrices can be routed non-simultaneously on the network. The routing scheme is dynamic if we can choose a (possibly) different routing for every matrix, it is static if the routing must be the same for all the matrices. The flows are unsplitable if each commodity can use only one path and splittable otherwise. We present the first exact branch-and-cut approach for the RNL problem with dynamic routing and splittable flows.

■ TF-32

Tuesday, 17:20-18:40

8.2.17

OR & Water Management

Stream: OR in Agriculture and Forest Management [c]

Contributed session

Chair: *Janne Helin*, Economics, Agrifood Research Finland, Luutnantintie 13, 00410, Helsinki, Finland, janne.helin@iki.fi

1 - Multicriteria Decision Support System for Surface Irrigation Design. Application to Ras-El-Ain Irrigation District, Syria

Hanaa Darouich, Administration of Natural Resources Research, General Commission for Scientific Agriculture Research, Quatli St - Duma, Damascus, Damascus, Syrian Arab Republic, m_hanaa20@yahoo.com, *José Manuel Gonçalves*, *André Muga*, *Paula Paredes*, *Luis S. Pereira*

The DSS SADREG for design and selection of farm surface irrigation systems and its application to Ras-El-Ain area, Syria, are described. It focuses on water savings, environmental and socio-economic issues adopting a multicriteria decision aid framework. The DSS allows designing and selecting an alternative set of solutions considering the criteria value functions, satisfaction pre-analysis and distance-based or ELECTRE II methods. The decision-maker interactively participates in the process, inputting field data, knowledge, and options. The advisable solutions considering several priority scenarios, and its trade-off between economic and environment aspects are included.

2 - GIS-based Water Distribution Schedule for Agriculture in Madeira Island

João Carlos Sousa, Intergraph Portugal, Rua Ivone Silva, 6, Piso 4, 1050-124, Lisboa, Portugal, joao.sousa@intergraph.com, *João Telhada*, *José Paixão*

Madeira Island has approx. 54k small individual owned parcels for which adequate amounts of water should be delivered, totaling 60k hours of watering. A network of canals, ca. 2800 Km, is used on which different types of infrastructures are installed. On the other hand, a large field team is available to operate some of the infrastructure elements. This workforce has to be managed such that meets water distribution schedule. A constructive intelligence approach is used to determine the deployed schedule, both for owners and the field team. A GIS is used to handle data in an interactive mode.

3 - Multiobjective Sustainable Water Management in Alentejo Region

Vladimir Bushenkov, Department of Mathematics, University of Evora, 7000, Evora, Portugal, bushen@uevora.pt, *Rui Frago*, *Carlos Marques*

The Feasible Goal Method/Interactive Decision Maps (FGM/IDM) approach is applied to solve a multiobjective problem of sustainable water management of the Odivelas irrigation system in the Alentejo region, Portugal, where water scarcity is real. This technique explores all water allocation combinations taking into account different water users interests. The Pareto frontier in the criteria space is visualized in the form of the tradeoff curves. The decision maker identifies here a preferred combination of the objective values (the goal) for which the computer calculates the model solution.

4 - Manure transport model for water protection of pig farms

Janne Helin, Economics, Agrifood Research Finland, Luutnantintie 13, 00410, Helsinki, Finland, janne.helin@iki.fi

Scale economies give raise to a larger unit size in animal production. On the flip side are increased transport costs and environmental problems. This study attempts to quantify how much costs the environmental regulation inflicts upon the Finnish farmers in form of increased manure transport distances based on economic farm management model and GIS. We find out that partly due the exceptions given in the environmental subsidy requirements for manure, the system does not force the modeled farms to export their manure outside their own farm land, but the allocation within the farm is shifted.

■ TF-33

Tuesday, 17:20-18:40

8.2.19

Optimality of alternative policy instruments for climate and energy policies

Stream: Energy, Environment and Climate

Invited session

Chair: *Pekka Pirilä*, Dept. of Energy Technology, Aalto University, POB 14100, 00076, Aalto, Espoo, Finland, pekka@pirila.fi

1 - Adaptation and mitigation strategies in the European power sector

Anne Held, Energy Policy and Energy Systems, Fraunhofer Institute for Systems and Innovations research, Breslauer Str. 48, 76139, Karlsruhe, Germany, anne.held@isi.fraunhofer.de, *Ulrich Reiter*, *Mario Ragwitz*

This work addresses climate change adaptation and mitigation requirements of the European power sector. A hybrid modelling approach is applied in order to investigate the future role of renewable and conventional thermal power generation technologies until 2050. A mitigation pathway characterised by a global temperature rise of 2 C by 2100 is compared to a scenario, where the power sector adapts to climate change assuming a temperature increase by 4 C. Finally, cost estimates are provided and recommendations for an optimal design of adaptation and mitigation policies are derived.

2 - Choosing policy instruments under influence of uncertain technological change and adaptation

Pekka Pirilä, Dept. of Energy Technology, Aalto University, POB 14100, 00076, Aalto, Espoo, Finland, pekka@pirila.fi

Optimal selection of policy instruments is dependent on the dynamic behaviour of technological change and other adaptation mechanisms. The problem is analysed using small models. Further results are obtained based on a case study on future heating choices for the city of Helsinki. The situation is complex due to greatly variable and uncertain alternatives: district heating based on nuclear power, coal with CCS, natural gas, biomass directly or gasified, as well as individual heat sources like heat pumps. The policy instruments may either support or counteract finding the optimal solution.

3 - Long term climate mitigation and the impact of the treatment of uncertainty

Ilkka Keppo, Policy Studies, Energy research Center of the Netherlands, Radarweg 60, 1043 NT, Amsterdam, Netherlands, keppo@ecn.nl

We tackle the issue of large uncertainty concerning the future environmental requirements using an energy system model and studying a set of scenarios, covering a range of climate targets and technology futures, from three angles; 1) assuming perfect foresight 2) using a myopic world view and 3) using a stochastic programming set-up. We find that if a very stringent target is a possibility, it dominates the solution. However, reaching the target comes at a high price, indicating that e.g. adaptation measures, or even climate damages, may be preferable to the high mitigation costs.

■ TF-34

Tuesday, 17:20-18:40

8.2.23

Generalized Convexity and Related Topics

Stream: Convex Optimization

Invited session

Chair: *Gabriela Cristescu*, Department of Mathematics and Computer Science, Aurel Vlaicu University of Arad, Aurel Vlaicu University of Arad, Department of Mathematics and Computer Science., Str. Revolutiei, No. 77., 310130, Arad, Arad, Romania, gcristescu@inext.ro

1 - Separation theorem for nonlinear inverse images of convex sets

Zsolt Pales, Institute of Mathematics, University of Debrecen, Egyetem tér 1, 4032, Debrecen, Hungary, pales@math.klte.hu, *Szabolcs Bajak*

First- and higher-order necessary conditions for the local disjointness of a finite system of sets that are nonlinear inverse images of convex sets are presented. The proof is based on the characterizations of alpha-admissible and alpha-tangent variations to nonlinear inverse images of convex sets and a necessary condition for the local disjointness in terms of these variations. As an application, the results are used to obtain first- and higher-order necessary conditions of optimality in constrained optimization problems.

2 - On Wright convexity of higher order

Gyula Maksa, Department of Analysis, University of Debrecen, Institute of Mathematics, University of Debrecen, 4010, Debrecen, Hungary, maksa@math.klte.hu, *Zsolt Pales*

In the talk, we define the concept of n-Wright convex functions and show that these functions can be represented as a sum of a continuous n-convex function and a generalized polynomial of degree at most n. In the proof, a decomposition result on functions having Riemann integrable higher order difference functions plays an important role.

3 - Subquadratic functions

Attila Gilanyi, Faculty of Informatics, University of Debrecen, Pf. 12, 4010, Debrecen, Hungary, gilanyi@math.klte.hu, *Csaba Kezi*, *Katarzyna Troczka-Pawelec*

Related to the theory of convex and subadditive functions, we investigate subquadratic mappings. Especially, we study the lower and upper hulls of such functions, we prove Bernstein-Doetsch-type theorems for them and we describe some connections between two different notions of subquadraticity.

4 - Abstract convexity for Convex Along Lines functions

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, *Ivan Ginchev*, *Matteo Rocca*, *Alexander Rubinov*

Abstract convexity arises from monographs by Pallaschke and Rolewicz, Singer, Rubinov. Several studies have been recently proposed within this topic, mainly due to closed relation and applications to global optimization. Still, many problems are open. Among them the characterization of functions defined as the upper envelope of min-type functions. It has already been proved that these functions are closely related to convex along rays functions. However, some refinements allow us to prove also Convex Along Lines functions (CAL) are abstract convex.

■ TF-35

Tuesday, 17:20-18:40

6.2.46

Recent advances in mixed-integer nonlinear and global optimization

Stream: Mixed-Integer Non Linear Programming

Invited session

Chair: *Chris Floudas*, Chemical Engineering, Princeton University, Olden St., 8540, Princeton, NJ, United States, floudas@titan.princeton.edu

1 - Synthesis of chromatographic protein purification processes using optimisation techniques

Eleftheria Polykarpou, Biochemical Engineering, UCL, United Kingdom, e.polykarpou@ucl.ac.uk, *Paul Dalby*, *Lazaros Papageorgiou*

This paper presents mixed integer optimisation techniques for the synthesis of downstream purification processes by determining the minimum number of chromatographic steps in the optimum sequence for given purity and recovery levels. Alternative mixed integer linear and non-linear programming (MILP/MINLP) models will be presented and discussed. The applicability of these models is demonstrated by examples that rely on experimental data together with comparative results.

2 - Global Optimization of Signomial Geometric Programming Problems

Pedro Castro, UMOSE, LNEG, 1649-038, Lisbon, Portugal, pedro.castro@ineti.pt, *João Teles*, *Henrique Matos*

This paper discusses some power-based transformation techniques that are especially useful when solving signomial optimization problems (SOP). A signomial MINLP problem is first transformed into a new reformulated problem containing artificial non-negative variables. By applying a discretization scheme with multi-parametric elements an upper bounding convex MILP problem can be derived and solved to global optimization with standard methods to overestimate the original SOP within a tolerable error. Numerical examples are presented to demonstrate the effectiveness of the proposed method.

3 - New formulations for the mixture design problem

Claire Adjiman, Chemical Engineering, Imperial College London, Department of Chemical Engineering, Centre for Process Systems Engineering, SW7 2AZ, London, United Kingdom, c.adjiman@imperial.ac.uk

The design of mixtures, e.g. optimal product formulations in the pharmaceutical and personal care industries, is an important and challenging problem. Even when the components of the mixture are known a priori, the problem is highly combinatorial and nonlinear, due to the complex relationships between composition and physical properties. This has hampered the formulation and solution of the design problem. In this paper, we present novel formulations of the mixture design problem based on Generalized Disjunctive Programming and demonstrate the effectiveness of this approach on case studies.

4 - A Mixed-integer Quadratic Approximation Algorithm for the Solution of Multiparametric Mixed-integer Nonlinear Programming Problems

Efstathios Pistikopoulos, Chemical Engineering and Chemical Technology, Imperial College London, SW72AZ, London, United Kingdom, e.pistikopoulos@imperial.ac.uk, *Luis Dominguez*

In this work we present a novel algorithm for the solution of multiparametric mixed-integer nonlinear programming (mp-MINLP) problems. Similar to the algorithm introduced earlier by Dua and Pistikopoulos (1999), the algorithm presented here is based on a decomposition strategy where a sequence of multiparametric nonlinear programming problems (primal mp-NLPs) and deterministic mixed-integer nonlinear programming problems (master MINLPs) are solved. In this work, we alleviate some of the limitations of the algorithm presented in Dua and Pistikopoulos (1999) by addressing the primal subproblems via novel multiparametric nonlinear programming techniques. The proposed algorithm solves the sequence of primal subproblems via a multi-parametric quadratic approximation (mp-QA) algorithm and the corresponding MINLP subproblems via a MINLP solver. Finally, we present numerical examples which demonstrate the computational advantages of the mp-MIQA algorithm versus previous ones.

■ TF-36

Tuesday, 17:20-18:40

3.1.05

Robust Optimization

Stream: OR and Real Implementations

Invited session

Chair: *Daniel Kuhn*, Department of Computing, Imperial College London, United Kingdom, dkuhn@doc.ic.ac.uk

1 - Multistage stochastic portfolio optimization in deregulated electricity markets using linear decision rules

Paula Rocha, Computing, Imperial College London, SE7 2AZ, London, United Kingdom,
paula.martins-da-silva-rocha08@imperial.ac.uk, Daniel Kuhn

We present a multistage stochastic mean-variance optimization model for the management of electricity portfolios from the viewpoint of a price-taking retailer. To reduce computational complexity, we perform two approximations: stage-aggregation and linear decision rules. The latter consists of restricting the set of decision rules to those affine in the history of the risk factors. When applied to mean-variance optimization models, it leads to convex quadratic programs. Since their size grows only polynomially with the number of stages, problems with many stages can be efficiently solved.

2 - Linearly Adjustable International Portfolio Optimization

Raquel Fonseca, Department of Computing, Imperial College, 180 Queen's Gate, SW7 2AZ, London,
r.fonseca@imperial.ac.uk, Daniel Kuhn, Berc Rustem

We present an approach to multiperiod international portfolio optimization based on the imposition of a linear structure on the recourse decisions. Multiperiod decision problems have traditionally been formulated as stochastic programs. These however can become severely intractable as the number of stages increases. By restricting the space of decision policies to linear rules, we obtain a conservative tractable approximation to the original problem. Local asset and currency returns are modelled separately, which allows for hedging policies regarding the currency risk to be implemented.

3 - Interdicting a project to develop nuclear weapons

Wolfram Wiesemann, Department of Computing, Imperial College of Science, Technology & Medicine, 180 Queen's Gate, SW7 2BZ, London, United Kingdom,
wolfram.wiesemann@gmail.com, Daniel Kuhn, Berc Rustem

We study a two-player game in which one player (the "proliferator") aims to develop a batch of nuclear weapons as quickly as possible, while the other player (the "interdictor") seeks to delay the completion of this project. The game is an instance of an "interdiction game", a problem class with applications in managerial and military decision-making. To date, interdiction games are solved as generalized semi-infinite optimization problems, which are difficult to solve in practice. We develop a novel reformulation based on robust optimization principles.

■ TF-37

Tuesday, 17:20-18:40

3.1.09

'MCDA & uncertainty

Stream: MCDA I: New Approaches and Applications

Invited session

Chair: Sarah Ben Amor, Telfer School of Management, University of Ottawa, 55 Laurier E (7123), K1N6N5, Ottawa, Ontario, Canada,
benamor@telfer.uottawa.ca

1 - A general framework for integrating imperfect information in the PROMETHEE methods

Sarah Ben Amor, Telfer School of Management, University of Ottawa, 55 Laurier E (7123), K1N6N5, Ottawa, Ontario, Canada,
benamor@telfer.uottawa.ca, Bertrand Mareschal

The PROMETHEE methods are well-known in the field of MCDA. One current limit of these methods is that they usually assume that perfect information is available. In practice however the evaluation of actions on some criteria may be imprecise or uncertain. In this paper we propose a general framework for integrating such imperfect information. Different models are considered including probability, possibility, fuzzy logic and evidence theory, as imperfect information can have different causes (uncertainty, imprecision, ...) Missing data is also included as a special case.

2 - Pre-posterior analysis for additional information in a multiple criteria context with information imperfections

Sarah Ben Amor, Telfer School of Management, University of Ottawa, 55 Laurier E (7123), K1N6N5, Ottawa, Ontario, Canada,
benamor@telfer.uottawa.ca, Kazimierz Zaras, Jean-Marc Martel

Multiple criteria decision aid situations are usually facing different types of information imperfections (uncertainty, imprecision ...) A unified procedure aiming at reducing these imperfections was designed to allow for processing additional information in such a context. It is based on the Bayesian decision model where prior and posterior analyses have been achieved leading to prior and posterior global preference relational systems. Pre-posterior analysis will be addressed in this paper for a pre-assessment of the resources that can be allocated to such additional information.

3 - Ranking medical equipment for protection against earthquakes: a multicriteria approach

Rui Oliveira, CESUR/IST, Technical University of Lisbon, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, roliv@ist.utl.pt,
Miguel Snow

It is vital that hospitals and the medical equipments they accommodate remain operational in case of earthquake occurrence so that the affected population receives proper medical care in that catastrophic scenario. In order to define appropriate strategies for medical equipment protection against earthquakes, a multicriteria model was developed, allocating a priority index to each piece of equipment. The model considers as fundamental points of view the equipment's price, seismic vulnerability and clinical relevance in that catastrophic scenario. The process associated with the development of the model is described, for which the Macbeth approach was extensively used to elicit value functions and weighting constants. Results and conclusions are presented herein.

■ TF-40

Tuesday, 17:20-18:40

6.2.52

Operation Planning and Control in Container Terminals

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

Chair: Loo Hay Lee, Industrial and Systems Engineering, National University of Singapore, Singapore, iselee@nus.edu.sg

1 - Dynamic Yard Storage Strategy for Container Terminal

Loo Hay Lee, Industrial & Systems Engineering, National University of Singapore, 10 Kent Ridge Crescent, 119260, Singapore, Singapore, iselee@nus.edu.sg, Ek Peng Chew,
Xinjia Jiang

In this talk, we will present a storage yard management problem in a transshipment hub where the loading and unloading activities are both concentrated and need to be considered at the same time. A dynamic yard template concept is proposed to reuse the storage space for different vessels during different shifts in order to make full use of the storage space. In addition, the consignment strategy is used to reduce the number of reshuffles and the high-low workload balancing protocol is used to reduce the traffic congestion of prime movers.

2 - Dispatching Vehicles Supporting Multi-lift Operations of Quay Cranes

Kap Hwan Kim, Industrial Engineering, Pusan National University, Jangjeon-dong, Gunjeong-gu, 609-735, Busan, Korea, Republic Of, kapkim@pusan.ac.kr, Vu Duc Nguyen

To improve the ship operation in container terminals, it is important to schedule different types of handling equipment to operate synchronously. For example, a vehicle with container receiving and lifting capabilities is used to transport containers from a storage yard to a vessel and vice versa, while a multi-lift quay crane (QC) can handle up to three 40-ft containers simultaneously. This paper discusses a method in which vehicles are assigned to containers to support such multi-lifts of QCs by using information about the locations and times of deliveries. A mixed-integer programming model is introduced to optimally assign delivery tasks to vehicles. This model considers the constraint imposed by the limited buffer space under each QC. A procedure for converting buffer-space constraints into time window constraints and a heuristic algorithm for overcoming the excessive computational time required for solving the mathematical model are suggested. A numerical experiment is conducted to compare the objective values and computational times of the heuristic algorithm with those of the optimizing method to evaluate the performance of the heuristic algorithm.

3 - Online Rules for Container Stacking at an import Terminal

Elco van Asperen, Center for Maritime Economics & Logistics, Erasmus University Rotterdam, Room H10-10, PObox 1738, 3000 DR, Rotterdam, Netherlands, vanasperen@ese.eur.nl, *Rommert Dekker*

Container stacking rules are an important factor in container terminal efficiency. In this paper, we investigate two concepts to increase efficiency and compare them to several benchmark algorithms, using a discrete-event simulation tool. The first concept is to use knowledge about container departure times, in order to limit the number of reshuffles. We stack containers leaving shortly before each other on top of each other. The second concept is the tradeoff between stacking further away in the terminal vs. stacking close to the exit points and accepting more reshuffles. It is concluded that even the use of imperfect or imprecise departure time information leads to significant improvements in efficiency. Minimizing the difference in departure times proved to be important. It was also found that the tradeoff between stacking further away in the terminal vs. stacking close by the exit points and accepting more reshuffles leads to improvements over the benchmark.

4 - Minimizing the makespan of container storages and retrievals

Amir Hossein Gharehgozli, Rotterdam School of Management, Erasmus University Rotterdam, Postbus 1738, 3000 DR, Rotterdam, Netherlands, agharehgozli@rsm.nl, *Yugang Yu*, *René de Koster*, *Jan Tijmen Udding*

We study in which sequence to finish a list of container storage and retrieval jobs for a container stack to minimize the total makespan. The container stack consisting of multiple rows, bays and tiers is managed by an automated yard gantry. The storage positions of the containers located at different Input/output (I/O) points are given. The I/O points are located at the both seaside and landside of each row. The retrieved containers can be delivered to any of the I/O points at the seaside or landside. We aim to develop an algorithm for efficiently and near-optimally sequencing the jobs.

■ TF-42

Tuesday, 17:20-18:40

3.1.07

Decision Making 2

Stream: Decision Making

Contributed session

Chair: *Jessika Grunwald*, FWW / Entrepreneurship, University Magdeburg, Universitätsplatz 2, G23 / R200, 39106, Magdeburg, Germany, jessika.grunwald@ovgu.de

1 - Opportunities for decision support in telematic acute stroke care

Jessika Grunwald, FWW / Entrepreneurship, University Magdeburg, Universitätsplatz 2, G23 / R200, 39106, Magdeburg, Germany, jessika.grunwald@ovgu.de, *Peter Knüppel*

Telemedical solutions are increasingly used to provide neurological expertise in networks of small primary care hospitals and stroke centers around the world. Electronic clinical decision support can hereby support physicians and optimize resource allocation. By using process analysis we identified ways of how Decision Support Systems can facilitate the acute stroke care process: 1) workflow-based control 2) support for differential diagnosis 3) outcome prognosis. On this basis we introduce initial modeling approaches as graphs, Bayesian networks and logistic regression equations.

2 - The Analysis of the Innovation Performance of the Countries through Bayesian Causal Map

Fusun Ulengin, Department of Industrial Engineering, Dogus University, Zeamet Sk., Acıbadem, Kadıköy, 34722, Istanbul, Turkey, fulengin@dogus.edu.tr, *Sule Onsel*, *Gündüz Ulusoy*, *Emel Aktas*, *Özgür Kabak*

In this study, the innovation performance of the countries is analyzed using a Bayesian Causal Map (BCM). Initially, a workshop is conducted to revise the innovation attributes used by the European Innovation Scoreboard (EIS). Similar to the EIS, these revised attributes are categorized as "innovation enhancers", "knowledge creation", "innovation and entrepreneurship", "applications", and "intellectual property". Causal map is derived based on a second workshop. Finally, integrating the probabilities, BCM is developed, thus, a road map is provided for the policy makers to develop strategies for improving the innovation level of their country.

3 - Tactical mission planning

Nils-Hassan Quttineh, Department of Mathematics, Linköping University, SE-581 83, Linköping, Sweden, niqt@mai.liu.se, *Kristian Lundberg*, *Kaj Holmberg*

We present a model for tactical mission planning, where the objective is to define a flight plan for aircrafts toward a target, maximizing the probability of mission success. Multiple units might need to approach the target simultaneously, adding the complexity of coordination to our problem. The surroundings are an important input to such problems, where features of nature (flat areas, high mountains) have significant impact on solutions. A decomposition approach is discussed, and by discretization of the environment we derive a network model to describe possible routes towards the target.

4 - Expanding the Process of Knowledge Discovery in Databases to advance the quality of prediction

Claudia Koschtial, Professur für ABWL, TU Bergakademie Freiberg, Lessingstr. 45, 09599, Freiberg, Germany, claudia.koschtial@web.de, *Carsten Felden*

With the goal of providing a reliable basis for decisions, it can be necessary to predict future developments. Knowledge Discovery in Databases (KDD) is a method by which patterns discovered in historical data are used to predict future values. This implicates the assumption, that there are no fundamental differences in basic parameters. But this can not supposed. For example there are fundamental changes in demographics effecting societies and of course economies. The article provides an extension of the established model of KDD by integrating future data in the process of KDD and shows by an intense literature review that this was not done before.

■ TF-43

Tuesday, 17:20-18:40

8.2.02

Simplicial methods in Global Optimization

Stream: Global Optimization

Invited session

Chair: *Eligius M.T. Hendrix*, Computer Architecture, Universidad de Málaga, Campus de Teatinos, ETSI 2.2.28, 29017, Malaga, Spain, eligius.hendrix@wur.nl

1 - Global optimization with simplicial partitions and Lipschitz bounds

Julius Zilinskas, Institute of Mathematics and Informatics, LT 08663, Vilnius, Lithuania, julius.zilinskas@ktl.mii.lt, *Antanas Zilinskas*

Various versions of global optimization algorithms have been proposed using Lipschitz model of objective functions. The efficiency of such methods crucially depends on estimation of Lipschitz constant. In the present work an algorithm is proposed based on branch and bound approach with simplicial partitioning of the feasible region and adaptive estimate of Lipschitz constant using radial basis function interpolation.

2 - The minimum volume simplex problem applied to spectral unmixing

Eligius M.T. Hendrix, Computer Architecture, Universidad de Málaga, Campus de Teatinos, ETSI 2.2.28, 29017, Malaga, Spain, eligius.hendrix@wur.nl, *I. Garcia*

We describe the minimum volume enclosing simplex problem, known to be a Global Optimization problem and illustrate its multimodality. The problem has been used as a basis to estimate so-called end-members and abundance fractions in unmixing spectral data from remotely sensed hyperspectral sensors. We explore the possibility of a new estimation algorithm using the minimum volume enclosing simplex problem. We investigate its behaviour numerically on designed instances, comparing its outcomes with a maximum volume enclosed simplex approach which is used frequently in spectral unmixing.

3 - Global optimization of Lipschitz differentiable functions

Dmitri Kvasov, Department of Electronics, Computer Science and Systems, University of Calabria, DEIS, Via P. Bucci, Cubo 42C, I-87036, Rende (CS), Italy, kvadim@si.deis.unical.it,
Yaroslav Sergeyev

Global optimization problems are considered where the objective functions are multidimensional, black-box, and their first derivatives satisfy the Lipschitz condition with unknown Lipschitz constants over a hyperinterval. A new method for solving such problems is presented and discussed from both the theoretical and numerical viewpoints. The proposed algorithm is based on efficient diagonal partitions and uses smooth auxiliary functions to approximate the objective function behavior at different parts of the search domain.

4 - Solving the Minimum Sum-of-Squares Clustering Problem by Hyperbolic Smoothing and Partition into Boundary and Gravitational Regions

Adilson Elias Xavier, Graduate School of Systems Engineering and Computer Sciences, 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

The Hyperbolic Smoothing Clustering Method adopts a smoothing strategy that solves a sequence of differentiable unconstrained optimization problems. The paper presents a new idea: the partition of the set of observations into two non overlapping parts. The first set, named boundary band zone, corresponds to the observation points relatively close to two or more centroids. The second set, named gravitational points, corresponds to observation points significantly closer to a single centroid. The combination of the two methodologies drastically simplify the computational tasks.

■ TF-44

Tuesday, 17:20-18:40
8.2.03

Vector and Set-Valued Optimization I

Stream: Vector and Set-Valued Optimization

Invited session

Chair: *Elena Molho*, Dipartimento di Economia Politica e Metodi Quantitativi, Università di Pavia, Via San Felice 5, 27100, Pavia, Italy, molhoe@eco.unipv.it

1 - Optimality conditions in scalar and vector optimization using a new second order directional derivative

Bienvenido Jiménez, Departamento de Matemática Aplicada, UNED, Calle Juan del Rosal, 12, 28040, Madrid, Spain, bjimenez@ind.uned.es, *César Gutiérrez*, *Vicente Novo*

We introduce a new second order directional derivative and study some properties. Using this derivative and the parabolic second order derivative we provide second order necessary and sufficient optimality conditions for a general scalar optimization problem through the asymptotic and parabolic second order tangent sets to the feasible set. By means of a suitable scalarization, these results are applied to a general vector optimization problem obtaining second order optimality conditions that generalize the differentiable case.

2 - Stopping criteria for a general model of genetic algorithm with applications to multiobjective optimization

Marcin Studniarski, Faculty of Mathematics and Computer Science, University of Lodz, ul. S. Banacha 22, 90-238, Lodz, marstud@math.uni.lodz.pl

We consider a general Markov chain model of genetic algorithm; see [1]. We establish an upper bound for the number of iterations which must be executed in order to find an optimal solution with a prescribed probability. By combining this upper bound with the results of [2], we obtain some stopping criteria for multiobjective evolutionary algorithms. [1] C.R. Reeves, J.E. Rowe, Genetic Algorithms - Principles and Perspectives: A Guide to GA Theory, Kluwer, 2003. [2] G. Rudolph, A. Agapie, Convergence properties of some multi-objective evolutionary algorithms, Proc. CEC 2000 (2), 1010-1016.

3 - Efficiency in V-KT- pseudoconvex control problems

Manuel Arana-Jiménez, Estadística e Investigación Operativa, University of Cadiz, C/Chile, 1, 11002, Jerez de la Frontera,

Cadiz, Spain, manuel.arana@uca.es, *Gabriel Ruiz-Garzón*, *Antonio Rufián-Lizana*, *Rafaela Osuna-Gómez*

Control problems are often applied to engineering problems. In order to study their optimal solutions, KT-convexity and FJ-convexity have been introduced. Our aim is to generalize these properties and classes of functions and functionals to multiobjective control problems, for which we comment a V-KT- pseudoconvex control problem. This vector control problem is characterized so that a Kuhn-Tucker point is an efficient solution. Furthermore, this generalizes recently obtained optimality results of multiobjective mathematical programming problems.

4 - An interior point method for linearly constrained multi-objective optimization without a priori scalarization

Elena Molho, Dipartimento di Economia Politica e Metodi Quantitativi, Università di Pavia, Via San Felice 5, 27100, Pavia, Italy, molhoe@eco.unipv.it, *Enrico Miglierina*, *Maria Cristina Recchioni*

An algorithm to find the critical points of a linearly constrained multiobjective optimization problem is developed without any "a priori" scalarization. It is an interior point method based on a dynamical system defined by a vector field of descent directions that play the role of the projected gradient-like directions in the feasible region. The limit points of the solutions of this system satisfy the Karush-Kuhn-Tucker (KKT) first order necessary optimality conditions for the linearly constrained multiobjective optimization problem. Some numerical results on test problems are provided.

■ TF-46

Tuesday, 17:20-18:40
8.2.14

Probabilistic Constrained Stochastic Programming

Stream: Stochastic Programming 2

Invited session

Chair: *Andras Prekopa*, RUTCOR, Rutgers University, 640 Bartholomew Road, 08854-8003, Piscataway, New Jersey, United States, prekopa@rutcor.rutgers.edu

1 - Stochastic Network Design with Normally Distributed Random Demands and Arc Capacities.

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, *Andras Prekopa*

Networks are considered where some of the demands at the nodes and some of the arc capacities are random variables that have joint normal distribution. The Gale-Hoffman and Prekopa-Boros feasibilities provide us with a system of inequalities. A network design problem is formulated where a probabilistic constraint assures the existence of a feasible flow by a large probability. The numerical solution uses the method of Prekopa that combines a cutting plane method with supporting hyperplane method.

2 - Uniform Quasi-Concavity in Probabilistic Constrained Programming

Kunikazu Yoda, Rutcor, Rutgers Center for Operations Research, Rutgers University, 640 Bartholomew Rd, 08854, Piscataway, NJ, United States, kyoda@rutcor.rutgers.edu, *Andras Prekopa*

A probabilistic constrained stochastic programming problem is considered, where the underlying problem has linear constraints with random technology matrix, the rows of which are assumed to be independent and normally distributed. The constraining function is a product of as many functions as the number of rows in the matrix. It is shown that the product is quasi-concave iff the factors are uniformly quasi-concave which implies that the covariance matrices are constant multiples of each other. Application to portfolio construction will be presented.

3 - A new method for the valuation of Bermuda options using univariate numerical integration and bounding.

Mariya Naumova, Rutcor, Rutgers Center for Operations Research, Rutgers University, 640 Bartholomew Road, 08854, Piscataway, NJ, United States, mnaumova@rci.rutgers.edu

Prékopa and Szántai (2010) presented a dynamic programming formulation to compute the value of the Bermuda option with dividend. The numerical solution of the equation is, however, computationally intensive because it requires multivariate normal probability calculation. In this paper we replace the multivariate integration by univariate to obtain sharp lower and upper bounds for the values at each step. The accuracy of the new method is as good as that of the former one as we show it by numerical examples.

4 - Solution of a Stochastic Network Design Problem with Probabilistic Constraint and Discrete Random Variables

Andras Prekopa, RUTCOR, Rutgers University, 640 Barholomew Road, 08854-8003, Piscataway, New Jersey, United States, prekopa@rutcor.rutgers.edu, *Merve Unuvar*

Stochastic single commodity network design problem is formulated and solved, where a probabilistic constraint takes care for reliability, i.e., the probability that all demands are met. Demands at the nodes are discretized and approximated by bi-variate and multivariate distributions. The application of the Gale-Hoffman, Prekopa-Boros and further, more recent theorems allow fast enumeration of the p-efficient points. Two different algorithms are used to solve the problem; the generation of the p-efficient points is part of the algorithm. Numerical examples will be presented.

■ TF-47

Tuesday, 17:20-18:40
8.2.16

Optimization in Water Systems II

Stream: OR in Water Management

Invited session

Chair: *Halil Önder*, Civil Engineering, Middle East Technical University, Middle East Technical University, Department of Civil Engineering, 06531, Ankara, Turkey, onde@metu.edu.tr

Chair: *Maria Cunha*, Civil Engineering, University of Coimbra, Polo 2, 3030-290, Coimbra, Portugal, mccunha@dec.uc.pt

1 - Optimism — a decision model for the optimal operation of multisource water supply systems

João Vieira, Civil Engineering, University of Coimbra, LHRHA-Departamento de Engenharia Civil, Pólo II-Universidade de Coimbra, 3030-290, Coimbra, Portugal, jvieira@dec.uc.pt, *Maria Cunha*, *Luís Nunes*, *José Monteiro*, *Luís Ribeiro*, *Tibor Stigter*, *João Nascimento*, *Helena Lucas*

The OPTISM model was designed for determining the optimal operation of multisource supply systems dependent on surface water and groundwater. The planning objectives defined for the interventions are the reduction of operating costs, the satisfaction of the demand in exclusiveness by the water utility, and the supply of water with the appropriate quality. The model is highly nonlinear with discontinuous derivatives and is solved with GAMS/MINOS. The application of the model shows its usefulness in handling complex systems and in improving the conjunctive use of the different water sources.

2 - Agricultural adaptation in a changing climate: optimizing multiple objectives

Olivier Crespo, CSAG, Dept. Environmental & Geographical Science, University of Cape Town, Private Bag X3, 7701, Rondebosch, Western Cape, South Africa, olivier.crespo@csag.uct.ac.za, *Mark Tadross*, *Peter Thorburn*

Income, sustainability or resources are among multiple objectives to take into account for adaptation to our changing climate. We present a multiobjective optimization approach for assessing agricultural adaptations to climate change in two study cases; the introduction of a climate-resilient crop in Australia and adapting water supply in South Africa. We use the APSIM crop model to simulate, in each case, the agricultural response under future climate conditions. The expected outcomes and usefulness of the multiobjective approach for exploring agricultural adaptation will be presented.

3 - Decision Support for Wastewater Systems Planning at Regional Level

João Zeferino, DEC, FCTUC, Coimbra, Portugal, zeferino@dec.uc.pt, *Antonio Antunes*, *Maria Cunha*

A decision support system for regional wastewater systems planning is presented. DSS is based on an optimization model that determines the best configuration for the system needed to drain the wastewater generated by the population centers of a region. Quality standards defined for the receiving water bodies is taking into account. A hybrid simulated annealing—local improvement algorithm is used for solving the model. This algorithm has been investigated with regard to computation effort and solution quality. The model is applied to a case study designed to mimic a real-world problem.

■ TF-48

Tuesday, 17:20-18:40
8.2.04

Nonlinear Optimization and Applications 2

Stream: Nonlinear Programming [c]

Contributed session

Chair: *Edite M.G.P. Fernandes*, Production and Systems, University of Minho, School of Engineering, Campus de Gualtar, 4710-057, Braga, Portugal, emgpf@dps.uminho.pt

1 - Measure theory approach in sliding mode control for nonlinear systems

Mohammad Reza Zarrabi, applied mathematics, ferdowsi, mashhad-ferdowsi univesity-applied mathematic departmant, 098, mashhad, Iran, Islamic Republic Of, mo.za870@gmail.com, *Mohammad Hadi Farahi*

A new sliding mode control (SMC) design approach using measure theory and Lyapunov functional candidate is presented for nonlinear control problems. A Lyapunov function is supposed for designing a sliding surface (SS). In fact the problem that is considered is as follows. A state trajectory from a given initial point reaches into a given point on a sliding surface in the minimum time, and then tends to the origin (equilibrium point) along the sliding surface. A measure theory approach with embedding process is used to solve such a problem in two phases. In the first phase, after designing an appropriate SS by a suggested Lyapunove function, and using measure theory, an embedding is constructed to solve a time optimal control problem such that the system trajectory reaches a SS in minimum time, then in the second phase, using SS, a control is designed such that the system trajectory tends to the origin along the SS. A numerical example is presented to illustrate the effectiveness of the proposed method.

2 - A new approach using interior point method with relaxation based upon modified logarithmic barrier

Mayk Coelho, UNICAMP, Brazil, mayk@cose.fee.unicamp.br, *Aurelio Oliveira*, *Anesio Santos*

An modified relaxed logarithmic interior point method for the optimal DC power flow solution of a hydrothermal power system. The dual nonnegative variables are updated via complementarity with relaxed logarithmic barrier, while the free dual variables are updated via Newton's method. The matrix structure results in a constant Jacobian therefore leading very fast iterations in comparison with traditional approaches. A case study using the IEEE30 test system is performed.

Wednesday, 9:00-10:20

■ WA-02

Wednesday, 9:00-10:20

3.2.14

Keynote Talk 9

Stream: Keynote Speakers

Invited session

Chair: *M. Grazia Speranza*, Dept. of Quantitative Methods, University of Brescia, C.da Santa Chiara, 50, 25122, Brescia, Italy, speranza@eco.unibs.it

1 - A Combinatorial Approach to Secondary Spectrum Auctions

Berthold Vöcking, Department of Computer Science, RWTH Aachen University, Templergraben 55, 52056, Aachen, Germany, voecking@cs.rwth-aachen.de

On the secondary spectrum market, licenses are valid only for local regions. Spectrum allocations have to take into account interferences between users in neighboring regions. We show that problem formulations for secondary spectrum auctions in well established, but rather technical models for wireless communication like, e.g., the protocol or the physical model, can be represented in terms of a plain combinatorial model in which interference conditions are described by a conflict graph. The conflict graphs obtained from the wireless models have an interesting combinatorial property: The so-called inductive independence can be bounded by a slowly growing function. We investigate how this property can be exploited for the design of approximation algorithms for efficient spectrum allocations. *Joint work with Martin Hoefer and Thomas Kesselheim

■ WA-04

Wednesday, 9:00-10:20

3.2.13

Resource sizing and allocation

Stream: Metaheuristics

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: *Simge Yelkenci*, Department of Industrial Engineering, Dokuz Eylul University - The Graduate School of Natural and Applied Sciences, Buca Tinaztepe Campus / IZMIR - TURKEY, 35160, Izmir, Turkey, simge.yelkenci@deu.edu.tr

1 - Buffer allocation in unreliable production lines using adaptive tabu search approach

Leyla Demir, Industrial Engineering, Dokuz Eylul University, Tinaztepe Campus - Buca, 35160, Izmir, Turkey, leyla.demir@deu.edu.tr, *Semra Tunali*

The buffer allocation problem, i.e. how much buffer storage to allow and where to place it within the line, is a nonlinear integer programming problem. In this study, buffer allocation problem is solved for unreliable production lines. The objective is to maximize the throughput of the line, i.e. production rate. To evaluate the throughput of the line the decomposition method is employed. An adaptive tabu search approach is proposed to optimize the buffer sizes for each location. The performance of the proposed approach is demonstrated using existing benchmark problems.

2 - Investigating Multi-Objective Buffer Allocation Problem in Unreliable Production Systems Using a Modified Artificial Immune System Algorithm

Yamani Massim, Institut Charles Delaunay (CNRS FRE 2848), LOSI, University of technology of Troyes, University of Technology of Troyes, 12 rue Marie Curie, 10000, Troyes, France, yamanimassim@yahoo.fr, *Farouk Yalaoui*, *Lionel Amodeo*, *Alice Yalaoui*, *Abdelkader Zeblah*

In this paper we investigate the multiobjective buffer allocation problem (MOBAP) in production systems under space constraint. The aim of the work is to determine the Pareto fronts related to the conflicting throughput and work in process inventory objectives which represent important measures of the production systems economic efficiency. A modified immune algorithm incorporating a solution upgrading heuristic has been developed to generate Pareto fronts for transfer lines and systems incorporating parallel machines. Outline of the algorithm as well as computational results are presented.

3 - A hybrid method combining genetic algorithm and simulation for buffer size allocation in a real manufacturing system

Simge Yelkenci, Department of Industrial Engineering, Dokuz Eylul University - The Graduate School of Natural and Applied Sciences, Buca Tinaztepe Campus / IZMIR - TURKEY, 35160, Izmir, Turkey, simge.yelkenci@deu.edu.tr, *Semra Tunali*

This study presents a simulation-based genetic algorithm approach to find optimal buffer sizes. The objective is to improve the capacity of production line by implementing proposed hybrid approach. First, a detailed stochastic and dynamic simulation model of the line is developed to identify bottleneck machines. After that GA-based simulation optimization approach is employed to decide how to allocate buffers to the bottleneck machines identified so that throughput of the line can be maximized. The proposed method is tested in the real manufacturing environment. Empirical results show promise for the practical application of the proposed methodology.

■ WA-05

Wednesday, 9:00-10:20

3.2.16

Networks

Stream: Metaheuristics

Invited session

Chair: *Roberto Battiti*, DIT - Dipartimento di Informatica e Telecomunicazioni, Università di Trento, Via Sommarive, 14, 38100, Trento, Italy, battiti@dit.unitn.it

Chair: *João Claro*, INESC Porto, Faculty of Engineering, University of Porto, Portugal, jclaro@fe.up.pt

1 - Genetic Algorithm approach for network intrusion detection using mobile agent

Khaled Sellami, Computer science, University of Bejaia, Route de targua ouzamour, Université de Bejaia, Algérie, 06000, Bejaia, Algeria, skaled36@yahoo.fr, *Mohamed Ahmed-nacer*, *Lynda Sellami*

Due to the increase in access of malicious data over the internet resources, intrusions Detection Systems (IDSs) have become the necessary component of the computer and information security framework. Although the field of IDSs is still developing, they are not able to detect all types of intrusions. This work discuss about the ways of implementing Genetic Algorithm (GA) to detect intrusions. We first use a mobile agent technology for collecting data properties. These data are evaluated by the genetic algorithm to improve the quality of basic rules by trying to find the best solution.

2 - A Multiobjective Approach for Rapid Transit Network Design

Erdem Gundogdu, Industrial Engineering, Istanbul Kultur University, IKU Atakoy Campus Room:210 Bakirkoy, 34156, Istanbul, gundogduerdem@gmail.com, *Orhan Feyzioglu*

Urban rapid transit network design consists of the location of train alignments and stations in an urban traffic context. In this study, we investigate the design of a single transit line with no predetermined origin and destination while considering the existing road network. The problem is formulated as a bilevel multiobjective optimization problem where line investment and car emissions are considered at the upper level, and user traffic behavior is considered at the lower level. A genetic algorithm is developed to obtain non-dominated solutions and it is applied on an illustrative example.

3 - Simultaneous Design of Urban Road and Public Transit Networks Using Hybrid Evolutionary Metaheuristics

Elnaz Miandoabchi, Industrial Engineering, AmirKabir University of Technology, 123456, Tehran, Iran, Islamic Republic Of, el.miandoabchi@aut.ac.ir, *Reza Zanjirani Farahani*

In this paper, a multi-modal urban road network design problem with auto and bus modes is considered. The problem is to concurrently design the road and bus networks. The road network decisions are, adding new streets, and new lanes to the existing streets, orienting one-way streets, and two-way street lane allocations. The bus network decisions are redesigning of routes of the existing bus lines. The problem is modeled as a multi-objective bi-level model with a combined modal-split/assignment problem. A genetic algorithm and a clonal selection algorithm are developed as solution methods.

4 - Mean-risk multistage transmission network expansion planning using multiobjective local search

João Claro, INESC Porto, Faculty of Engineering, University of Porto, Portugal, jclaro@fe.up.pt, *A. Miguel Gomes*

We present a multiobjective local search approach for a mean-risk multistage formulation of the Transmission Network Expansion Planning problem. Uncertainty in generation costs and demand loads is captured through a scenario tree. In each period, discrete decisions concerning the investment in the network, and continuous decisions concerning the utilization of the network, are considered. The approach integrates liner programming to address the utilization problem. We present experimental results with a set of instances derived from the literature.

■ WA-06

Wednesday, 9:00-10:20

8.2.30

DEA Application V — Industry and natural resources

Stream: DEA and Performance Measurement

Invited session

Chair: *Vania Sena*, Aston University, B4 7ET, Birmingham, United Kingdom, v.sena@aston.ac.uk

1 - Data Envelopment Analysis for Privatizing Decisions of Sugar Factories

Ezgi Aktar Demirtas, Industrial Engineering, Eskisehir Osmangazi University, Eskisehir Osmangazi University Department of IE, Meselik ESKISEHIR/TURKIYE, 26480, ESKISEHIR, Turkey, eaktar@ogu.edu.tr, *Abdullah Korkut Üstün*

Data envelopment analysis (DEA) is a nonparametric method for the estimation of production frontiers. It is used to empirically measure efficiency scores of decision making units. In this study, the efficiency scores of 26 sugar factories are evaluated by both input and output oriented DEA models. These efficiency scores and input/output target values can be used for privatizing decisions of public factories in Turkey.

2 - Technical and economic efficiency analysis applied to artisanal fisheries

Manuela Maria Oliveira, U-REMS, IPIMAR, Portugal, moliveira@ipimar.pt, *Ana Camanho*, *Miguel Gaspar*

The research sought to determine the efficiency of vessels using DEA models. Using data on the prices of each species in wholesale market, revenue efficiency was also estimated to complement the technical efficiency analysis. An advantage of this approach resides in the ability to separate technical from allocative aspects in the efficiency assessment, enabling a graphical representation of the performance of vessels in two dimensions. This approach enables the specification of targets for inefficient vessels that corresponds to the amount of captures by species that enable maximizing the revenue

3 - Efficiency of Public Forestry Firms in Switzerland

Alexander Mack, Engineering and Information Technology, Bern University of Applied Sciences, Quellgasse 21, 2501, Biel, Switzerland, alexander.mack@bfh.ch, *Bernur Acikgoz*

This paper is an empirical study of the productive efficiency of public forestry firms in Switzerland, using original unpublished data. By comparing various forestry firms among themselves, one can identify the most efficient units and their distinctive features. In order to determine the productive efficiency, DEA analysis is used. In-depth analysis suggests that management style, environmental influences (e.g., hurricane Lothar), and the forest region affect the efficiency of the firms. In addition, Pedroni panel cointegration technique is applied by using the DEA scores.

4 - Productivity change of textile and clothing firms in world regions with an application of Malmquist index with bootstrap

Magdalena Kapelko, Department of Business Administration, Universidad Carlos III de Madrid, Calle Madrid 126, Office 7.0.56, 28903, Getafe (Madrid), Spain, magdalena.kapelko@gmail.com

The purpose of this paper is to study the productivity change of 4985 observations of firms in the textile and clothing industry for 1995-2004 time-period. To differentiate from previous research we analyze the firms in different world regions. We use the Malmquist index with bootstrap and decompose it into three sources of productivity change. Our results indicate a relatively small deterioration in productivity, which is driven by the technical and scale efficiency decline, in spite of the technological progress. However, those tendencies are not a common feature for the regions considered.

■ WA-07

Wednesday, 9:00-10:20

8.2.47

Project scheduling

Stream: Project Management and Scheduling

Invited session

Chair: *Willy Herroelen*, Decision Sciences and Information Management, Katholieke Universiteit Leuven, Naamsestraat 69, 3000, Leuven, Belgium, willy.herroelen@econ.kuleuven.be

1 - Project scheduling in the financial management of supply chains

Bajis Dodin, Anderson Graduate School of Management, University of California, Anderson Graduate School of Management, University of California, 92521, Riverside, California, United States, bajis.dodin@ucr.edu, *Abdelghani Elimam*

Most research on managing Supply Chains has focused on the physical aspects, very little on the Financial Management of SC (FMSC). However, return on investment can be a complicated task in large SCs. Long cycle times affect the value of material, and the cost of borrowing/investing the necessary funds. In this paper we first determine the issues affecting the FMSC, and then use project scheduling methods to analyze the relationship between these issues and the SC cycle time. This analysis led to establishing optimal and near optimal cash management policies for all participants of the SC.

2 - Tactical risk management in the construction industry

Stefan Creemers, K.U.Leuven, 3000, Leuven, Belgium, stefan.creemers@econ.kuleuven.be

Construction projects may be divided into several phases: design, build, finance, operate and/or maintain. Typically, contractors are only involved in the build phase. In PPPs (public private partnerships) however, contractors assume additional responsibilities as to improve the time to market, to cut costs, etc. Additional responsibilities give rise to additional risks; risks that contractors traditionally did not face. We devise a practical tool that helps contractors to make the right decisions.

3 - Applying Critical Chain Scheduling and Buffer Management on the Discrete Time/Resource Trade-off Problem

Erik Demeulemeester, Decision Sciences and Information Management, Katholieke Universiteit Leuven, Naamsestraat 69, 3000, Leuven, Belgium, erik.demeulemeester@econ.kuleuven.be, *Wendi Tian*

Goldratt's Critical Chain scheduling and Buffer Management methodology, which relies on deterministic scheduling techniques to build a baseline schedule that is made robust by inserting various types of buffers, has attracted attention for scheduling the resource-constrained project scheduling problem (RCPSP) in a robust way. We extend CC/BM to the discrete time/resource trade-off problem in which the duration of an activity is assumed to be a discrete, non-increasing function of the amount of a single renewable resource committed to it. Extensive computational results will be presented.

4 - Robust optimization for resource-constrained project scheduling with uncertain activity durations

Christian Artigues, LAAS, CNRS, 7 avenue du Colonel Roche, 31077, Toulouse Cedex 4, artigues@laas.fr, Roel Leus, Fabrice Talla Nobibon

We propose models and methods for resource-constrained project scheduling with uncertain activity durations. Our modeling techniques stem from robust optimization and the objective is to find a scheduling policy that minimizes the maximum absolute regret over all scenarios. We propose lower and upper bounds for the maximal regret, integer linear programming formulations and a scenario-relaxation-based solution method. We provide computational results that illustrate the compromise between solution quality and robustness.

■ WA-08

Wednesday, 9:00-10:20

6.1.36

Shop Scheduling

Stream: Project Management and Scheduling

Invited session

Chair: Pierre Lopez, Groupe MOGISA, LAAS-CNRS, 7 avenue du Colonel Roche, 31077, Toulouse, France, pierre.lopez@laas.fr

1 - Job-Shop with several transport robots with non unary capacities

Mohand Larabi, LIMOS (ISIMA), Blaise Pascal University, LIMOS (ISIMA), Campus des Cezeaux, 63177, Clermont-Ferrand, Puy-de-Dôme, France, larabi@isima.fr, Philippe Lacomme, Tchernev Nikolai

This paper concerns the Job-Shop scheduling problems with several transport robots having non unary capacities. The problem is a generalisation of the job-shop including transport operations achieved by a fleet of homogenous robots with multi load capacity. To model the problem we extend the classical disjunctive graph dedicated to job-shop. We propose a framework based on a powerful local search which uses new specific problem properties. Experiment shows that the method compete with the well known methods on the case of the job-shop with several robots of unary capacities.

2 - Generalized resource constraint propagation for job shop scheduling with time lags

Pierre Lopez, Groupe MOGISA, LAAS-CNRS, 7 avenue du Colonel Roche, 31077, Toulouse, France, pierre.lopez@laas.fr, Marie-José Huguet, Christian Artigues

The aim of this work is to illustrate the efficiency of generalized resource constraint propagations for solving job shop scheduling problems with time lags. We propose a heuristic based on job insertion and a branch-and-bound benefiting from generalized resource constraint propagation techniques. This generalization comes from the search for longest paths on a complete constraint network associated with the scheduling problem. We evaluate the impact of our insertion heuristic and we show the interest of generalized propagation through experimental results and comparisons with other methods.

■ WA-09

Wednesday, 9:00-10:20

6.2.53

Recent Developments and Applications 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: Leena Suhl, Int. Graduate School of Dynamic Intelligent Systems, University of Paderborn, Decision Support & OR Lab, Warburger Str. 100, 33098, Paderborn, Germany, suhl@upb.de

1 - On the Conjecture of Aouchiche and Hansen about the Randic Index

Ljiljana Pavlovic, Department of Mathematics, Faculty of Natural Sciences and Mathematics, Radoja Domanovica 14, 34000, Kragujevac, Serbia, Serbia, pavlovic@kg.ac.rs, Marina Stojanovic

Let $G(k,n)$ be the set of connected simple graphs which have n vertices and the minimum degree of vertices is k . The Randic index of a graph G is defined as $\sum d(u)d(v)$ 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 . In this paper we prove the conjecture on the graphs for which the Randic index attains its minimum value when k is greater or equal to $n/2$. We show that the extremal graphs have only degree k and degree $n-1$, and the number of vertices of degree k is as close to $n/2$ as possible.

2 - Integrating production, staff size and product price in aggregate planning

Amaia Lusa, IOC Research Institute / Management Department, Universitat Politècnica de Catalunya, Avda. Diagonal 647, p11, 08028, Barcelona, Spain, amaia.lusa@upc.edu, Carme Martinez, Marta Mas

Integrating decisions of different areas is a current trend in operations management that it is possible thanks to improvements both in hardware and software capacity. In this work, we discuss an aggregate planning problem that includes production, staff size, cash management and marketing decisions. The demand is considered to be a nonlinear function of the product price. The problem, which is modelled as a mixed integer linear program, can be solved using standard optimization software. The results of a computational experiment show the efficiency and convenience of the proposed model.

3 - Optimizing a job-shop plant using queuing networks techniques

Artur Barreiros, Mechanical Engineering Department, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, barreiros@ist.utl.pt, Dulce Silva

This paper applies open queuing networks to evaluate and optimize the performance of a job-shop plant. The performance diagnostics involves analysis of the work-in-process and the production lead-times. We assume that the plant can be modelled by a collection of stations. The optimization procedure involves the probabilistic characterization of the demand and characterization of the probability of transference of customers. A waiting-cost function is evaluated using the queuing parameters, which is used to compare alternative solutions.

4 - Computational Experiments with Multi-Row Cuts

Franz Wesselmann, Decision Support & OR Lab, University of Paderborn, Warburger Str. 100, 33098, Paderborn, Germany, wesselmann@dsor.de, Leena Suhl, Uwe Suhl

Recently, there has been a renewed interest in cutting planes from multiple rows of the simplex tableau. In particular, a beautiful correspondence between minimal valid inequalities for the infinite group relaxation and maximal lattice-free convex polyhedra was discovered. In this talk, we discuss our implementation of multi-row cut generators. We detail the construction of the multi-row relaxation and the selection of a maximal lattice-free convex set. We also report on computational experience with multi-row cutting planes and empirically compare them with Gomory mixed-integer cuts.

■ WA-10

Wednesday, 9:00-10:20

6.2.56

OR in Supply Chain Management I

Stream: Emerging Applications of OR

Invited session

Chair: Eren Ozceylan, Industrial Engineering, Natural and Applied Sciences, Selcuk University Industrial Engineering Department, Campus, 42031, Konya, Turkey, eozceylan@selcuk.edu.tr

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: Edite M.G.P. Fernandes, Production and Systems, University of Minho, School of Engineering, Campus de Gualtar, 4710-057, Braga, Portugal, emgpf@dps.uminho.pt

1 - Characterizing and modeling supply chain system dissipations

Iskander Zouaghi, CERAG, Grenoble University, 150 rue de la chimie, 38400, Saint Martin d'Hères, France, iskander.zouaghi@upmf-grenoble.fr, *Tarik Saikouk, Alain Spalanzani*

The complexity of firms' environment is characterized by open markets, globalization, information technologies, decreasing of products lifecycles, increased demand, but also by consumers who are becoming increasingly demanding. Demand has become too volatile. We use a multi-objective optimization model to conceptualize dissipations in supply chain systems, by considering two main conflicting objectives. These objective functions are optimized under dissipation constraints.

2 - The Robust Model of Multiple Sourcing: Alchemy of Risk Reduction in Supplier Selection

Adel Azar, Tarbiat Modarres, 12345678, Tehran, azara@modarres.ac.ir, *Masood Rabieh, Mohammad Javad Feyzollahi*

Selecting appropriate suppliers can significantly increase the competitiveness of organizations. Challenges of new complex environments cause increased uncertainty, so that we use robust optimization. A robust nonlinear optimization model is developed for supplier selection of raw material at Isfahan Steel Company. Then the robust model is solved with different risk levels. The quality of solutions is analyzed by a simulation technique.

3 - Multiple Sourcing Strategies: Trade-off between Cost-oriented and flexibility-oriented Supplier

Yuan-Du Hsiao, Business Administration, Chungyu Institute of Technology, No40, Yi7th Rd, Keelung20103, Taiwan, R.O.C., 6f, No46, Dong-Guang Rd, Keelung20103, Taiwan, R.O.C., 20103Taiwa, Keelung, City, Keelung, Taiwan, R.O.C, Taiwan, yuduhsiao4471@yahoo.com.tw, *Fan-Yun Pai, Tsu-Ming Yeh*

Within the environment of SCM, a multiple sourcing strategy can be adopted to take advantages of different suppliers with their different capabilities. We construct a tailored sourcing model to find out the retailer's orders allocation mechanism between emergency vendor and discount vendor. From the analysis results, the existence of an emergency vendor will reduce order quantity from discount vendor. The profit depends on the difference between the order quantity from a discount vendor and from an emergency vendor and the expected value of demand function.

4 - DEA Analysis with Data Which are not Crisp

Soheila Ebrahimkhany Ghazy, basic Science college, Science and Research Branch, IAU, TEHRAN -POUNAK SQUARE-HESARAK- SCIENCE AND RESEARCH UNIVERSITY, Ave sheikhbahae . St west kashfiyan Nom:43 Building star, 1477893855, tehran, Iran, Islamic Republic Of, soheila7764@yahoo.com, *Mohsen Rostamy-malkhalifeh*

Earlier methods in classic DEA investigate congestion for DMUs with crisp data. Although in real world we face with data that aren't crisp necessarily, available methods in this situation are not enough. Congestion occurs when the reduction of selected inputs causes some, rather than all, outputs to increase, without a worsening of others. As a result in this paper for investigation of congestion we promote a new method with Fuzzy data. Then explain our method with a numerical example.

■ WA-11

Wednesday, 9:00-10:20

8.2.38

Various New OR Tools and Technologies II: Quality Management Emphasized

Stream: Emerging Applications of OR

Invited session

Chair: *Gulser Koksakal*, Industrial Engineering, Middle East Technical University, Inonu Blvd., 06531, Ankara, Turkey, koksakal@ie.metu.edu.tr

Chair: *Tatiana Tchemisova*, Departamento of Mathematics, University of Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, tatiana@ua.pt

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - A Feature Extraction Method for Fault Detection of Cyclic Signals

Jonghyuck Park, Graduate School of Information Management and Security, Korea University, Anamdong, Sungbukgu, 136-713, Seoul, Korea, Republic Of, nrevival@gmail.com, *Jun-Geol Baek, Sung-Shick Kim*

This paper presents a feature extraction method based on Wavelet Multi-Resolution Analysis to detect faults in cyclic signals. The proposed method is expected to reduce the size of data and well reflect the characteristic of original signal. However, extracted features vary by the signals due to the variations of the process; common features should be chosen to build up a fault detection model. Therefore, feature scoring algorithm for the selection of common feature is also presented. Performance evaluation of the proposed method is provided in comparison to well-known feature selection rules.

2 - Beta-Geometric Model for Estimating the Product Quality After Multiple Inspections

Young Chun, Infor. Sys. & Dec. Sci., Louisiana State University, College of Business, 70803-6315, Baton Rouge, LA, United States, chun@lsu.edu

A complex product such as a software document is inspected more than once to further improve its software quality. Authors have proposed various estimation methods for the number of faults still remaining in the software document. For each fault, the probability that it will be detected during one review cycle is an unknown constant to be estimated. We propose a beta-geometric inspection model. In a numerical study, we compare the effectiveness of our beta-geometric model with those of traditional inspection models in which the detection probability is assumed to be a constant.

3 - Competition in Remanufacturing

Serra Caner, Operations, University of Groningen, Nettelbosje 2, 9747 AE, Groningen, Netherlands, s.caner@rug.nl, *Ruud Teunter, Xiang Zhu*

We study remanufacturing competition between an Original Equipment Manufacturer and an Independent Operator. Differently from literature, the OEM and IO compete for cores with their acquisition prices. We consider a 2-period model with manufacturing by the OEM in the first period, and manufacturing as well as remanufacturing in the second. We determine optimal policies for both players by establishing a Nash Equilibrium in the second period. A sensitivity analysis leads to a number of managerial insights. Further insights are obtained from a numerical investigation.

4 - Controlling product returns from sales demonstrations

Luc Muyldermans, Business School, Nottingham University, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, luc.muyldermans@nottingham.ac.uk, *Luk Van Wassenhove, Daniel Guide*

Some manufacturers demonstrate their products so that customers can gain experience before making a purchase. We analyse a case where the product returns from sales demonstrations are substantial, and derive optimal demo policies analytically. The key trade-off in our model is either to reuse returned demo products repeatedly, or to sell ex-demo products on a secondary market and use new products to fulfil demo requests. The optimal policies are straightforward in the case of constant product prices, but become more intricate when the resale price on the secondary market erodes over time.

■ WA-12

Wednesday, 9:00-10:20

8.2.39

ANP 06

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Ziya Ulukan*, industrial engineering, galatasaray university, ciragan cad. no:36, ortakoy, 34357, istanbul, Turkey, ziyaulukan@hotmail.com

1 - An integrated AHP - ANP Quality Function Deployment framework for the competitive position improvement

George Paltayan, Department of Business Administration, University of Macedonia, 156 Egnatia Street, 54006, Thessaloniki, Thessaloniki, Greece, gpaltag@uom.gr, *Andreas Georgiou*, *Katerina Gotzamani*, *Andreas Andronikidis*

An integrated AHP — ANP - Quality Function Deployment (QFD) framework is presented in order to distinguish and translate customers' needs into goals. The applicability of the proposed framework is demonstrated in a case which summarizes the interventions and suggestions of the model's application for a bank. It is worth investigating methods and techniques that could improve the competitive position and as a result, increase market share and profitability and the proposed framework can be employed in this direction to translate the customers' needs into various effective strategies.

2 - Selection of a suitable WEEE management system using fuzzy ANP

Ziya Ulukan, industrial engineering, galatasaray university, ciragan cad. no:36, ortakoy, 34357, istanbul, Turkey, ziyaulukan@hotmail.com, *Sigrid de Mendonca Andersen*

Socially acceptable, economically affordable, technologically reliable and environmentally friendly scenario's for WEEE are the major concerns. The aim of this paper is to provide a multi-criteria decision making tool to select the best scenario. Firstly, fuzzy AHP is used to determine the relative importance of the selection criteria. And then, with a fuzzy version of ANP, different WEEE management systems are evaluated. An illustrative application is also given to demonstrate the effectiveness of the methodology. The alternatives and the criteria are determined from the literature

3 - Determining effective criteria on investment priorities of wood and paper industries, Case of the study: Iran Qom province

Majid Azizi, wood and paper sciences and technology, Faculty of natural resources, University of Tehran, karaj, tehran, Iran, Islamic Republic Of, mazizi@ut.ac.ir, *Mehdi Faezipour*, *Reza Roknedin Eftekhari*, *Rafat Dehghan Krooki*

Since the province has special capability to invest in wood and paper industries, determining effective criteria is vital. AHP has been applied and a decision tree planned with five major criteria: infrastructure, economic & financial, material & product, man force & technical, social & cultural and 37 their sub criteria. The questionnaires have been distributed and gathered from the experts. Expert Choice used to synthesize the results. Among criteria and sub criteria, economic & financial criterion and investment attraction sub criterion have the highest priorities respectively.

■ WA-13

Wednesday, 9:00-10:20

2.2.21

Applications of Location

Stream: Location Analysis

Invited session

Chair: *Mercedes Landete*, Departamento de Estadística y Matemática Aplicada, University Miguel Hernández of Elche, Avda. del Ferrocarril s/n, 03202, Elche, Alicante, Spain, landete@umh.es

1 - Optimal location of safety cameras at urban intersections for road accidents control: a pilot study in the city of Rome

Antonino Sgalambro, Dipartimento di Statistica, Probabilità e Statistiche Applicate, Sapienza Università di Roma, Piazzale Aldo Moro 5, 00185, Roma, Italy, antonino.sgalambro@uniroma1.it, *Paolo Dell'Olmo*, *Nicoletta Ricciardi*, *Riccardo Colicchia*, *Katia Chiusolo*

We consider the optimal location of safety cameras at urban road intersections to maximize road control and reduce accident effects. Integrated use of geographical information systems and statistical analyses on historical data is proposed to individuate black-spots, i.e. areas with high risk of accidents. The optimal location of safety cameras is then formulated and solved as a maximal covering location problem. The results of a pilot study on the application of this methodology to real data on road accidents that occurred in Rome between the years 2006 and 2009 is presented and discussed.

2 - A Mathematical Model for Urban Concentrations with Respect to the Advance of Japanese Railway Networks

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

The locational dynamics of commercial activities in cities has been explored by the Harris-Wilson's balancing-mechanism model. In this study, we take the balancing-mechanism in the general urban activities, and analyze the locational dynamics of urban activity distribution with respect to the advance of Japanese railway networks. In particular, focusing on the high-speed transit system, we examine how the constructions of Shinkansen bullet train and Maglev train affect the developments of cities in Japan. As a result, we clarified that the opening of high-speed transit system promotes the further concentrations to large cities, and miserable declinations of small cities.

3 - The retrofit of a closed-loop distribution network: the case of lead batteries

Maria Isabel Gomes, CMA - FCT - Universidade Nova de Lisboa, Monte da Caparica, 2829-516, Caparica, Portugal, mirg@fct.unl.pt, *Ana Fernandes*, *Ana Paula Barbósa-Póvoa*

Nowadays many companies face new challenges regarding the management of end-of-life products. Their supply chains, once designed to efficiently satisfy customers' demands are now facing a new product flow, the reserve flow. The simultaneous optimization of both networks is now an emerging challenge. In this work, the closed-loop supply chain of a company that produces, distributes and collects lead batteries is optimized by means of a multi-product, multi-period, location-allocation model. The results obtained are compared with the existing network and important conclusions are drawn.

4 - A multi-level approach to sitting EOL treatment resources

Branislava Ratkovic, Logistics, Faculty of Traffic and Transport Engineering, University of Belgrade, Vojvode Stepe 305, 11000, Belgrade, Serbia, b.ratkovic@sf.bg.ac.rs, *Milorad Vidovic*

This paper presents the modeling approach for establishing reverse logistics network, through defining optimal locations of collection points, consolidation points and treatment facilities. The active participation of consumers is essential for achieving any recovery objective, and in order to model the influence of distance between consumers and collection points on the optimal locations of three types of facilities to be located on this network, we introduce the collection point's catchment area. Proposed modeling approach was tested on the numerical example.

■ WA-15

Wednesday, 9:00-10:20

2.2.12

Vehicle Routing Applications II

Stream: Vehicle Routing

Invited session

Chair: *Min Wen*, DTU Transport, DTU Transport, Building 115, Technical University of Denmark, 2800 Lyngby, Denmark, 2800, lyngby, Copenhagen, Denmark, mw@transport.dtu.dk

1 - Utilization and Positioning of Transshipment Points in Pickup and Delivery

Michael Schneider, BISOR, University of Kaiserslautern, Erwin-Schrödinger-Straße, Geb. 42-420, Kaiserslautern, 67653, Kaiserslautern, Germany, schneider@bisor.de, *Oliver Wendt*

The pickup and delivery problem with transshipment (PDPT) allows the transfer of goods between vehicles and thus the fulfilment of one pickup and delivery request using several vehicles. We tailor an established solution method for the classical PDP to be able to handle transshipment points. Our numerical studies investigate the structural properties of problem instances for which the utilization of transshipment points is beneficial. Moreover, we study the effectiveness of different schemes for determining the number and position of effective transshipment points.

2 - Vehicle Routing Problem with Availability Constraints

Farhana Johar, Mathematics, University of Southampton, School of Mathematics, Highfield Campus, SO17 1BJ, SOUTHAMPTON, United Kingdom, farhana1279@yahoo.com

This research is classified as non-classical Vehicle Routing Problem (VRP) where the maximum release date of customer's demand of the route determine the vehicle departure time. Thus, there could be lateness on the delivery process from awaiting all customers' demand of the route to be released. A mathematical formulation is developed to represent the problem studied. Insertion method based on the cheapest cost is used to generate an initial solution. Then, Local Search technique is applied to improve the solution in term of minimization of total traveling and tardiness cost.

3 - Combined Vehicle Routing and Foldable Container Scheduling

Jan Zazgornik, Institute of Production and Logistics, University of Natural Resources and Applied Life Sciences, Vienna, Feistmantelstrasse 4, 1180, Vienna, Austria, jan.zazgornik@boku.ac.at, *Patrick Hirsch*, *Manfred Gronalt*

This work deals with a combined vehicle routing and container scheduling problem in forest industry. The problem is modeled as a vehicle routing problem with time windows and additional constraints for using foldable containers. These constraints ensure that containers are available at the pick-up locations when needed. Therefore, the problem is state-dependent during execution. Two Tabu Search variants with different neighborhood structures have been developed and tested in extensive numerical studies. The results show that the methods generate good solution in reasonable computing time.

4 - The dynamic multi-period vehicle routing problem

Min Wen, Department of Management Engineering, Technical University of Denmark, DTU - Bygning 426, room 043, 2800, Lyngby, Denmark, mw@imm.dtu.dk, *Jean-François Cordeau*, *Gilbert Laporte*, *Jesper Larsen*

This presentation addresses the Dynamic Multi-Period Vehicle Routing Problem which deals with the distribution of orders from a depot to a set of customers over a multi-period time horizon. Customer orders and their feasible service periods are dynamically revealed over time. The objectives are to minimize total travel costs and customer waiting, and to balance the daily workload over the planning horizon. This problem is modeled as a mixed integer linear program, and solved by means of a three-phase heuristic that works over a rolling planning horizon. Computational results show that the proposed approach can yield high quality solutions within reasonable running times.

■ WA-16

Wednesday, 9:00-10:20

2.2.14

Case studies in planning and operations

Stream: Public Transport

Invited session

Chair: *Konstantinos Gkoumas*, DITS (Dipartimento di Idraulica Trasporti e Strade), Sapienza Università di Roma, Via Eudossiana 18, 00184, Rome, Italy, konstantinos.gkoumas@uniroma1.it

1 - Public transport service reliability in high- and low frequency systems

Konstantinos Gkoumas, DITS (Dipartimento di Idraulica Trasporti e Strade), Sapienza Università di Roma, Via

Eudossiana 18, 00184, Rome, Italy, konstantinos.gkoumas@uniroma1.it, *Michael Schachtebeck*, *Anita Schoebel*

The aim of this study is the comparative service reliability analysis of high frequency (e.g. metro) and low frequency (e.g. railway) public transport systems. We critically review known reliability indices with respect to this question before we introduce a novel index accounting for the average delay experienced by the passengers in the network. We present numerical tests on the performance of this index, using close to real world data from the German railway system and from the Athens metro. We also discuss the effects of delay management strategies in high and low frequency systems.

2 - Equity and externalities issues in the bus network design

Ernesto Cipriani, Dept. Civil Engineering, University of Roma TRE, Via Vito Volterra 62, 00146, Roma, Italy, ecipriani@uniroma3.it, *Marco Petrelli*, *Gaetano Fusco*

The present paper represents the development of an optimization method for the bus network design, developed by authors, to define the network configuration in terms of bus routes and service frequencies minimizing an objective function representing total costs, internal and external, involved by the multi-modal transport system with elastic demand. The main novelties of the design methodology presented in this paper concern with: a) the introduction of the equity concept in terms of level of bus service supply among different urban districts; b) the application of an explicit constraint to line capacity; c) a new procedure for the externalities estimation based on analytical computation.

3 - Analysis of Bus Rapid Transit Systems

Marco Petrelli, Università Roma Tre, Italy, mpetrelli@uniroma3.it, *Ernesto Cipriani*, *Stefano Gori*

The present paper deals with a procedure for the evaluation of the performance of Bus Rapid Transit (BRT) systems and other related issues about the capabilities of BRT to provide a network of high quality and high reliability services in medium-high demand corridors. The problem addressed involves the performance analysis from the point of view of both the operators and the users and it deals with the basic BRT system implementation problem: the definition of the variables that establish the performance of each different system and the optimal field of existence of these elements.

4 - Transit frequency optimization through Neural Networks

Daniele Tiddi, DITS, University of Rome "Sapienza", Via Eudossiana 18, 00184, Rome, Italy, daniele.tiddi@uniroma1.it, *Guido Gentile*

In the proposed work, we aim to minimize total travel time of public transport users, subject to constraints of resources availability. User travel time is evaluated by a deterministic transit assignment based on hyperpaths. Whilst the constraints yield a convex feasible set, the objective function is not convex due to the nature of user path choice (deterministic and based on hyperpaths). A neural network is then trained from the assignment results. Properties of the resulting function between line frequencies and total travel time are then investigated.

■ WA-17

Wednesday, 9:00-10:20

1.3.14

Network Design for Road Transportation

Stream: Transportation Planning

Invited session

Chair: *Mariano Gallo*, Dipartimento di Ingegneria, Università degli Studi del Sannio, Piazza Roma 21, 82100, Benevento, Italy, gallo@unisannio.it

1 - A Scatter Search algorithm for solving the road network design problem

Mariano Gallo, Dipartimento di Ingegneria, Università degli Studi del Sannio, Piazza Roma 21, 82100, Benevento, Italy, gallo@unisannio.it, *Luca D'Acerno*, *Bruno Montella*

In this paper we focus on the road network design problem in regional contexts; in this case a planner may have financial resources to be invested for improving performances of an existing network. In the literature many optimisation models for solving this problem exist; we propose a model that considers also the evaluation of environmental external costs in the objective function. Then, the paper will focus on the solution algorithm: we will propose a Scatter Search algorithm that will be able to solve the problem for real-scale networks in acceptable computing times.

2 - A Multiobjective Metaheuristic Approach to Support the Rural Network Planning

Pablo Maya, Environment, technology and technology management, University of Antwerp, Stadscampus, S.B.513, Prinsstraat 13, 2000, Antwerp, Belgium, pmayaduque@gmail.com

The departmental government of Antioquia (Colombia) has defined a methodology to build a ten year investment plan for the rural road network in the different subregions of the department. The aim of this work is to complement and improve this methodology by proposing strategies to support the decision making processes involved. The strategy we propose is based on multiobjective optimization model that integrates the different decisions and provides the decision makers with a tool to evaluate plans with different level of compromise of the multiple criteria considered.

■ WA-18

Wednesday, 9:00-10:20

1.3.15

Graph Theory and Combinatorial Optimization

Stream: Stochastic Modeling and Simulation

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

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - On the cubical dimension of four new classes of trees

Kamal Kabyli, Laboratory of Modeling and Optimization of Systems LAMOS, Commercial Sciences Department, University of Bejaia, Algeria, 06000, Bejaia, Algeria, k_kabyle2000@yahoo.fr, *Abdelhafid Berrachedi*

The hypercube of dimension n is the graph in which the set of vertices are binary n -tuples, and two vertices are adjacent if and only if they differ in only one component. Many authors have studied the embedding of trees in hypercube which allowed to characterize certain classes. The problem consist of giving the smallest dimension of a hypercube in which a given tree G is embeddable. We talk then about optimal hypercube and cubical dimension of a hypercube of the tree. In this paper, we give four new classes of trees for which the cubical dimension is established.

2 - Dynamically Maintaining Chordal and Weakly Chordal Graphs

Mohamed Amine Boutiche, Operations research, University of science and technology, BP 32, El Alia, 16111, Bab Ezzouar, Algiers, Algeria, boutichemedamine@yahoo.fr

We present an algorithm that support operations for modifying a tree decomposition representation of chordal and weakly chordal graphs, by adding and deleting edges or vertices, such that after each modification the tree decomposition representation of both graphs is repaired in a minimal way. In particular, if the graph is not chordal (resp. weakly chordal) after the modification, the algorithm computes a valid tree decomposition for the modified graph. Moreover, we update the two parameters tree-length and tree-width of both graph classes after each modification.

3 - On defining a combinatorial space

Sergii Sirenko, V.M. Glushkov Institute of Cybernetics NAS Ukraine, Kyiv, Ukraine, ssirenko@acm.org, *Leonid Hulianyskyi*

We introduce a formal approach to defining the important notions in combinatorial optimization: a combinatorial optimization problem (COP), a combinatorial space, a combinatorial object, a neighbourhood, a move operator, a path and a segment. The key distinction from currently dominating view is a possibility of the combinatorial space to be countable. It is defined using the notion of locally finite space. The combinatorial object generalizes Berge's combinatorial configuration. Suggested definition of the directed segment provides constructive mechanism for using them for COP solving.

4 - Integer Linear Stochastic Programming with Multiple Objective

Amrouche Salima, Mathématiques, université Saad Dahlab Blida, Université SAAD DAHLAB Blida Route De Soumaa BP 270 BLIDA, amrouchesalima@gmail.com, Algeria, amrouchesalima@gmail.com

Real life decision problems have three main properties: (i) conflicting objectives in the problem structure, (ii) stochasticity in the description of problem parameters in contexts where the probability distribution of random parameters is known, and (iii) involvement of integer decision variables which increase the dimension. The proposed modeling and solution methods are able to identify all the integer feasible solutions which are efficient and with convergence in a finite number of iterations.

■ WA-20

Wednesday, 9:00-10:20

1.3.33A

Data Mining and Credit Risk

Stream: Data Mining and Decision Making

Invited session

Chair: *Christophe Mues*, School of Management, University of Southampton, SO17 1BJ, Southampton, United Kingdom, C.Mues@soton.ac.uk

1 - Tuning metaheuristics: A data mining based approach for particle swarm optimization

Stefan Lessmann, Institute of Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, lessmann@econ.uni-hamburg.de, *Idel Montalvo Arango*, *Marco Caserta*

Metaheuristics are powerful procedures for solving complex optimization problems. Their performance will usually depend upon a fine tuning of algorithmic parameters. Since metaheuristics operate in an iterative manner, data concerning effective parameter settings is naturally produced during execution. We propose employing this data for building regression models that facilitate an automatic tuning of parameters within an online learning framework. The feasibility of this approach is explored for different types of regression models in a case study of particle swarm optimization.

2 - Mixture cure models in consumer credit risk

Edward Tong, School of Management, University of Southampton, School of Management, University of Southampton, SO17 1BJ, Southampton, Hampshire, United Kingdom, e.tong@soton.ac.uk, *Christophe Mues*, *Lyn Thomas*

Mixture cure models were proposed in medical statistics to model long-term survival of cancer patients as two distinct subpopulations — those cured of the event of interest along with those that are uncured and susceptible to relapse. We examine the performance of the mixture cure model relative to Cox regression and logistic regression on a UK personal loan portfolio. We develop default prediction models and assess discrimination and calibration performance on a validation dataset. Results for credit scoring at an account level and prediction of defaults at a portfolio level are discussed.

3 - When to rebuild and when to recalibrate credit scorecards

Lyn Thomas, University of Southampton, United Kingdom, l.thomas@soton.ac.uk, *Gimun Jung*

Credit scorecards "age" and need recalibrating and rebuilding from time to time. This is similar to the maintenance and replacement problem which has become standard for physical equipment. We identify a simple way of describing the state of the scorecard in terms of two parameters which are used to construct the log odds to score graph, and then model the dynamics of these parameters from real data sets. Thus we are able to build a dynamic programming model of when one should recalibrate and when one should rebuild a scorecard so as to minimise the expected total cost of running the system.

4 - Support of managerial decision making processes by transductive learning

Hubertus Brandner, Universität Hamburg, Germany,
hubertus.brandner@studium.uni-hamburg.de, Stefan Lessmann

This study analyses to which extent the promising findings of transductive approaches can be transferred to business problems of classification. Different variants of Support Vector Machines are examined to compare the established inductive learning and the transductive technique. To that end a hybrid metaheuristic is implemented to solve the mathematical programming formulations in the same way. Empirical results confirm the potential of transductive inference. Therefore it is advisable to utilize the information of unlabeled data in the context of managerial decision making and planning.

■ WA-21

Wednesday, 9:00-10:20
6.2.47

Optimization Algorithms I

Stream: Software for OR/MS

Invited session

Chair: *Simone Garatti*, Dept. of Electronics and Information, Politecnico di Milano, p.zza L. da Vinci 32, 20133, Milan, Italy, sgaratti@elet.polimi.it

1 - Solving uncertain programs via the scenario approach: the FAST algorithm

Simone Garatti, Dept. of Electronics and Information, Politecnico di Milano, p.zza L. da Vinci 32, 20133, Milan, Italy, sgaratti@elet.polimi.it, *Algo Carè*, *Marco Campi*

Uncertainty is ubiquitous in decision problems, and this leads naturally to uncertain programs (UP). Robust and chance-constrained solutions to UP can be difficult to obtain in general. In this talk, we discuss the use of the scenario approach, a handy methodology based on random sampling of constraints, to solve UP with a guaranteed degree of approximation. In particular, we introduce FAST (Fast Algorithm for the Scenario Technology), a variant of the standard scenario algorithm with reduced complexity, which improves the applicability of the scenario methodology to a high extent.

2 - Scheduling optimization in virtual enterprises based on the hybridization of a CSP with a genetic algorithm

Rabah Kassa, mathematique, Universite Bejaia algerie, universite de bejaia 06000 bejaia algerie, 06000, bejaia, Algeria, rabah_kassa2002@yahoo.fr, *Djamila Boukredera*, *Zaidi Sahnoun*

Production scheduling represents an important manufacturing function whose quality remains an essential stake for virtual enterprises. To optimize its scheduling, a virtual enterprise aims to improve its profitability while minimizing the customer's service costs and respecting manufacturing constraints. This can be formulated as a CSP. We suggest an optimization method of the CSP based on the genetic algorithm. This hybridization aim at better taking over of this kind of problem defined by a large research space and a complex constraint set and finds solutions of good quality.

3 - ParadisEO: a framework for metaheuristics

El-ghazali Talbi, University of Lille - INRIA - CNRS, Lille, El-ghazali.Talbi@lifl.fr

We present the ParadisEO white-box object-oriented framework dedicated to the reusable design of metaheuristics. It provides a broad range of features including population based metaheuristics and single-solution metaheuristics. It bases on a conceptual separation of the solution methods from the problems they are intended to solve. The fine-grained nature of the classes allows a high flexibility. ParadisEO is of the rare frameworks providing most common parallel and distributed models; implementation is portable and models can be exploited transparently.

■ WA-23

Wednesday, 9:00-10:20
6.2.49

Model Selection in Regression Analysis

Stream: Data Mining in the Financial Sector

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

Chair: *Vadim Strijov*, Computing Center of the Russian Academy of Sciences, Klara Zetkin 13-79A, 127299, Moscow, Russian Federation, strijov@ccas.ru

1 - Model generation and model selection in credit scoring

Vadim Strijov, Computing Center of the Russian Academy of Sciences, Klara Zetkin 13-79A, 127299, Moscow, Russian Federation, strijov@ccas.ru

The credit scorecard is the logistic regression model; it maps the feature space to the probability of default of a banking client. A classical scorecard is constructed by an analyst, who manually selects informative features and creates combinations of them. We propose a new technique for the automatic scorecard construction. To develop a scorecard, one must assign a set of primitive functions and model generation rules. The result model is an admissible superposition of the primitive functions and features. The coherent Bayesian inference is used to select features and their superpositions.

2 - Algorithms of feature selection for volatility estimation of European options

Ekaterina Krymova, Control/Management and Applied Mathematics, Moscow Institute of Physics and Technology, 9,35 b.3, Nagornaya st., Moscow, 141981, Moscow region, Dubna, Bogolubova 33-304, 117186, Moscow, Russian Federation, ekkrym@gmail.com

The problem of multicollinearity is commonly encountered in regression analysis. This problem may lead to overfitting and result in unstable model parameters. New approach to the feature generation and feature selection was proposed. The feature generation technique is based on Kolmogorov-Gabor polynomial construction. The features are superpositions of primitive functions and free variables. The generated features require reduction of multicollinearity. For this purpose, the LARS modification is developed. Historical data of European options is used as practical example.

3 - A topological approach to formulating conditions of the uniform convergence of frequencies to probabilities

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

Existence of the uniform convergence of frequencies to probabilities over an appropriate events class is a well known sufficient consistency condition of the empirical risk minimization (ERM) in machine learning. The traditional approach for proving such convergence is based on a sublinear growth of entropy of the event class in question and obtaining upper VCD bounds for this class. In this paper, existence of the uniform convergence of frequencies to probabilities over an event class is related to some topological properties of the sigma-algebra, induced by this class.

4 - Benchmarking Framework for Financial Text Mining

Caslav Bozic, Institute AIFB, IME Graduate School, Karlsruhe Institute of Technology (KIT), Institute AIFB - 05.20, KIT Campus South, 76128, Karlsruhe, BW, Germany, bozic@kit.edu

Different data mining methods for financial text and various sentiment measures are described in the existing literature, without common benchmark for comparing these approaches. Implemented system (which is a part of FINDS Project) and proposed framework are based on theoretical data integration, and they facilitate combining more sources of financial data into comprehensive integral dataset. The dataset is then used to analyse the candidate measure by regressing it on different returns and other financial indicators that can be defined using the system's novel data transformation approach.

■ WA-24

Wednesday, 9:00-10:20

6.2.50

Workforce Scheduling 2

Stream: Timetabling and Rostering

Invited session

Chair: *Shuangqing Liao*, Laboratoire Genie Industriel, Ecole Centrale Paris, Grande Voie des Vignes, F-92 295 , CHÂTENAY-MALABRY Cedex, France, shuangqing.liao@ecp.fr

1 - Call Center staffing with uncertain arrival rates

Shuangqing Liao, Laboratoire Genie Industriel, Ecole Centrale Paris, Grande Voie des Vignes, F-92 295 , CHÂTENAY-MALABRY Cedex, France, shuangqing.liao@ecp.fr, *Christian Van Delft*, *Ger Koole*, *Oualid Jouini*

We consider a multi-shift contract center staffing problem with two types of jobs: calls and emails. It is modeled as a newsboy-type model and is to minimize the salary cost and the unsatisfied service penalty. We suppose that all shifts are without breaks then the shift-period matrix is unimodularity. The pure call center integer staffing problem (no emails) can be relaxed to a linear problem with automatical integer solutions. We decompose our original problem by the benders' decomposition. Thanks to the relaxation and decomposition, we can arise the shift and scenarios numbers.

2 - A heuristic branch-and-bound approach for aircraft line maintenance staffing and scheduling

Jeroen Beliën, Center for modelling and simulation, Hogeschool Universiteit Brussel, Stormstraat 2, 1000, Brussel, Belgium, jeroen.belien@hbrussel.be, *Erik Demeulemeester*, *Brecht Cardoen*

In this paper, we investigate how a line maintenance service company should determine its staffing and scheduling decisions in order to minimize the resulting labor costs. We develop a heuristic branch-and-bound approach that was successfully applied to the problem setting occurred in a line maintenance service provider at Brussels National Airport. Next to this case study, the algorithm was tested on a large set of generated problem instances, based on real-life data. We present the computational results and managerial insights gained from this experiment.

3 - Large-Scale Staff Scheduling in Airport Ground Handling

Andreas Klinkert, Institute of Data Analysis and Process Design, Zurich University of Applied Sciences, Rosenstrasse 3, P.O. Box, CH-8401, Winterthur, ZH, Switzerland, andreas.klinkert@zhaw.ch

An integer programming model is presented to solve a large-scale acyclic days-off scheduling problem for multi-skill staff in airport ground handling. Special focus is given to a tractable formulation of the daily staffing level constraints in order to provide enough workers with appropriate skills for every combination of shifts. The developed model successfully solves the complex problem instances posed by the industrial project partner and CPLEX 11 generates high quality solutions within a few hours which clearly outperform the sophisticated solutions constructed manually by the planning experts of the ground handling company.

4 - Appointment Scheduling with Discrete Random Durations and Applications

Mehmet Begen, Richard Ivey School of Business, University of Western Ontario, 1151 Richmond St. N., Ivey, N6A3K7, London, ON, Canada, mbegen@ivey.uwo.ca, *Maurice Queyranne*

We determine optimal appointment schedule in polynomial time for a given sequence of jobs (e.g., surgeries) on a single processor (e.g., operating room), to minimize the expected total underage (idle-time of the processor) and overage costs (waiting time of jobs and overtime of the processor) when each job has an integer random processing duration given by a joint discrete probability distribution. Besides surgeries, there are other applications such as project scheduling, container vessel and terminal operations, gate and runway scheduling of aircrafts in an airport.

■ WA-25

Wednesday, 9:00-10:20

6.2.48

ROADEF/EURO challenge junior session 2

Stream: ROADEF/EURO challenge

Invited session

Chair: *Eric Bourreau*, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr

1 - ROADEF/EURO Challenge 2010: A large-scale energy management problem with varied constraints

Guillaume Dereu, EDF, France, guillaume.dereu@edf.fr, *Christian Artigues*, *Eric Bourreau*, *H. Murat Afsar*, *Ender Ozcan*

We present the subject of the ROADEF/EURO 2010 challenge, an international optimization contest proposed jointly by EURO, the French OR society (ROADEF) and an industrial partner (EDF). The subject concerns an integrated nuclear power plant outage scheduling and electricity production planning problem, under several demand scenarios. The subject was announced in 2009 at EURO Bonn. From 44 teams that initially registered, 20 teams are still competing for the final round. Results will be announced during the last session of the challenge stream.

2 - A local search algorithm with a repair procedure for the RoadeF 2010 challenge

Henri Tokola, Department of Engineering Design and Production, Aalto University, School of Science and Technology, Puumiehenkuja 3, 02015, Espoo, Finland, henri.tokola@tkk.fi, *Lauri Ahlroth*, *Andre Schumacher*

We present an algorithm for solving the energy management problem of the RoadeF 2010 challenge. Our algorithm consists of multiple separate parts. First, it generates an initial solution using a backtrack method. Then we use a local search method to improve the initial solution. Due to tight constraints on the outage start dates, some candidates that are generated may be infeasible. In order to obtain a feasible solution, we modify the candidate using a repair procedure, which is based on the min conflict heuristic.

3 - Constraint programming and local search for a large-scale energy management problem with varied constraints

Niels Kjeldsen, Dept. of Mathematics and Computer Science, University of Southern Denmark, Campusvej 55, 5000, Odense, Denmark, nhk@imada.sdu.dk, *Steffen Godskesen*, *Rune Larsen*, *Thomas Sejr Jensen*

The ROADEF challenge 2010 asks to decide maintenance schedules, refuel amounts, and production levels of nuclear power plants. The combination of these decisions makes the problem difficult. We construct an initial maintenance schedule by constraint programming on a reduced model for one average scenario, and decide the refueling and energy production levels by a greedy heuristic. We improve the solution by local search on the maintenance schedule with feasibility of refueling and energy production ensured by the greedy heuristic. A final post-processing refines the solution for each scenario.

4 - A constraint integer programming approach to solve large-scale energy management problem with varied constraint

Stefan Heinz, Zuse Institute Berlin, Germany, heinz@zib.de, *Thomas Schlechte*

In this talk, we present a constraint integer programming (CIP) model for the large-scale energy management problem of the ROADEF/EURO Challenge 2010. Furthermore, we give a brief description of the main components and techniques used in the constraint integer programming solver SCIP, which has been submitted to the challenge. Finally, we introduce the extensions we used for the solver SCIP, to solve this class of problem efficiently.

■ WA-26

Wednesday, 9:00-10:20

3.1.11

Special classes of cooperative games and allocation rules

Stream: Cooperative Game Theory

Invited session

Chair: *Marco Slikker*, Department of Industrial Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB, Eindhoven, Netherlands, m.slikker@tue.nl

1 - A new bankruptcy rule emerged from an old cooperative value

Mikel Álvarez-Mozos, Estadística e Investigación Operativa, Universidade de Santiago de Compostela, Rúa Lope Gómez de Marzoa, s/n, Campus sur, 15782, Santiago de Compostela, Afghanistan, mikel.alvarez@usc.es, *Jose M^a Alonso-Meijide*, M^a Gloria Fiestras-Janeiro

Bankruptcy problems study situations in which a group of agents claim a proportion of a resource larger than the amount available. Different rules have been proposed to divide the amount available among the agents, and many properties have been discussed in the literature. Using axiomatic characterizations one can study the different features of each rule. In this work we propose a new bankruptcy rule and study its main features. Our rule corresponds to a widely known value of the cooperative game associated with the bankruptcy problem.

2 - Reasonable costs allocation rules for ATM games

Andrés Jiménez-Losada, University of Seville, 41092, Seville, Spain, hispan@esi.us.es, *Casi Chacón*, *Esperanza Lebrón*

ATM games were introduced to define rules for allocating costs in a bank ATM (Automated Teller Machines) network. There are two different approaches from the cooperative game theory: Gow and Thomas (1998) [Naval Research Logistic 45(4) 407-417], and Bjorndal et al. (2004) [Mathematical Methods of Operations Research 59(3) 405-418]. We propose a common point of view of these papers introducing them in a family of reasonable solutions for the problem. These new rules take in account the different behaviour of the banks according to the locations of their ATMs

3 - About a new solution concept of cooperative TU-games

Nadezhda Smirnova, Faculty of Applied Mathematics and Control Processes, Saint-Petersburg State University, Russian Federation, nadezhda.v.smirnova@gmail.com, *Svetlana Tarashnina*

In our work we describe a new solution concept of cooperative TU-games, called a set of a-prenucleoli. A set of a-prenucleoli takes into account both constructive power and blocking power of coalition S with all possible ratios. We show that a-prenucleoli of an arbitrary n -person TU-game coincides with the prenucleolus of a certain n -person constant-sum game, which is constructed as the weighted sum of the game and its dual. Also we consider what the connections are between a set of a-prenucleoli and such solutions as prenucleolus, SM-nucleolus, the Shapley value.

4 - Spare parts inventory pooling games

Marco Slikker, Department of Industrial Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB, Eindhoven, Netherlands, m.slikker@tue.nl, *Frank Karsten*, *Geert-Jan van Houtum*

We study a situation where several independent companies separately stock spare parts of the same item for a technically advanced machine. They may reduce expected joint holding and downtime costs by pooling inventory. We analyze these situations by defining a cooperative cost game. For situations allowing companies to have non-identical demand rates and base stock levels and for situations allowing companies to have non-identical downtime costs, we show that the core of the associated game is non-empty. However, in general, the associated game may have an empty core.

■ WA-27

Wednesday, 9:00-10:20

8.2.06

TRAFFIC AND ENVIRONMENT

Stream: Transportation and Logistics

Invited session

Chair: *Ana Luísa Ramos*, Economics, Management and Industrial Engineering, University of Aveiro, Campo de Santiago, 3810-193, Aveiro, Portugal, aramos@ua.pt

1 - A dss solution for air pollution emergencies managing with traffic flows

Valerio de Martinis, Depart.of Transportation Engineering, via Claudio21, 80125, Naples, Italy, vdemartinis@unina.it, *Luigi Biggiro*, *Roberta Di Pace*

The main objective of this work is to analyze the correlation between the PM10 and the climatic (wind, temperature, mm and days of rain) and traffic variables; moreover it focuses the attention on the effects of the adopted traffic regulation strategies by the municipality in the city of Naples. For this purpose, two approaches have been implemented (the ARIMA model - Autoregressive Integrated Moving Average - and the Artificial Neural Networks) in order to forecast the PM10 of the following days and the results have been discussed. Finally, a Decision Support System through Decision Maps approach has been implemented in order to evaluate the traffic strategies for avoiding PM10 emergencies.

2 - Shortest Path Performance within Real Road Network in Malaysia Perspective

Rohaizan Ramlan, Department of Technology Management, University of Tun Hussein Onn Malaysia, 86400, Batu Pahat, Johor, Malaysia, rohaizan@uthm.edu.my, *Faiz Shamsuddin*

Computational performance of shortest path algorithm has been testing in many research (Cherkassky et al. 1993);(Zhan And Noon, 1998, etc. However most of the computational testing on shortest path algorithms has been based on randomly generated networks, which may not have the characteristics of real road networks (Zhan and Noon, 1998). The purpose of this study is to identify the performance of shortest path on Malaysia road network. The runtimes is collected to obtain the result and performance each of shortest path algorithm is known.

3 - Optimal hierarchical system of a grid road network

Masashi Miyagawa, Ecosocial System Engineering, University of Yamanashi, 4-3-11 Takeda, Kofu, 400-8511, Yamanashi, Japan, mmiyagawa@yamanashi.ac.jp

This paper develops a simple analytical model for determining the hierarchical system of road networks. The model is based on a grid road network. We derive the optimal ratios of road areas that minimize the average and maximum travel time. Minimizing the average travel time provides an efficient solution, whereas minimizing the maximum travel time provides an equitable solution. Both of the solutions are expressed in terms of road widths and travel speeds. As an application of the grid network model, we evaluate the hierarchical system of the road network of Tokyo.

4 - Model Based Systems Engineering for Traffic & Environment

Ana Luísa Ramos, Economics, Management and Industrial Engineering, University of Aveiro, Campo de Santiago, 3810-193, Aveiro, Portugal, aramos@ua.pt, *José Vasconcelos Ferreira*, *Jaume Barcelo*

The immaturity of the Systems Engineering field argues for empirical research to drive knowledge evolution. In order to contribute to this development, it was decided to work out on a contemporary real world challenging problem. The application domain, "at the agenda" of world leaders, national and local governors, and academia, is the system 'Intelligent Urban Traffic & Environment Operations' which is characterized by significant dimension, complexity, interdisciplinarity, and relevant socio technical patterns. The emerging MBSE approach is being used to develop the proposed system.

■ WA-28

Wednesday, 9:00-10:20

8.2.10

Scheduling with Transportation

Stream: Scheduling

Invited session

Chair: *Gul Didem Batur*, Industrial Engineering, Gazi University, Gazi University Engineering Faculty, Industrial Engineering Department, 06570, Ankara, Turkey, dbatur@gazi.edu.tr

1 - Transporting Jobs Through a Processing Centre with Two parallel Machines

Alan Soper, School of Computing and Mathematical Sciences, University of Greenwich, Old Royal Naval College, Park Row, SE10 9LS, Greenwich, London, United Kingdom, A.J.Soper@gre.ac.uk, *Hans Kellerer*, *Vitaly Strusevich*

We consider the problem of scheduling jobs on two identical parallel machines, allowing preemption. The jobs are brought to the system by a single transporter and moved between the processing machines by the same transporter. The purpose is to split the jobs into batches and to find the sequence of moves of the transporter so that the time by which the completed jobs are collected together on board the transporter is minimal. We present an FPTAS for the problem.

2 - A dynamic approach to hybrid flow shop scheduling with transportation requests

Verena Gonddek, Department of Mathematics, Universität Duisburg-Essen, Forsthausweg 2, LE 431, 47057, Duisburg, Germany, verena.gonddek@uni-due.de

This work is motivated by a real-life problem arising in steel producing industries. For monitoring the manufacture of steel, samples are taken at different stages of the production process and are sent to an automatic laboratory to check their quality. The efficient organization of the workflow in this laboratory can be classified as a hybrid flow shop scheduling problem with transportation requests and jobs arriving over time. Due to vast restrictions in computational time, we develop and evaluate a two phase heuristic approach to accomplish the required on-line optimization.

3 - Multiple Part-Type, 3 Parallel Machine Scheduling in Robotic Cells

Gul Didem Batur, Industrial Engineering, Gazi University, Gazi University Engineering Faculty, Industrial Engineering Department, 06570, Ankara, Turkey, dbatur@gazi.edu.tr, *Serpil Erol*

We focus on the scheduling problem arising in 3-machine manufacturing cells which repeatedly produce a set of multiple part-types, where the parts are carried between the machines by a robot. Due to the flexibility property of CNC machines, robot may choose either to perform all the processing of a part completely on any one of the machines or to share them among the machines. Decisions to be made include finding the robot move cycle, the part sequence and the allocation that jointly minimize the production cycle time. The problem is modeled as a special travelling salesman problem (TSP).

■ WA-29

Wednesday, 9:00-10:20

8.2.11

Simulation and Optimization Modeling in Finance

Stream: Financial Modeling

Invited session

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 - No-Arbitrage Conditions, Scenario Trees, and Multi-Asset Financial Optimization

Michael Hanke, Dept. of Banking and Finance, University of Innsbruck, Universitaetsstr. 15, 6020, Innsbruck, Austria, Michael.Hanke@uibk.ac.at, *Alois Geyer*, *Alex Weissensteiner*

Many numerical optimization methods use scenario trees as a discrete approximation for the true (multi-dimensional) probability distributions of the problem's random variables. Realistic specifications in financial optimization models can lead to tree sizes that quickly become computationally intractable. In this paper we focus on the two main approaches proposed in the literature to deal with this problem: scenario reduction and state aggregation. We show that neither of these methods is suitable to solve financial optimization models in asset-liability or portfolio management.

2 - Multi-stage stochastic interest rate management

Ronald Hochreiter, Finance, Accounting and Statistics, WU Vienna University of Economics and Business, Augasse 2-6, 1090, Vienna, Austria, ronald.hochreiter@wu.ac.at

A major part of a banks total interest rate risk is due to the position of non-maturing deposits. In this talk, a multi-stage stochastic programming model for managing this risk factor will be shown. The uncertainty is given both in the interest rate development as well as the volume of the specific product. Different deposit products from an Austrian retail bank will be used to show the applicability of the model.

3 - Empirical Analysis of two Bi-directional Online Trading Algorithms

Esther Mohr, Information and Technology Management, Saarland University, P.O. Box 151150, 66041, Saarbrücken, Germany, em@itm.uni-sb.de, *Günter Schmidt*, *Mike Kersch*

Trading decisions in financial markets can be supported by the use of online algorithms. We evaluate the empirical performance of two bi-directional trading algorithms and compare it to a moving average algorithm, a trading range breakout algorithm, an optimal algorithm, and to buy-and-hold. The algorithms are compared using geometric returns generated with historical DAX prices for the years 2000 to 2009. The performance of the algorithms found in the simulation runs is analyzed using a t-test and a bootstrap procedure. We also compare its performance to results from worst case analysis.

4 - Accounting for defined benefit plans (IAS 19) — Information bias in case of a degenerating workforce

Prof. Dr. Matthias Amen, Chair for Quantitative Accounting & Financial Reporting, University of Bielefeld, Universitaetsstrasse 25, 33615, Bielefeld, Germany, Matthias.Amen@web.de

Accounting for pension obligations is addressed in the international accounting standard (IAS) 19. The complexity in accounting arises from the difficulty of calculation, the stochastic nature, and the long forecast horizon. It is known that human expectations on system behavior generally fail under these circumstances (Tversky/Kahneman (1974)). Furthermore unforeseeable effects might happen, even if the assumptions are „best estimates“ (Anderson (1992)). We present results of a simulation study and discuss the information bias in financial reporting that arises from the current IAS 19.

■ WA-30

Wednesday, 9:00-10:20

8.2.13

MCDM 3

Stream: MCDA II: Axiomatic Basis, Meaningfulness, and other Issues [c]

Contributed session

Chair: *Tihomir Hunjak*, Faculty of organization and informatics, University of Zagreb, Pavlinska 2, 42000, Varazdin, Croatia, tihomir.hunjak@foi.hr

1 - Computation of Non-Cooperative Equilibrium in Multi-criteria Games

Naouel Yousfi, Operational Research, Laboratory of Modelling and Optimization of Systems, Algeria, yousfi_na@hotmail.com, *Mohammed Said Radjef*

In order to analyze several economic situations and model a lot of real world applications, finite multicriteria games can be used.

This paper deals with the non cooperative multicriteria games. We propose to find a Non-cooperative equilibrium by transforming finite multicriteria games to an ordinal game using outranking methods. For the transformed game we developed an algorithm to find these equilibria if they exist. Finally, we illustrate the result given by the algorithm on a numerical example.

2 - Multi-criteria semantic association ranking based on instance knowledgebase analysis for criminal organisation identification.

Mariusz Chmielewski, Cybernetics, Military University of Technology, Poland, mchmielewski@wat.edu.pl, *Rafal Kasprzyk*

The main method assumption shows that generation of semantic network based on registered atomic events, provides data, in which the proposed algorithms identify indirect links between the vertices of the network. Developed semantic model had been extended towards multi-criteria decision-making. Ranking semantic associations requires more than filtering for relevance but also must consider extended quantity analysis. Based on multicriteria optimization the evaluation function for semantic association is able to exploit weights for ranking criteria according to analyst preferences. This way ranking process can be parameterized distinguishing the relevance of the associations.

3 - A Multi-Criteria Ranking Procedure for ERP Software Selection

Tugba Efendigil, Yildiz Technical University, Turkey, tfdolas@yildiz.edu.tr

Enterprise Resource Planning (ERP) software selection is one of the most important decision making issues covering both qualitative and quantitative factors for organizations. This study presents a beneficial structure to the managers for use in ERP software vendor selection process. We utilized grey relational analysis (GRA) to rank the ERP software vendors by making a multi-criteria weighted-average with respect to several criteria. In the end of this study, a numerical example is also presented to illustrate efficiency of the methodology and its applicability in practice.

4 - Comparison of two models for tender evaluation in public procurement

Tihomir Hunjak, Faculty of organization and informatics, University of Zagreb, Pavlinska 2, 42000, Varazdin, Croatia, tihomir.hunjak@foi.hr, *Vjerran Strahonja*, *Dragutin Kermek*

In public sector procurement an open or restricted procedure are preferred if we are comparing them with a negotiation procedure. In this paper two models of public tendering of complex software will be presented. Both based on the economically most advantageous tender. First model is a model of open and restricted procedure of public procurement and second model is a model based on the negotiation procedure in public procurement. The models are different but focused on the same criteria. There are special conditions for selecting the negotiated procedure instead of usually used open or restricted procedure. The advantages and disadvantages of these approaches will be analyzed.

■ WA-31

Wednesday, 9:00-10:20
8.2.15

Industrial applications of scheduling and routing I

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 - Aspects of routing problems in media product distribution

Geir Hasle, Applied Mathematics, SINTEF ICT, P.O. Box 124 Blindern, NO-0314, Oslo, Norway, Geir.Hasle@sintef.no, *Oddvar Kloster*, *Morten Smedsrud*

Efficient construction and revision of delivery routes for newspapers and other media products is critical. We illustrate important aspects of routing problems in this industry. Typically, the goal is to optimize on several criteria that are partly in conflict: number of routes, delivery costs, route balancing, and route segregation. We describe how these aspects may be modeled and solved. Results from computational experiments on industrial cases and standard benchmarks are presented. The importance of cloud computing and parallel algorithms for modern computer architectures is described.

2 - Optimization in Waste Management

Jens Baudach, Lehrstuhl für Verkehrssysteme und -logistik, Technische Universität Dortmund, Leonhard-Euler-Str. 2, 44227, Dortmund, NRW, Germany, baudach@vsl.mb.tu-dortmund.de

Waste management involves an efficient planning of the two major resources collection-vehicles and corresponding crews. As a result of an applied research project we present an integrated approach which first optimizes disposal districts (i.e., corresponding routes of the vehicles) and then finds optimal schedules for the crews. We focus on the crew scheduling phase which includes network based column generation, lagrangean relaxation models, and problem specific algorithms. Computational results based on practical data sets by public and private companies will be presented.

3 - Solving a Solid Waste Collection Real Problem

Nuno Lebreiro, Production and Systems Department, University of Minho, Portugal, Edf.Engenharia2, Campus de Gualtar, 4710-057, Braga, Portugal, nflebreiro@gmail.com, *José Oliveira*, *Manuel Figueiredo*

The large scale selective waste routing process congregates a lot of information and is subject to a huge number of constraints, which makes it a hard problem to solve by exact methods. This project is based on a real case scenario for one of the most important selective waste Portuguese operators. We focus on the Vehicle Routing Problem optimization using heuristics. The estimation of the solid waste generation is based on a model using demographic and economic data. Preliminary results will be presented and discussed.

4 - Handling due-date Rendezvous in Vehicle Routing Problems

Stanislas Francfort, CORE/M2V, Orange Labs, 38-40 rue du general leclerc, issy les moulineaux, France, stanislas.francfort@orange-ftgroup.com, *Matthieu Chardy*

For Orange, the provision of services and the maintenance of networks involve dozens of millions technicians' interventions a year. Thus the optimization of field interventions management is a key issue, which can be modeled as variants of the Vehicle Routing Problem (VRP). This work deals with the modeling of due-date Rendezvous (trainings, meetings, breaks or hours-off...) in VRP and their impact on the tractability of the subproblems when column generation based solution methods are in use. Results of extensive testing performed on both academic and real-life instances are presented.

■ WA-32

Wednesday, 9:00-10:20
8.2.17

Meeting EURO-WG OR in Agriculture and Forest Management

Stream: OR in Agriculture and Forest Management
Invited session

Chair: *Lluís Miquel Pla*, Mathematics, University of Lleida, Fac. Dret i Economia, Jaume II, 73, 25001, Lleida, Implà@matematica.udl.cat

1 - Meeting EURO-WG OR in Agriculture and Forest Management

Lluís Miquel Pla, Mathematics, University of Lleida, Fac. Dret i Economia, Jaume II, 73, 25001, Lleida, Implà@matematica.udl.cat

Meeting EURO-WG OR in Agriculture and Forest Management

■ WA-33

Wednesday, 9:00-10:20
8.2.19

Optimal policy in the energy markets

Stream: Energy, Environment and Climate
Invited session

Chair: *Elisabetta Allevi*, Quantitative Methods, University of Brescia, Contrada Santa Chiara, 50, 25122, Brescia, Italy, allevi@eco.unibs.it

1 - A Quasi-Variational model of imperfect coordination: an illustration from electricity restructuring

Giorgia Oggioni, Department of Quantitative Methods, University of Brescia, Italy, Contrada Santa Chiara, 50, 25122, Brescia, Italy, Italy, oggioni@eco.unibs.it, *Yves Smeers*, *Elisabetta Allevi*, *Siegfried Schaible*

Recent papers propose methods for finding a set of solutions of quasi-variational inequality problems. We apply these methods to a problem of imperfect coordination of operation encountered in the restructuring of the electricity system. We first discuss the economic interpretation of the variational inequality problem and some of its implications for algorithmic purposes. We then apply the methods to a set of case studies and report the results as well as the advantages and shortcoming encountered. The paper emphasises the numerical aspects.

2 - Modelling Policies for the EU ETS allowances

Paolo Falbo, Dipartimento Metodi Quantitativi, Università degli Studi di Brescia, Contrada Santa Chiara, 50, 25122, BRESCIA, Italy, falbo@eco.unibs.it, *Cristian Pelizzari*

In this work the price of allowances in the EU ETS is linked to the value of the expected penalty for the CO₂ produced in excess by diverse economic players. Too severe environmental policies cause a rise in the price of allowances. The compliance of such objectives can increase the production costs causing inflation and loss of competitiveness. An equilibrium model is advanced where the regulatory authority can influence the choices of the players by tuning several parameters, such as the emission cap, the number of allowances and their allocation to the economic sectors, the penalty level.

3 - Data Envelopment Analysis with undesirable and uncertain outputs

Rossana Riccardi, Statistics and Applied Mathematics, University of Pisa, Via ridolfi, 10, 56124, Pisa, Italy, riccardi@ec.unipi.it, *Roberta Toninelli*

In this paper a Data Envelopment Analysis (DEA) model with undesirable and uncertain outputs is presented. It is known that the production processes may generate undesirable externalities like emissions of greenhouse gases, sulfur oxides or waste generation. The aim of the model is to measure the performance of these processes highlighting, as a reference standard, those processes that combine greater amounts of desirable production with lower levels of undesirable outputs. The model is applied to a real case study related to the impact of CO₂ emissions on industry sectors.

4 - The "Invisible Hand" for Risk Averse Investment in Electricity Generation

Daniel Ralph, Judge Business School, Cambridge University, Trumpington St, CB2 1AG, Cambridge, United Kingdom, d.ralph@jbs.cam.ac.uk, *Yves Smeers*

We consider a perfectly competitive situation consisting of an electricity market (2nd stage) preceded by investment in generating plant capacity (1st stage). The classical "Invisible Hand" says that if generators and consumers act in their own best interests, the result will be to minimize the net cost (or max net welfare). Motivated by energy developments in the European Union, our interest is the case when electricity generators are risk averse, and the cost of future production is assessed via "coherent risk measures" instead of expectations.

■ WA-34

Wednesday, 9:00-10:20
8.2.23

Computational Methods

Stream: Convex Optimization

Invited session

Chair: *Laura Martein*, department of statistics and applied mathematics, University of Pisa, via Ridolfi, 10, 56124, Pisa, Italy, lmartein@ec.unipi.it

1 - Semismooth Newton method for quadratic programs with bound constraints

Anna Daryina, Department of Nonlinear Analysis and Safety Problem, Institution of Russian Academy of Sciences

Dorodnicyn Computing Centre of RAS, Vavilova str, 40, Moscow, Russian Federation, daryina@ccas.ru, *Alexey Izmailov*

We propose to solve convex quadratic programs with bound constraints by applying the semismooth Newton method (SNM) to the appropriate reformulation of the corresponding variational inequality. SNM was compared with the gradient projection method and active set methods. Numerical experiments demonstrate that for strongly convex problems, SNM can be considerably more efficient than the traditional approaches.

2 - Solving large-scale nonnegative least squares using an adaptive non-monotonic method

Suvrit Sra, AGBS, Max Planck Institute for Biological Cybernetics, Spemannstr. 38, 72076, Tuebingen, Germany, suvrit@gmail.com, *Dongmin Kim*, *Inderjit Dhillon*

We present an efficient algorithm for large-scale non-negative least-squares (NNLS). We solve NNLS by extending the unconstrained quadratic optimization method of Barzilai and Borwein (BB) to handle nonnegativity constraints. Our approach is simple yet efficient. It differs from other constrained BB variants as: (i) it uses a specific subset of variables for computing BB steps; and (ii) it scales these steps adaptively to ensure convergence. We compare our method with both established convex solvers and specialized NNLS methods, and observe highly competitive empirical performance.

3 - Block Hessian matrices with 0-1 quadratic convex reformulations

Yasmin Rios-solis, graduate school of systems engineering, Universidad Autonoma de Nuevo Leon, facultad de Ingenieria Mecanica y Electrica, av. Universidad s/n, 65450, monterrey, nuevo Leon, Mexico, agueda.riossl@uanl.edu.mx

Many combinatorial optimization problems can be formulated as a binary non-convex quadratic function with linear constraints. When these problems involve parallel machines (scheduling) or zones (territory design), their Hessian have a block structure. To exactly solve these problems by a quadratic branch and bound, we propose convex reformulations that take advantage of the Hessian block structure. We aim a trade off between the quality (tightness of the continuous relaxation) and the computing time of these reformulations. Computational experimentation show the interest of this method.

4 - Optimal Load Balancing Between Erlang-C Queueing Systems

Jorge Sá Esteves, Dep. of Mathematics, University of Aveiro, Campus Santiago, 3810-193, AVEIRO, Portugal, saesteves@ua.pt

In computer networking, load balancing is a technique to distribute workload evenly across two or more computers, network links, or other resources, in order to get optimal resource utilization using different criteria (maximize throughput, minimize response time, avoid overload, etc.). In this talk the overall system is modeled as set of independent Erlang-C queueing systems. The optimization problem solved may be seen as a multicriterion convex separable problem. Pareto Optimal solutions are computed and computational and graphical results are presented.

■ WA-35

Wednesday, 9:00-10:20
6.2.46

MINLP: new developments and applications

Stream: Mixed-Integer Non Linear Programming

Invited session

Chair: *Sonia Cafieri*, LOTA, Ecole Nationale d'Aviation Civile, 31055, Toulouse, France, sonia.cafieri@recherche.enac.fr

1 - Feasibility Based Bounds Tightening as a Fixed Point in the Interval Lattice

Leo Liberti, LIX, Ecole Polytechnique, LIX, Ecole Polytechnique, 91128, Palaiseau, France, leoliberti@gmail.com, *Pietro Belotti*, *Sonia Cafieri*, *Jon Lee*

Feasibility Based Bounds Tightening (FBBT) is a device used at every node of the spatial Branch-and-Bound algorithm for Mixed-Integer Nonlinear Programs in order to tighten the variable ranges. FBBT works by deriving implicit constraint bounds using the original variable ranges and interval arithmetic, and then propagating the given constraint bounds to hopefully tighter variable ranges using inverse interval arithmetic. This basic iteration is then applied until convergence. In order to address the problem of FBBT's erratically slow convergence, we see FBBT as a monotone, deflationary operator on a lattice of interval vectors under set inclusion, intersection and interval union. We show that the sequence of intervals derived by the repeated application of FBBT converges to its greatest fixed point, which we compute by simply solving an auxiliary Linear Program.

2 - Global Optimization of Large Scale Quadratically Constrained MINLP Models

Christodoulos Floudas, Chemical Engineering, Princeton University, 08544, Princeton, NJ, United States, floudas@princeton.edu

In this talk, we present novel theoretical and algorithmic results for the global optimization of large scale quadratically constrained MINLP models that arise in generalized pooling problems. Convex relaxations of bilinear terms via a variety of novel piecewise linear underestimations are presented and embedded within an effective branch and bound framework. Extensive computational results on case studies with distinct bilinear terms ranging from 48 to 1,260 demonstrate the potential of the proposed deterministic global optimization approach to address large scale models to global optimality.

3 - A cutting-plane framework for weakly-coupled 0/1 SOCPs

Sarah Drewes, Department of Mathematics, Technische Universität Darmstadt, Dolivostr. 15, 64293, Darmstadt, Germany, drewes@mathematik.tu-darmstadt.de, *Sebastian Pokutta*

We devise a cutting-plane framework for a special class of mixed 0/1 second order cone programs, where the fractional and binary variables are solely coupled via the conic constraints. The derived cuts are based on an implicit Sherali-Adams reformulation and the generalized Benders cut. They are very effective as symmetric solutions are simultaneously cut off and each equivalence class of 0/1 solutions is visited at most once. We give preliminary computational results showing the effectiveness of our method.

4 - Extensions of Interval Branch-and-Bound Algorithms for Mixed Global Optimization Problems with Real and Categorical Mixed Variables

Frederic Messine, ENSEEIHT-IRIT, 2 rue Camichel, 31000, TOULOUSE, France, Frederic.Messine@n7.fr, *Bernard Jeannot*

Real global optimization problems often imply to take into account different kinds of variables: discrete and continuous. In this presentation, we study mixed problems which combine real and categorical variables (discrete variables without ordering). Four methods are presented and discussed in order to compute bounds for the categorical variables. This yields some properties and permits some extensions of classical interval branch-and-bound global optimization algorithms. Numerical tests will validate our approaches and a real example of design is then considered.

■ WA-36

Wednesday, 9:00-10:20
3.1.05

OR in the Public Sector

Stream: OR and Real Implementations
Invited session

Chair: *Zilla Sinuany-Stern*, Industrial Engineering and Management, Ben Gurion University, Beer-Sheva, Israel, 84105, Israel, zilla@bgu.ac.il

1 - Efficiency evaluation of Greek engineering departments

Yorgos Goletsis, Dept. of Economics, University of Ioannina, University campus, GR 45110, Ioannina, Greece, goletsis@cc.uoi.gr, *Vassiliki Brahou*

As Greek universities are public institutions there is a growing pressure for efficient use of public funds. Due to their non-profit nature financial measures of efficiency are not applicable nor a typical production function is available. We use Data Envelopment Analysis (DEA) for evaluating 30 Engineering departments. Additionally, the Malmquist Total Factor Productivity index is used for examining productivity change over time while the notion of super-efficiency is used for obtaining complete rankings. Quality considerations are also discussed.

2 - Mixed integer least squares optimization for flight and maintenance planning of mission aircraft

George Kozanidis, Mechanical Engineering, University of Thessaly, Leoforos Athinon, Pedion Areos, 38334, Volos, Magnisia, Greece, gkoz@mie.uth.gr, *Eftychia Kostarelou*, *Andreas Gavranis*

We address the problem of generating a joint flight and maintenance plan for a unit of mission aircraft. We propose a mixed integer nonlinear programming formulation and an exact search algorithm for the solution of the problem. We analyze the computational complexity of this algorithm and we present results, which evaluate its computational performance. These results reveal that the total computational effort required for the solution of the problem depends mainly on the size of the unit and the space capacity of the maintenance station.

3 - Assessing the Influence of Operating Theatres on the ICU Bed Occupancy

Fermin Mallor, Statistics and O.R., Public University of Navarre, Campus Arrosadía, 31192, Pamplona, Spain, mallor@unavarra.es, *Cristina Azcarate*

Usually, a big percentage of arrivals to Intensive Care Units (ICU) come from operating theatres. This high flow of patients influences both the ICU bed occupancy and the operating theater scheduling, leading sometimes to cancel operations or to reject emergency patients because of lack of beds. Here, a simulation model for the ICU and the operating theatres of the Hospital of Navarre is used to point out these influences and to assess the consequences of managerial rules. We use the information of all ICU patients from 2000-2009 to estimate patient arrivals and length of stays.

4 - Coping with the Efficiency-Equity Dilemma in Organ Sharing

Amir Alalouf, Industrial-Engineering and Management, Ben-Gurion University, PoBox 603, 84105, Beer-Sheva, Israel, aamir@bgu.ac.il, *Israel David*, *Joseph Pliskin*

In order to compare organ allocation policies we developed the dynamic organ-sharing evaluation system (DOSES). The DOSES is simulation-based software designed to be a decision support system. The DOSES is modular, to enable easy updating of the various components and provides an easy methodic way to quantify allocation policies. In addition we will present a new allocation policy called the extended David and Yechiali (EDY), and we will use the DOSES to compare EDY to other allocation policies, like UNOS (United Organ Sharing) and FCFT (first-come-first-transplanted).

■ WA-37

Wednesday, 9:00-10:20
3.1.09

MCDA applications in agricultural and environmental management

Stream: MCDA I: New Approaches and Applications
Invited session

Chair: *Antonio Boggia*, DSEEA, University of Perugia, Borgo XX giugno, 74, 06121, Perugia, boggia@unipg.it

1 - Development of a benefit transfer model using dominance based rough set approach

Lucia Rocchi, DSEEA, University of Perugia, Borgo XX giugno 74, 06121, Perugia, lucia.rocchi@unipg.it, *Antonio Boggia*, *Salvatore Greco*

Benefit Transfer Methods (BTMs) are a cluster of methods for a second best evaluation of environmental goods. Although there are several studies regarding the theoretical basis of BTMs, their reliability and effectiveness are still not clear. However, BTMs are useful when saving time and money is important. Multi-criteria analysis, in particular the Dominance Based Rough set Approach (DRSA), provides a possible useful tool to improve the reliability of the methods. In particular, we used DRSA before utility function transfer to evaluate environmental and recreational services of a lake.

2 - Multiobjective optimization for farms using the dominance-based rough set approach

Luisa Paolotti, DSEEA, University of Perugia, Borgo XX
Giugno 74, 06121, Perugia, Italy, luisa.paolotti@gmail.com,
Antonio Boggia, Salvatore Greco

The objective of the paper is to underline the applicability of the MCDA method combining the Dominance-based Rough Set Approach with the Interactive Multiobjective Optimization (Greco et al., 2008) to the agricultural sector, in order to determine optimal planning strategies for farms. The method is a novelty in the multiobjective optimization sector. It has been applied within a case study, to determine an optimal strategy to integrate economic and environmental objectives. We developed a strategy able to conciliate high income with low nitrogen leaching, soil erosion and water consumption.

3 - Assessing biodiversity and sustainability in natura 2000 sites. a multicriteria approach

Carla Cortina, DSEEA, University of Perugia, Borgo XX giugno
74, 06121, Perugia, Italy, ccortina@unipg.it, Antonio Boggia

This paper shows how Multicriteria Decision Analysis (MCDA) can help in a complex process such as the assessment of the level of biodiversity in the Nature 2000 sites. In order to assess biodiversity, a methodological approach based on multi-criteria analysis has been developed. The aim is to rank Nature 2000 sites in order to understand the level of biodiversity and the environmental pressure of human activities which are subject. This is what decision-makers need for having support to their decisions and could be useful in order to promote sustainable development in protected areas.

4 - Implementation of dominance based rough set approach module in a geographic information system

Antonio Boggia, DSEEA, University of Perugia, Borgo XX
giugno, 74, 06121, Perugia, boggia@unipg.it, Salvatore Greco,
Gianluca Massei

This paper presents the implementation of dominance based rough set approach module in an open source GIS system. Features, possible use and output of the implemented module are presented. To implement the algorithms GRASS 6.3 has been used, adding a specific module written in C language. In addition, the new module has been included in the GRASS toolbox, in QGIS 0.10. We present the application of the implemented module to a case study.

■ WA-38

Wednesday, 9:00-10:20

6.2.44

Issues in Inventory Management Applications I

Stream: Inventory Management

Invited session

Chair: Thomas Wensing, Chair of Production and Operations Management, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 84049, Ingolstadt, Germany, thomas.wensing@ku-eichstaett.de

1 - Managing subassemblies and components for safety stock of multi products

Emre Cakmak, International Logistics, Okan University, Okan University, Akfirat Kampusu, 34959, Istanbul, Turkey, emre.cakmak@okan.edu.tr, Hande Gul kac, Mehmet Tanyas

The modern business environment is highly unpredictable. Safety stock plays an important role to avoid stock-out due to the uncertainty and variability of products demands and raw materials supply. High safety stock level for products and raw materials can cause an increment of holding and financial costs. Otherwise the condition of dissatisfaction of demands can result in the decline of the consumer service level which will lead consumer dissatisfaction in the long term. In Assembly to Order (ATO) production systems components and/or subassemblies are stocked. The advantage of stocking subassemblies rather than stocking components is the escalation of consumer reaction speed. The advantage of stocking components rather than subassemblies is having the least holding costs. The aim of this paper is to manage components and subassemblies for safety stock of multi products by evaluating stock out and inventory costs with the help of a simulation program.

2 - Analysis of an inventory system when orders may crossover

Thomas Wensing, Chair of Production and Operations Management, Catholic University of Eichstaett-Ingolstadt, Auf der Schanz 49, 84049, Ingolstadt, Germany, thomas.wensing@ku-eichstaett.de, Heinrich Kuhn

We study a periodic-review order-up-to (r,S) inventory system with a stochastic lead time process that allows for orders to crossover. Customer orders arrive on a periodical basis. We show that performance indicators such as the ready rate, fill rate and mean inventory levels may exactly be calculated if customer order volumes are constant. For stochastic order volumes, the approach is approximate, however we observe fairly accurate results if the demand volatility is moderate.

■ WA-39

Wednesday, 9:00-10:20

6.2.45

Real-time scheduling of logistic warehouse operations

Stream: Scheduling under Resource Constraints

Invited session

Chair: Vicente Valls, Departamento de Estadística e Investigación Operativa, University of Valencia, Dr. Moliner,50, Burjasot, 46100, Valencia, Spain, Vicente.Valls@uv.es

1 - Real-time scheduling of picking and storing operations in a warehouse

M. Angeles Pérez, Mathematics for Economy, University of Valencia, Avda Naranjos s/n, 46021, Valencia, Spain, angeles.perez@uv.es, Francisco Ballestin, M.Pilar Lino, Sacramento Quintanilla, Vicente Valls

In this paper, we deal with the problem of scheduling picking and storing operations in a warehouse in which the utilisation of the two main resources — forklifts and storage locations available in a limited amount — has to be optimized for an efficient management of warehouse operations and where picking and storing orders may have due dates associated to them. We present several real-time dispatching policies for this problem. Computational experiments analyse the relative efficiency of the proposed policies and the benefits of using, or not, real-time information and/or dual routes.

2 - Efficient utilisation of resources in the management of warehouse operations: storage location dispersion and forklift workload balance

Sacramento Quintanilla, Economía Financiera y matemática, University of Valencia, Avda. Naranjos s/n, 46071, Valencia, Spain, Maria.Quintanilla@uv.es, Francisco Ballestin, M.Pilar Lino, M. Angeles Pérez, Vicente Valls

The problem of scheduling picking and storing orders consists in: being given a set of orders, finding a set of storage locations, sequencing the fulfilment of the orders, and assigning a forklift and a route for each order minimizing the total flow time. This time is largely influenced by congestion. Congestion occurs when multiple orders are intended to be executed at the same time in the same area. We present an evolutive algorithm for assigning locations to orders which aims at maximising the dispersion of the selected locations and a minimum cost flow model for forklift workload balance.

3 - An optimisation-based decision tool for the management of warehouse operations

Jose Ignacio Llop, Matemáticas para la Economía y la Empresa, Universidad de Valencia, Avda. Tarongers s/n, 46022, Valencia, Spain, j.ignacio.llop@uv.es, Francisco Ballestin, M.Pilar Lino, M. Angeles Pérez, Sacramento Quintanilla, Vicente Valls

We present and describe a decision tool for the management of warehouse operations. The tool has been developed using commercial simulation software, models defined by different sets of parameters and optimisation algorithms. The tool visualises in 3D the structure and the logistic processes in a warehouse, statistically analyses the results obtained and uses several graphics to better understand the results of numerical optimization. The tool is intended for both practitioners training and research validation.

4 - Modeling with simulation for the synchronization of manufacturing and warehousing activities in a paint production company

Noyan Sebla GÜnay, Industrial Engineering, Okan University, Turkey, sebla.gunay@okan.edu.tr, Emre Cakmak, Mehmet Tanyas

Nowadays, managing resources effectively and efficiently requires great importance. In this context, speed of products from production department and put away rate in warehousing must be equal to each other to avoid stock in the transition area between departments of production and storage. In this paper, a simulation model was developed for the synchronization of filling and warehousing departments of a paint manufacturing company which has Make To Stock policy. ABC rule is taken into consideration for shipping rate of products during the modeling.

■ WA-40

Wednesday, 9:00-10:20

6.2.52

Berth Allocation in Maritime Container Terminals

Stream: Container Terminal Operations

Invited session

Chair: *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

Chair: *Giovanni Giallombardo*, Dept. of Electronics Informatics and Systems, University of Calabria, Via Pietro Bucci, Cubo 41C, 87036, Rende, Italy, giallo@deis.unical.it

1 - Packing based formulations and local branching approaches to the solution of the berth allocation problem

Pasquale Legato, Dipartimento di Elettronica, Informatica e Sistemistica, Università della Calabria, Via P. Bucci, 41C, 87036, Rende (CS), Italy, legato@deis.unical.it, *Daniel Gulli*

The BAP focuses on the optimal matching between a set of space slots available along the quay and a set of incoming vessels to be berthed in these slots in a fixed time horizon. Starting from a so-called relative positioning formulation (packing based), we propose a new model where space slots are managed as discrete berthing points. It used to support the search process for an optimal solution to the original formulation. A local branching strategy, initialized by a greedy heuristics, is specialized for both models by suitable local branching cuts. Numerical results will be discussed.

2 - The robust paradigm for the Berth Allocation Problem: a review and new perspectives

Giovanni Giallombardo, Dept. of Electronics Informatics and Systems, University of Calabria, Via Pietro Bucci, Cubo 41C, 87036, Rende, Italy, giallo@deis.unical.it, *Giovanna Miglionico*, *Luigi Moccia*

It is well known that some critical sources of uncertainty may significantly affect an "optimal" berth plan, leading, at runtime, to implement an adjusted solution which is actually far from optimality. This has motivated the recent interest in dealing with uncertainties in berth allocation models. In particular, the robust paradigm, based on the worst-case approach, seems to play a key role as it allows to construct berth plans that are less sensitive to uncertainties than minimal-cost ones. In such a context, we review the existing literature, and propose extensions and new perspectives.

3 - Optimizing seaside operations at dedicated marine container terminals: The limited berth capacity case

Georgios Saharidis, Civil Engineering, Rutgers University, 623 Bowser Road, 08854, Piscataway, NJ, United States, saharidis@gmail.com, *Mihalis Goliias*, *Maria Boile*, *Sotirios Theofanis*

We present a mixed integer programming model to optimize the diverted demand from a dedicated to a multi-user terminal by minimizing the total handling and delayed departure costs for the vessels associated with the dedicated terminal operator. Handling costs for the diverted demand is a discrete function of the resources requested by the dedicated terminal operator. A combination of an evolutionary and exact algorithm is proposed to solve the resulting problem. The applicability of a game theoretic framework to model the behavior of the two players is also discussed.

■ WA-41

Wednesday, 9:00-10:20

3.1.06

Long Term Decisions in Forestry

Stream: Long Term Financial Decisions

Invited session

Chair: *Christian Clasen*, Fachgebiet fuer Waldinventur und nachhaltige Nutzung, TU Muenchen, Am Hochanger 13, 85354, Freising, Germany, clasen@forst.wzw.tum.de

1 - Learning to Formulate Forest Stand and Enterprise Planning Problems

Ruth Dirsch, Bayerische Landesanstalt für Wald und Forstwirtschaft, 85354, Freising, ruth@dirsch.com

Formulations integrating stand treatment alternatives - meaning different thinning intensities - into optimisation approaches on forest enterprise level are difficult to find. Ways of solving the problem by dynamic programming as well as a linear programming for the overall enterprise optimisation will be discussed. The applied framework of different management alternatives on enterprise level yielded better results when incorporating thinning alternatives.

2 - Real options, optimal forest rotation and long-term land conversion decisions: an afforestation case study for the Canadian Agriculture-Forestry interface

Denys Yemshanov, Great Lakes Forestry Centre, Natural Resources Canada, Canadian Forest Service, 1219 Queen Street East, P6A 2E5, Sault Ste. Marie, Ontario, Canada, dyemshan@nrcan.gc.ca, *Geoff McCarney*, *Marty Luckert*, *Jim Unterschultz*, *Dan McKenny*

We have developed a spatial model that evaluates the decision to change land use between agriculture and forestry, inclusive of the option value to delay the land conversion decision. We used a modified Black-Scholes European spread option and illustrated the concept with an afforestation case study for Alberta, Canada. Compared with the scenarios based on static NPV criteria, the option value premium shortens the optimal rotation age if the NPV of alternative, non-forest land use is considerably higher.

3 - On the use of the "forestry interest rate" as approximation approach in an uncertain world

Thomas Burkhardt, Campus Koblenz, IfM, Universitaet Koblenz-Landau, Universitätsstr. 1, 56070, Koblenz, Germany, tburkha@uni-koblenz.de

In forestry it is widespread acknowledged that an interest rate below market rates, even below the risk free rate should be used in order to get valuations by the present value approach close to observed market prices. This so called "forestry interest rate" has been subject to intensive debates. We show a real options approach to the valuation and demonstrate that the use of the traditional forestry interest rate in present values might be interpreted as a reasonable first approximation to the more demanding real options approach.

4 - Long-term investment in forests under changing conditions — A risk/reward analysis

Christian Clasen, Institute of Forest Management, Technische Universität München, Hans-Carl-von-Carlowitz-Platz 2, 85354, Freising, Bavaria, Germany, clasen@forst.wzw.tum.de

This paper will focus on the financial consequences that today's forest management decisions and the expected climatic change will have on the future generations of forest owners. These influencing factors and the long-term investment period of a forest exceedingly determine gains and losses. To illustrate the impact of changing conditions, a forest growth model was used to simulate the growth of different forest types within various districts of Bavaria, Germany. A Monte-Carlo simulation-based model has been constructed to consider timber price fluctuations and natural hazards.

■ WA-42

Wednesday, 9:00-10:20

3.1.07

Decision Making 3

Stream: Decision Making

Contributed session

Chair: *Cheng-Ru Wu*, Yuanpei University, Taiwan, alexru00@ms41.hinet.net

1 - Modelling Airport Performance Trade-off Analysis

Michael Madas, Department of Management Science and Technology, Athens University of Economics and Business, Evelpidon 47A and Lefkados 33, 11362, Athens, Greece, mmadas@aueb.gr, *Konstantinos Zografos*, *Yiannis Salouras*

The airport decision making process necessitates the deployment of advanced models to support airport planning decisions for a total airport (airside and land-side) by capturing the trade-off aspects among various measures of airport effectiveness (capacity, delays, level of service, safety, noise, cost-effectiveness). The objective of this paper is twofold: i) to describe the development process of a Decision Support System for total airport performance assessment and trade-off modelling, and ii) to demonstrate the decision support capabilities and basic functionalities of the proposed system.

2 - Considering Customers' Preferences to Analyze the Development of the LEDTV Market in Taiwan

Fang-Mei Tseng, International Business, Yuan Ze University, 135 Yuan-Tung Rod., 320, Chung-Li, Taiwan, fmtseng@saturn.yzu.edu.tw, *Yadi Lin*

Science and technology faces sharp variations in market surroundings and drastic competition, with innovative products being introduced into the market quickly; to satisfy the consumer's needs and increase the firm's revenue. When a firm wishes to develop a new product, understanding the desires of buyers in advance becomes particularly important. Furthermore, knowing about the substitution and diffusion of products is also very important, for it will affect companies as they make decisions regarding the quantity to ship. The recent technological reports, indicate that light-emitting diode (LED) TVs will be the main new TV products in 2010. Therefore, taking the customer's preferences into consideration in analyzing the market shares of different TVs in the future is becoming increasingly important to firms. In accordance with prior studies, some researchers have used the technological replacement model to forecast the shipments and market potential of TVs, but they do not consider the consumer's real needs. Hence, we employ Conjoint Analysis to analyze the consumer's preferences and Delphi to evaluate the variations in market share in Taiwan's TV market for each different generation, i.e., CRT, CCFL-LCD, LED, OLED TVs. when 2010, 2015, and 2020. Furthermore, we combine the results of the Conjoint Analysis and Delphi into an Innovative Diffusion Model, to forecast the sales volume for each generation in Taiwan over the next 10 years.

3 - Pareto-efficient sub-branches of the decision tree

Toms Reizins, Ventspils University College, Latvia, toms.reizins@gmail.com, *Andrejs Jaunzems*

Goal oriented planning means knowing potentially possible versions of action and choosing the most appropriate alternative. The graphical model of decision making problem is almost always shown as oriented graph or decision tree. In this article we look at decision tree with postulate stochastic alternative probabilities, different durations of processes and different time winnings. The article introduces Pareto (μ , λ)-effective strategy concept, to improve determination methods of rational strategy. The summary of the proposed method is illustrated with an example.

4 - Evaluate Outsourcing Commerce Semiconductor Industry Based on Grey Situation Decision-making

Juo-Yi Sun, Yuanpei University, 306 Yuanpei St., Hsin Chu 300, Taiwan, R.O.C., Taiwan, rowena3056@mail.ypu.edu.tw, *Chia-Chun Liao*, *Cheng-Ru Wu*, *Che-Wei Chang*

Grey situation decision-making (GSDM) for this purpose of this study focused on decision support tools, statistical process control (SPC) in high-tech semiconductor industry to collaborate Commerce Systems of the case studies. Grey situation decision-making (GSDM) is used to evaluate the synergy of a number of Commerce system characteristics the quality of performance. The main contribution of the outsourcing commerce system (OCS) can provide decision-makers to do the quality control of internal referral decision.

■ WA-43

Wednesday, 9:00-10:20

8.2.02

Operational Research in Sustainable Urban Development

Stream: OR for Sustainable Development

Invited session

Chair: *Marija Burinskien*, Department of Urban Engineering, Vilnius Gediminas technical university, Saultekio ave. 11, LT-10223, Vilnius, Lithuania, marbur@ap.vgtu.lt

1 - Application of operation research for sustainable urban development

Marija Burinskien, Urban Engineering, Vilnius Gediminas Technical University, Saultekio av. 11, LT-10223, Vilnius, Lithuania, marija.burinskiene@vgtu.lt, *Vitalija Rudzkien*, *Jrat Venckauskait*

The sustainable urban development covers the consensus of a wide range of activities and aimed at equivalent coordination of the impact of economic, social and environmental factors. The article integrates the theoretical attitudes related to future insights into the sustainable urban development. Conceptual modelling principles are applied to determine critical values of the indicators that characterise the sustainable development. A system that helps to define features of urban districts, development alternatives and achievable permitted marginal values of the living quality is created.

2 - Multi-Actor Multi-Criteria Analysis: A case study on night time delivery for urban distribution

Ellen Van Hoeck, MOSI-T, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussels, Belgium, Ellen.Van.Hoeck@vub.ac.be, *Sara Verlinde*, *Annelies Heemeryck*, *Cathy Macharis*, *Frank Witlox*

This paper presents the multi-actor multi-criteria analysis (MAMCA) (Macharis, 2004) as the appropriate tool for measuring public support for night-time delivery in urban surroundings as it enables to incorporate the views of different stakeholders. In this case we considered the receivers, the transport sector, society as a whole and the employees as the most important stakeholders. These stakeholders were interviewed on their attitude towards five different scenarios in which the time periods for deliveries and/or the accompanying measures differ.

3 - Sustainability in supplier selection: application of the MACBETH methodology

Luis Ferreira, DEGEI, Universidade de Aveiro, Campus Universitário Santiago, 3810-193, Aveiro, Portugal, lmferrera@ua.pt, *Vitor André*

The present situation of the environmental degradation has caused a significant change in the business world. A critical process is the supplier selection process. It is a crucial activity in any company with a significant importance in the improvement of the environmental responsibility. In this research project we intend to integrate environmental criteria in the supplier selection process. Such task was elaborated using the MACBETH methodology. The above mentioned model was developed, validated and applied in the context of a company integrated in the automotive sector in Portugal.

■ WA-44

Wednesday, 9:00-10:20

8.2.03

Vector and Set-Valued Optimization II

Stream: Vector and Set-Valued Optimization

Invited session

Chair: *Miguel Sama*, Matemática Aplicada, Universidad Nacional de Educación a Distancia, CJuan del Rosal, 12, 28040, Madrid, Spain, msama@ind.uned.es

1 - An Approximation Algorithm for Convex Multi-objective Programming Problems

Matthias Ehrgott, Engineering Science, University of Auckland, Private Bag 92019, 1001, Auckland, New Zealand, m.ehrgott@auckland.ac.nz

We propose an algorithm for approximating the non-dominated set of a convex multi-objective nonlinear programme. The algorithm extends Benson's outer approximation algorithm for multi-objective linear programmes. We prove that it computes a set of epsilon-nondominated points. For the case of differentiable objectives and constraints we describe an efficient way to perform the main step of the algorithm. We provide examples that show that this cannot always be done in the same way in the case of non-differentiable objectives or constraints.

2 - Generalizing trade-off directions in multiobjective optimization

Yury Nikulin, Department of Mathematics, University of Turku, Matematiikan laitos, Turun yliopisto, Vesilinnantie 5, Luonnontieteiden talo, 20014, Turku, Finland, yurnik@utu.fi, *Marko M. Mäkelä, József Mezei*

We consider a general multiobjective optimization problem with five basic optimality principles: efficiency, weak and proper Pareto optimality, strong efficiency and lexicographic optimality. We generalize the concept of trade-off directions defining them as some optimal surface of appropriate cones. We derive necessary and sufficient geometrical optimality conditions in terms of corresponding trade-off directions for both convex and nonconvex cases.

3 - On epiconvergence for vector-valued functions

Ruben Luis Lopez Montoya, Departamento de Matematica y Física Aplicadas, Universidad Católica de la Santísima Concepción, Alonso Ribera 2850, Campus San Andrés, Facultad de Ingeniería, casilla 297, Cardenal Cisneros 448, Lomas de San Andrés, 409-0541, Concepción, VIII Region, Chile, rlopez@ucsc.cl, *César Gutiérrez*

The aim of this work is to study an epiconvergence for vector-valued functions where the image space is partially ordered by a (solid) pointed closed convex cone. We characterize this convergence and obtain some properties similar to those for the scalar case. Finally, we apply this epiconvergence for studying vector optimization problems.

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

4 - Graphical differentiation of the gradient

Miguel Sama, Matemática Aplicada, Universidad Nacional de Educación a Distancia, C/Juan del Rosal, 12, 28040, Madrid, Spain, msama@ind.uned.es, *Bienvenido Jiménez, Vicente Novo*

A natural manner of defining a second order derivative notion for a nonsmooth map is by considering the derivative of the gradient in some sense. In this talk we follow this approach, in particular we study the properties of the contingent derivative of the Clarke gradient of a Lipschitzian map at a point in order to define new notions of second order derivatives. We study the relationship of these derivatives with other notions of second order derivative and we give applications in optimization. An extension to the vector case is also explored.

■ WA-45

Wednesday, 9:00-10:20

8.2.12

New technologies in facility Logistics

Stream: Facility Logistics

Invited session

Chair: *Kai Furmans*, IFL, University of Karlsruhe, Gotthard-Franz-Str. 8, 76131, Karlsruhe, Germany, kai.furmans@ifl.uka.de

1 - A Storage System with Virtual Aisles

Kai Furmans, IFL, University of Karlsruhe, Gotthard-Franz-Str. 8, 76131, Karlsruhe, Germany, kai.furmans@ifl.uka.de, *Kevin Gue*

We describe an abstract model for a storage system with "virtual aisles." The system is based on a grid, which manages unoccupied cells to create aisle segments as needed in order to move desired items to an input-output boundary. Control of the system is completely decentralized; that is, each cell takes action based only on the states of cells in its neighborhood. The system has the curious property that higher loads lead to less congestion.

2 - Optimal zone boundaries in a Dense, Autonomous and Intelligent storage system

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, *Yugang Yu, René de Koster*

This paper studies a dense, autonomous and intelligent (DAI) storage system. Loads can move in x- and y-directions as long as an empty slot is available next to it. The system uses class-based storage; products with high turnover are stored in the zone closest to the output location. We derive the expected travel time of a random load from its storage location to the output. Using this expression we optimize zone boundaries, leading to the minimum travel time. Results show that, compared to random storage, class-based storage with optimal boundaries can significantly reduce the travel time.

3 - The Internet of Things in Facility Logistics

Moritz Roidl, Chair of Materials Handling and Warehousing, Technische Universität Dortmund, Emil-Figge-Str. 73, 44221, Dortmund, Germany, moro@flw.mb.tu-dortmund.de, *Michael ten Hompel*

The Internet of Things (IoT) is a concept for the control of material flow systems in facility logistics that features decentralized control strategies and layouts. We have implemented a demonstrator that introduces a distributed Service-oriented Architecture (SOA) in combination with a multiagent-based control system. The real-time capabilities of the system can be demonstrated via an 3D visualization. We discuss the implications for analyzing such systems in respect to their real-time requirements and capabilities. In doing so, we focus on the interplay between material and information flow.

4 - Analysis of the discrete-time GX[G[L,K]]1-queue

Eda Özden, Institut für Fördertechnik und Logistiksysteme, Karlsruher Institut für Technologie, Germany, eda.oezden@ifl.uni-karlsruhe.de, *Kai Furmans*

This paper presents a discrete-time method to compute the waiting time distribution for the GX[G[L,K]]1-queue with batch arrivals and batch services under the minimum batch size policy. This is achieved based on a bivariate Markov chain. The quality of the analytical results are evaluated by means of simulation. Moreover, the waiting time distribution of a modified system with sufficiently many servers is derived. A number of applications of the introduced methods to transport systems are also discussed. Finally, the effect of the vehicle availability on the throughput time is studied.

■ WA-46

Wednesday, 9:00-10:20

8.2.14

Stochastic Programming Tools

Stream: Stochastic Programming 2

Invited session

Chair: *Tamas Szantai*, Institute of Mathematics, Budapest University of Technology and Economics, Muegyetem rkp. 3., 1111, Budapest, Hungary, szantai@math.bme.hu

1 - Ranking and Optimization PMS Algorithm with Traffic Forecasting

Andras Bako, Information Science, Technical College of Budapest, 6, Doberdo str., Budapest, Hungary, H1034, Budapest, bakoa@bmf.hu, *Foldesi Peter, Szuts Istvan*

The Road Management Systems (and the PMS) usually do not take into consideration the future traffic change. The maintenance and rehabilitation actions and the development of the road network structure and the changing traffic structure modify the amount of the traffic on the road section. The deterioration process depends on mostly the volume of the traffic. That is why it is important to take into consideration the change of the traffic volume during the planning time horizon. Four different models are used for traffic forecasting and assignment. In the lecture some techniques are shown which handle this problem: in multiperiod, long time model at each planning period the traffic volume change is taken into consideration. The objective is also changed, instead of the traditional minimization an other function is used, which can be transforming to a linear function. In ranking models the problem could be handled and solved. In the case of one period Markov stable model there is nothing to do. In the multiperiod model the problem could be solved also.

2 - Modeling radial cellular mobile networks in random environment

Mj Lopez-Herrero, Statistics and O.R. III, Universidad Complutense de Madrid, Escuela Univ. de Estadística, 28040, Madrid, Spain, lherrero@estad.ucm.es, *Jesus Artalejo*

Real systems often operate in varying environment conditions. In this talk, we show how the matrix-analytic formalism gives one the ability to construct and study versatile cellular mobile networks with user retrials operating in random environment. More specifically, we investigate two four-dimensional Markovian models which allow us to represent two different options for the use of the guard channel concept. We put emphasis on the numerical evaluation of the radial behavior and the environmental factors on the system performance.

3 - Probabilistic constrained stochastic programming with copula generated multivariate probability distributions

Tamas Szantai, Institute of Mathematics, Budapest University of Technology and Economics, Muegyetem rkp. 3., 1111, Budapest, Hungary, szantai@math.bme.hu, *Edith Kovacs*

In this talk we will investigate the applicability of copula generated multivariate probability distributions in probabilistic constrained stochastic programming. In the first part of talk we will compare the bivariate Gumbel and Gaussian copulas. It is well known that the bivariate Gumbel family of copulas has upper tail dependence for any of its parameter values greater than one. In the same time the bivariate Gaussian family of copulas has upper tail independence for any of its parameter values (correlation coefficient) less than one. We will show how these facts influence the feasible domain of probabilistic constrained stochastic programming problems. In the second part of talk we will show how can be solved probabilistic constrained stochastic programming problems with different families of multivariate Archimedean copulas, like Gumbel, Clayton and Frank copula families. In fact, we do not need multivariate numerical integration at all when solving these types of problems.

■ WA-47

Wednesday, 9:00-10:20

8.2.16

OR in Educational Problems and Systems

Stream: Young People for System Theory, Optimization and Education

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

Chair: *Alexis Pasichny*, Students' Science Association, National Technical University of Ukraine "Kyiv Polytechnic Institute", 37, Peremohy av., 03056, Kiev, Ukraine, alexis.pasichny@gmail.com

1 - Usage of OR methods for research of contemporary geopolitics

Alexis Pasichny, Students' Science Association, National Technical University of Ukraine "Kyiv Polytechnic Institute", 37, Peremohy av., 03056, Kiev, Ukraine, alexis.pasichny@gmail.com

Current report focuses on the numerical evaluation of the differences between global cultures. During the research different OR approaches are used: Analytic Hierarchy Process for development of the set of criterion, fuzzy logic methods for mathematical description of countries and cultures, expert evaluation methods for acquiring the quantified characteristics of culture differences. Measuring of culture differences allows to make conclusions about contemporary geopolitical picture of the world and check the hypothesis of "clash of civilizations" made by Samuel Huntington.

2 - Scenarios Development Methodology Based on SWOT and Morphological Analysis

Kateryna Pereverza, Students Science Association, National Technical University of Ukraine, Kyiv, Revutskogo, 19/1, app. 282, 02091, Kyiv, Ukraine, pereverza.kate@gmail.com

In this paper methodology of scenarios development will be presented. Proposed methodology assume usage of sustainable development indicators at the stage of key variables' identification, SWOT analysis at the stage of current situation description, morphological analysis at the stage of scenarios construction and analysis and expert evaluation methods for detecting of current trends and interests of external actors. Scenario approach allows to explore the possible future and get prepared for it. As an example the result of this methodology usage the scenarios for Ukraine will be described.

3 - Social Indicators for Supply Chain Analysis

Ana Carvalho, Management, CEG-IST, Av Prof Cavaco Silva,, 2780-990, Porto Salvo,, Portugal, anacarvalho@ist.utl.pt, *Ana Paula Barbósa-Póvoa*

The sustainability concept has been based on the triple bottom line (People, Planet, Profit). Work has been done in the economic and environmental areas. Methodologies and models have been proposed to address these two issues, however the social area has not received the necessary attention. For the full study of sustainability, it is urgent to include the social part. We propose to analyse the actual situation of the social analysis. Based on that analysis, a set of social indicators will be proposed to evaluate the supply chains performance in terms of social responsibility.

■ WA-48

Wednesday, 9:00-10:20

8.2.04

Variational inequalities and applications to economic market models

Stream: Iterative Methods for Economic Models

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 - An inverse variational inequality approach to the evolutionary spatial price equilibrium problem

Laura Scrimali, DMI, Università di Catania, Viale Andrea Doria 6, 95125, Catania, Italy, scrimali@dmi.unict.it

It is well-known that the time-dependent spatial price equilibrium problem, can be transformed into and studied as an evolutionary variational inequality. However, in some situations, control policies may be imposed to the end of regulating the amounts of production and consumption. As a consequence, the problem becomes a time-dependent spatial price equilibrium control problem and is formalized as an evolutionary inverse variational inequality. The existence of solutions is then investigated and numerical examples are also provided.

2 - Mitigating Global Supply Chain Risks through Corporate Social Responsibility

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

This paper presents a decision model that captures supply side disruption risks, social risks, and demand side uncertainty within an integrated global supply chain and corporate social responsibility (CSR) modeling and analysis framework. The global supply chain decision-makers must decide on the level of investment in CSR activities and the choice of trading partners (manufacturer or retailer) given their CSR consciousness and perceived riskiness in order to maximize profit and minimize their overall risk. The results show that CSR activities can be used to mitigate global supply chain risk.

3 - Dynamic oligopolistic market equilibrium problem with long-term memory: Lipschitz continuity and infinite dimensional duality theory

Annamaria Barbagallo, Department of Mathematics and Computer Science, University of Catania, Viale Andrea Doria, 6, 95125, Catania, Italy, barbagallo@dmi.unict.it, *Antonino Mangeri*, *Rosalba Di Vincenzo*

The aim of the talk is to provide a more realistic model for the dynamic oligopolistic market equilibrium problems. In particular, a long-term memory is introduced and the corresponding variational inequality model is discussed in order to study the problem in presence of delay. Moreover, existence and regularity results are proved, giving more relevance to a Lipschitz continuity theorem. Finally, applying the infinite-dimensional duality results, the existence of the Lagrange variables, which allow to describe the behaviour of the market, is provided.

4 - Combined Methods for Dynamic Spatial Auction Market Models

Adriana Gnudi, Mathematics, Statistics, Computer science and Applications, University of Bergamo, Via dei Caniana, 2, 24127, Bergamo, Italy, adriana.gnudi@unibg.it, *Igor Konnov*, *Elisabetta Allevi*

An equilibrium model for description of behavior of dynamic system of auction markets of a homogeneous commodity joined by transmission lines subject to joint balance and capacity flows constraints is suggested. The model involves the cost commodity storage within a given time period. An extended primal-dual system of variational inequalities is given whose solutions yield an equilibrium trajectory of this system. Several splitting type methods are proposed to find its solution.

Wednesday, 10:40 - 12:00

■ WB-02

Wednesday, 10:40 - 12:00

3.2.14

Keynote Talk 10

Stream: Keynote Speakers

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

1 - Exact and Heuristic Algorithms for the Vertex Coloring Problem

Paolo Toth, DEIS, University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, paolo.toth@unibo.it

Given an undirected sparse graph $G = (V, E)$, where V is the vertex set and E the edge set, the Vertex Coloring Problem (VCP) requires to assign a color to each vertex in such a way that colors on adjacent vertices are different and the number of colors used is minimized. The VCP is a well known NP-hard problem, and has received a large attention in the literature, not only for its real world applications in many engineering fields (including scheduling, timetabling, register allocation, frequency assignment and communication networks), but also for its theoretical aspects and for its difficulty from the computational point of view.

In this talk, we review the main Integer Linear Programming formulations, exact algorithms, lower bounding procedures, heuristic and Metaheuristic algorithms proposed for the VCP. Extensive computational experiments on benchmark instances from the literature are reported, comparing the performance of the most effective exact and heuristic algorithms.

■ WB-04

Wednesday, 10:40 - 12:00

3.2.13

Assignment and clustering problems

Stream: Metaheuristics

Invited session

Chair: *Daniel Tuytens*, Mathematics and Operations Research, University of Mons, FPMs-MATHRO, Rue de Houdain, 9, 6000, Mons, Europe, Belgium, daniel.tuytens@umons.ac.be

Chair: *Skander Htiouech*, SysCom-ENIT National Engineering School of Tunis, Tunisia, htiouchskander@yahoo.fr

1 - Approximation algorithms for the multi-resource agent bottleneck generalized assignment problem

Ozlem Karabulut, Industrial Engineering, Middle East Technical University, ODTU Endusrti Muh. Bolumu, Oda No:328, 06531, Ankara, Turkey, ozlem@ie.metu.edu.tr, *Meral Azizođlu*

In this study, we consider a Multi-Resource Agent Bottleneck Generalized Assignment Problem with equal-length periods. Our aim is to balance the workloads of the agents by minimizing the maximum workload over all agents. We first study the Linear Programming (LP) relaxation of the problem and introduce some valid cuts. We then develop a tabu search algorithm to find approximate solutions. Our computational results have revealed the satisfactory performance of our procedures.

2 - A Preference Based Multiobjective Algorithm for the Clustering Problem

Kerem Demirtaş, Industrial Engineering, Middle East Technical University, ODTU Endusrti Muhendisligi Bolumu, Oda: 326, 06531, Ankara, Turkey, demirtas@ie.metu.edu.tr, *Nur Evin Ozdemirel*, *Esra Karasakal*

In this study, we develop a preference-based evolutionary algorithm for clustering problem. Clustering, which can be defined as unsupervised classification of data points into meaningful groups (clusters), is an NP-Hard problem. In addition to its computational complexity, the problem is also difficult in its concept since the definition of an optimal solution is not well defined. We include the preferences of the decision maker into a well known multiobjective evolutionary algorithm, namely SPEA2, using reference points and achievement scalarizing functions to find the best clusters.

3 - Using surrogate information to solve the multidimensional multi-choice problem

Skander Htiouech, SysCom-ENIT National Engineering School of Tunis, Tunisia, htiouechskander@yahoo.fr

A new heuristic for solving MMKP is presented. We explore both sides of the feasibility border that consists in oscillating between constructive and destructive phases. Performance analysis of the method demonstrates the merits of using surrogate constraint information as choice rules for solving this problem class. A constraint normalization method is also used to strengthen the surrogate constraint information in order to improve the computational results. Numerical results show that the performance of this approach is superior to previously published ones and also much better efficiency.

4 - A GRASP algorithm to solve the label printing problem

Daniel Tuytens, Mathematics and Operations Research, University of Mons, FPMs-MATHRO, Rue de Houdain, 9, 6000, Mons, Europe, Belgium, daniel.tuytens@umons.ac.be, *Arnaud Vandaele*

In this paper, the label printing problem, which consists in the assignment of a fixed number of labels on different templates in order to fulfill the order requirements and to minimize the waste excessive printed labels, is discussed. Allocating suitable labels to each template is a strategical task. The considered problem is hard and we propose a GRASP algorithm to solve it. The proposed algorithm is tested on some references instances, comparing the obtained results with those found in the literature. The results prove that the GRASP algorithm is particularly well suited to this problem.

■ WB-05

Wednesday, 10:40 - 12:00

3.2.16

Graph problems

Stream: Metaheuristics

Invited session

Chair: *Maria Soto*, Lab-Sticc, Université de Bretagne Sud, Rue Saint Maude, 56100, Lorient, Brittany (Bretagne), France, maria.soto@univ-ubs.fr

1 - A metaheuristic approach to the graceful labeling problem of graphs

Houra Mahmoudzadeh, Industrial Engineering, Sharif University of Technology, P.O.Box 4168685451, No 59, 96 Street, Golsar Avenue, Rasht, Gilan, Iran, +98131, Rasht, Gilan, h_mahmoudzadeh@alum.sharif.edu, *Kourosh Eshghi*

In this paper, the well-known graceful labeling problem of graphs is represented as an optimization problem, and an algorithm based on Ant Colony Optimization metaheuristic is proposed for finding its solutions. Then, the proposed algorithm is applied to different classes of graphs, and the results are compared with the few existing methods in the literature. The computational results show that ACO metaheuristic is a powerful tool for finding solutions for the graceful labeling problem of graphs, and outperforms the other existing methods in certain classes of graphs.

2 - New Methods to solve the Graph Partitioning Problem

Mark Macedo, INESC Porto, Rua Dr. Roberto Frias, 378, ., 4200 - 465, Porto, Porto, Portugal, mmacedo@inescporto.pt, *João Pedro Pedroso*, José Soeiro Ferreira

The graph partitioning problem is a classical NP-Hard combinatorial optimization problem which consists of partitioning a graph into two subsets with the same cardinality, such that the number of edges whose endpoints are in different subsets is minimized. New methods are described and discussed, based on well-known heuristics like the min-max greedy, on tabu search, and on partial tree search. Computational results based on standard benchmark instances are reviewed, and an evaluation of the different methods, based on the overall computational experience is presented.

3 - A metaheuristic for a graph clustering formulation

Mariá C. V. Nascimento, Instituto de Ciências Matemáticas e de Computação, São Carlos, Universidade de São Paulo, Av. Trabalhador-são-carlense, 400, 13560-970, São Carlos, São Paulo, Brazil, maria.cris@gmail.com, *Franklina Toledo*

Graph clustering is a research topic which can be approached using several mathematical formulations, mostly based on graph partitioning models. One example is the maximization of the modularity of graph partitions. In this formulation, the partitions are evaluated according to the expected number of connections inside the clusters. The solutions found by it are characterized by their high quality for different types of graphs. Due to the combinatorial nature of this problem, this study presents a metaheuristic hybridized with the spectral relaxation for this formulation.

4 - Hybrid Electromagnetic-like metaheuristic for the Generalized Minimum Spanning Tree Problem

Jouhaina Chaouachi Siala, Laboratory of Mathematical Engineering, Ecole Polytechnique de Tunisie, 2078, La Marsa, Tunisia, chaouachijouhaina@yahoo.fr, *Ichraf Zaidi*

In this paper we investigate the Generalized Minimum Spanning Tree Problem (GMST) which requires spanning at least one vertex out of every set of disjoint vertices in a graph. For this NP-Hard problem, we develop a hybrid electromagnetic-like meta-heuristic (HEM). We describe also a Hybrid Discrete Particle Swarm Optimisation meta-heuristic (HDPSO). Our computational study through benchmark instances reveals that these newly developed methods are a powerful device to solve combinatorial optimization problems. The proposed HEM outperforms state-of-art existing meta-heuristics.

■ WB-06

Wednesday, 10:40 - 12:00

8.2.30

DEA Application VI — Utilities

Stream: DEA and Performance Measurement

Invited session

Chair: *Rui Marques*, Department of Civil Engineering and Architecture, CESUR-IST, Technical University of Lisbon, Av. Rovisco Pais., 1049-001, Lisbon, rmar@civil.ist.utl.pt

1 - Economies of scope in the Portuguese water utilities

Pedro Carvalho, Departamento de Engenharia Civil e Arquitectura, Instituto Superior Técnico - Universidade Técnica de Lisboa, CESUR, Av. Rovisco Pais, 1049-001, Lisboa, Portugal, pcarvalho@civil.ist.utl.pt, *Rui Marques*

This paper applies different non-parametric techniques to analyze the existence of economies of scope in the water sector in Portugal. We employed the approach of Morita (2003), the methodology proposed by Daraio and Simar (2005) which analyzes the influence of exogenous variables in the production process and a non-parametric method based on the Data Envelopment Analysis (DEA) and bootstrap simulation techniques, proposed by Daraio and Simar (2007). We make some judgments about the different techniques available in the literature to compute the economies of scope.

2 - Comparing public and private urban waste services in Portugal

Pedro Simões, Center of Urban and Regional Systems (CESUR), Instituto Superior Técnico, Technical University of Lisbon, Instituto Superior Técnico, Technical University of Lisbon, Av. Rovisco Pais, 1049-001, Lisbon, Portugal, psimoes@civil.ist.utl.pt, *Rui Marques*

The current paper presents a research that compares the performance of the private urban waste utilities with the public urban waste utilities in Portugal. It comprises private and public "wholesale" and "retail" companies. We apply the non-parametric frontier benchmarking technique of data envelopment analysis (DEA) to analyse the performance of more than 100 urban waste services which encompass more than 60% of the Portuguese population in the 'retail' segment. For the wholesale segment the sample includes all the companies of the country. The outcomes pointed out a significant inefficiency and showed that private companies perform better than the public ones.

3 - The application and utilization of data envelopment analysis for evaluating the cost efficiency of brazilian electricity distribution utilities

Marcus Vinicius Pereira de Souza, Engenharia Industrial, PUC-Rio, Rua Marquês de São Vicente 225 - Gávea, 22451-041, Rio de Janeiro, RJ, Brazil, mvinic@engenharia.ufjf.br, Madiagne Diallo, Reinaldo Souza, Tara Keshar Nanda Baidya

In this paper we describe the use of Data Envelopment Analysis (DEA) for measuring the efficiency scores of 60 Brazilian electricity distribution utilities. In this framework, we develop an alternative approach based on cluster analysis and Cone-Ratio Method. It is worth pointing out that these developments can reduce the information asymmetry and improve the regulator's skill to compare the performance of the utilities, a fundamental procedure in incentive regulation schemes. Last, we examine the problem of detecting influential observations.

4 - Evaluating police stations' performance via DEA

Zilla Sinuany-Stern, Industrial Engineering and Management, Ben Gurion University, Beer-Sheva, Israel, 84105, Israel, zilla@bgu.ac.il, Doron Alper, Vered Berdugo-Kushnir

This study estimates the relative productivity of 60 police stations in Israel during 2006-2007, based on two inputs and 16 outputs, using Data Envelopment Analysis (DEA). We utilized several DEA versions: constant and variable return to scale, with and without bounds on the virtual variables. Moreover, benchmark analysis was done. The police stations were ranked via cross efficiency analysis, and the Maverick index was derived for each station. The validation of DEA was implied when the various models were highly correlated. Regression analysis did not depict external factors to explain the variability of the efficiencies of the police stations.

■ WB-07

Wednesday, 10:40 - 12:00
8.2.47

Scheduling Approaches for Complex Manufacturing Systems

Stream: Project Management and Scheduling

Invited session

Chair: Lars Moench, Chair of Enterprise-wide Software Systems, University of Hagen, 58097, Hagen, Germany, lars.moench@FernUni-Hagen.de

1 - Lot-Streaming and Just-In-Time Scheduling on Identical Parallel Machines with a Common Due Date

Oncu Hazir, Laboratoire d'Informatique de Paris 6, France, oncu.hazir@lip6.fr, Kedad-sdihoum Safia

In this research, we examine an integrated lot-streaming and just-in-time scheduling problem with a common due date. We address scheduling customer orders in batches of limited size in production systems with single or identical parallel machines. The objective is to find a feasible schedule to meet the requirements, which satisfies the batch size constraints and minimizes the sum of tardiness and earliness penalties and setup costs, which involves the cost of creating a new batch.

We present some structural properties of an optimal solution and analyze some polynomial cases and propose solution algorithms.

2 - Batch scheduling problems with parallel machines and identical jobs

Liji Shen, TU Dresden, Striesener Str. 14, 01307, Dresden, Germany, liji@liji.de, Lars Moench, Udo Buscher

This study addresses a batch scheduling problem with parallel machines to minimize total weighted completion time. More precisely, we consider serial batching problems where sequence dependent family setup times are present. We focus on the special case of identical jobs in the same family, which is known to be relevant in many manufacturing industries. In our study, structural properties are first examined, based on which, we present both mixed integer programming formulations and heuristics. Computational experiments are also conducted to test the performance of the proposed approaches.

3 - A Column Generation Approach to Minimize Total Weighted Tardiness for Jobs on Parallel Machines

Lars Moench, Chair of Enterprise-wide Software Systems, University of Hagen, 58097, Hagen, Germany, lars.moench@FernUni-Hagen.de, Timm Ziametzky

A column generation (CG) approach is studied to minimize the performance measure Total Weighted Tardiness on parallel identical machines. We suggest an efficient method for the solution of the sub problems that is based on random key genetic algorithms. This method is appropriate for large scale instances and outperforms corresponding heuristics based on dynamic programming. We provide the results of computational experiments for randomly generated test instances that clearly show that the CG outperforms list scheduling approaches based on the Apparent Tardiness Cost dispatching rule.

4 - A multistage mathematical programming based scheduling approach for lithography areas in complex semiconductor manufacturing systems

Andreas Klemmt, Electronics Packaging Laboratory, Tu-Dresden, Helmholtzstr. 18, 01062, Dresden, Germany, klemmt@avt.et.tu-dresden.de, Gerald Weigert

Typically, a bottleneck of a wafer fab is the lithography area since of its expensive tools and complex resource constraints. In this research, a multistage mixed integer programming based optimization approach for planning such an area is presented. Thereby, existing process constraints like equipment qualification, resist availability, vertical dedication, mask availability are taken into account. Goals are the maximization of throughput, the minimization of setup costs and a balancing of machine utilization. Based on real manufacturing data the benefit of the proposed approach is examined.

5 - Scheduling Jobs with Ready Times and Incompatible Families on Unrelated Parallel Batch Machines

Lars Moench, Chair of Enterprise-wide Software Systems, University of Hagen, 58097, Hagen, Germany, lars.moench@FernUni-Hagen.de, Christian Almeder

This research is motivated by a scheduling problem found in the diffusion areas of wafer fabs. We model the problem as an unrelated parallel batch machine problem with incompatible families and unequal ready times of the jobs. The objective is to minimize the total weighted tardiness (TWT). Given that the problem is NP-hard, we propose a Variable Neighbourhood Search (VNS) scheme and a greedy randomized adaptive search procedure (GRASP) that is based on the Apparent Tardiness Cost (ATC) dispatching rule. We compare the performance of the two heuristics by randomly generated test instances.

■ WB-08

Wednesday, 10:40 - 12:00
6.1.36

Approximation and Competition

Stream: Project Management and Scheduling

Invited session

Chair: Sergei Chubanov, University of Siegen, Hoelderlinstr. 3, Siegen, Deutschland, 57076, Siegen, Germany, sergei.chubanov@uni-siegen.de

1 - Decomposed Software Pipelining for VLIW with precedence delays and resource constraints.

Abir Benabid, Lip6, 104 av Kennedy 75016 Paris, 104 av Kennedy, 75016, Paris, France, abir.benabid@lip6.fr, Claire Hanen

We consider the problem of scheduling loops on VLIW architectures used in embedded systems. We address the cyclic problem of finding periodic schedules with minimal period taking into account all constraints induced by uniform data dependencies and pipelined functional units. A guaranteed approach, called decomposed software pipelining (DSP), is extended to consider the above constraints. A theoretical worst case ratio is evaluated and the practical interest of DSP is established using real VLIW architecture (ST200 of STMicroelectronics) and a benchmark of graphs issued from ST compiler.

2 - Approximation results for the two machine cross-docking problem

Christophe Rapine, G-SCOP, ENSGI-INPG, 38031, Grenoble, France, christophe.rapine@g-scop.inpg.fr, *Damien Prot*, *Olivier Goldschmidt*

The two machine cross-docking problem is to schedule two sets of tasks, each set on a dedicated machine. Precedence constraints only exist from a task of the first set to task of the second. Minimizing the makespan is strongly NP-hard even in the UET case, but any greedy method yields a 2-approximation solution. We show that a r -approximation algorithm on a connected precedence graph leads to a $(1+r/2)$ -approximation in the general case. Also we prove that, in the UET case, if the precedence graph has inner degree k , then there exists a linear time algorithm with guarantee $(2-1/(k-1))$.

3 - Cooperation and Competition of Subcontracted Operations

George Vairaktarakis, Operations, Case Western Reserve University, 44106, Cleveland, Ohio, United States, gxv5@case.edu

Manufacturers capable to process their own jobs are willing to improve cost performance by subcontracting part of their workload to a single 3rd party (3P). Under competition, 3P announces a workload-based priority rule and the players decide the amount to subcontract so as to minimize their makespan. Alternatively, a central decision maker dictates the subcontracted amount and when it would be scheduled so as to maximize 3P utilization. We present polynomial equilibrium and centralized solutions, and transfer payment schemes that make all players better off to coordinate.

■ WB-09

Wednesday, 10:40 - 12:00
6.2.53

New Frontiers in the Application of Mathematical Programming

Stream: Mathematical Programming
Invited session

Chair: *Tatiana Tchemisova*, Departamento of Mathematics, University of Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, tatiana@ua.pt

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Reverse Automatic Differentiation in Shape Optimisation: Non-Axisymmetric Vesicle Shape Parameterisation Case Study

Redouane Boudjemaa, Department of electrical and electronic engineering, University Mohamed Bougara of Boumerdes, Avenue de l'indépendance, 35000, Boumerdes, Boumerdes, Algeria, rboudjemaa@umbb.dz

This work investigates the implementation of Reverse Automatic Differentiation as a tool in shape optimisation. Non-axisymmetric shapes are accurately parameterised based on a numerical optimisation of a surface energy model. The RAD process evaluates derivatives by applying systematically the chain rules of differentiation to a function computer program. The smooth surfaces are produced as a solution to a bounded sixth order elliptic partial differential equation, controlling parameters are introduced through the boundary conditions.

2 - The Layout Design of a Semiconductor Fab with Direct-Transport Guide Paths

Ying-Chin Ho, Institute of Industrial Management, National Central University, No.300, Zhongda Rd, 320, Chung-Li, Taoyuan, Taiwan, ho@cc.ncu.edu.tw, *Ta-Wei Liao*

One common way to arrange guide paths in a semiconductor fab is that intra-bay guide paths of different bays are not directly connected and intra-bay guide paths are connected via a stocker. To eliminate negative effects of existing disadvantages, a new guide path arrangement has been used in some fabs. We study the layout problem with not only the intra-/inter-bay but also direct-transport guide paths. Mathematical programming and heuristics are proposed. We minimize the total flow distance in the system. An example illustrates the effectiveness and applicability of our methods.

3 - Column Generation based Primal Heuristics

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, *Cédric Joncour*, *Sophie Michel*, *Ruslan Sadykov*

Generic primal heuristics have made their way into commercial MIP solvers. Extensions to a column generation context are not straightforward: there are technicalities specific to the dynamic generation of variables. The column generation literature reports many application specific studies. There remains to extract generic methods that could be seen as black-box primal heuristics. We review generic classes of column generation based primal heuristics. We then focus on and test so-called "diving" methods and other forms of truncated Branch-and-Price.

4 - New Mathematical Models for Balance Stability in U-Type Assembly Lines

Banu Guner, Industrial Engineering, Anadolu University, Iki Eylul Campus, 26555, Eskisehir, Turkey, badogan@anadolu.edu.tr, *Servet Hasgul*

In this study, some mathematical models are presented for U-type assembly line balancing problems. These models consider some ergonomic factors that may be encountered in work environments. It is seen that assembly line balancing will be more stable by taking care of these mentioned factors. The model parameters are examined as deterministic and fuzzy. Illustrative examples are presented to demonstrate the validity of the proposed models.

■ WB-10

Wednesday, 10:40 - 12:00
6.2.56

Emerging Nonlinear Optimization Applications of OR

Stream: Emerging Applications of OR
Invited session

Chair: *A. Egemen Yilmaz*, Electronics Engineering, Ankara University, Ankara Universitesi Tandogan Kampusu, Elektronik Muh. Bolumu, 06100, Ankara, -, Turkey, aeyilmaz@eng.ankara.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Hierarchical Multi-player Game-solution Identification for Cooperative Advertising Supply Chain Using Multi-objective Particle Swarm 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, *Ming-Hui Chen*, *Shiuan-Yiang Huang*, *Wei Ting Cho*, *Po-Liang Chao*, *Chung-Chang Lien*

We construct mathematic models in different market response functions associated with the hierarchical Stackelberg game structure, identify its equilibrium and explore some preference conditions for both supply chain players. An algorithm is proposed to optimize the vertical cooperative advertising multi-objective problems. We implement a real case and their numerical results are compared with different strategies which demonstrate the cooperative advertising and robustness of MOPSO-CD.

2 - Robust R&D Project Management

Ruken Duzgun, ISE Dept, Lehigh University, 200 W Packer Ave, 18015, Bethlehem, PA, United States, rukenduzgun@gmail.com, *Aurelie Thiele*

We consider robust optimization approaches to R&D project selection when investments are done in stages and cash flows are uncertain. We consider an approach with two ranges (high and low) at each time period and a parameter limiting the number of times the cash flow of the projects can be in the low range. The use of binary variables to represent project selection raises challenges to develop tractable robust counterparts. We discuss ways to address these issues and present theoretical insights as well as numerical results, and we provide extensions to the initial setup.

3 - Novel Approaches in Particle Swarm Optimization and Potential Applications in OR

Okkes Tolga Altinoz, Bala Vocational School of Industrial Electronics, Hacettepe University, 06100, Ankara, taltinoz@hacettepe.edu.tr, *A. Egemen Yilmaz*, *Gerhard-Wilhelm Weber*

Particle Swarm Optimization is a simple but powerful heuristic technique for the solution of the complicated multidimensional optimization problems. Since its development many derivatives of PSO and its hybridizations with other methods have been proposed for different purposes. We will try to revise the most significant and interesting recent ideas in PSO; and we will try to identify and discuss the potential usages of these recent PSO formulations in the OR discipline.

4 - A Stochastically Perturbed Particle Swarm Optimization for Identical Parallel Machine Scheduling Problems

Mehmet Sevkli, Industrial Engineering, Fatih University, Fatih University, Buyukeckmece, 34500, ISTANBUL, Turkey, msevkli@fatih.edu.tr

A Stochastically Perturbed Particle Swarm optimization algorithm with a different search strategy is proposed for the identical parallel machine scheduling problems. The algorithm is applied to the non-preemptive parallel machine scheduling problem with the objective of minimizing makespan. SPPSO's performance is compared with against two other recent PSO algorithms. The SPPSO algorithm performed better in terms of obtaining optimum solutions and consumes less time.

■ WB-11

Wednesday, 10:40 - 12:00
8.2.38

Recent Advances in Quality Management and OR in Reliability Engineering

Stream: Emerging Applications of OR

Invited session

Chair: *Gulser Koksak*, Industrial Engineering, Middle East Technical University, Inonu Blvd., 06531, Ankara, Turkey, koksak@ie.metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Improving the Quality of Plastic Injection Molding Using Taguchi Method and PCA

Fong Jung Yu, Industrial Engineering and Technology Management, DaYeh University, 168, university road, Dacun, 51591, Changhua, Taiwan, fischer@mail.dyu.edu.tw, *Chingpou Chang*, *Kai-I Huang*

The combination of Taguchi method and principal component analysis (PCA) is used to promote product quality of conventional plastics injection molding process through the optimization of the parameters in this study. We found that PCA could be effectively used in multiple-quality-characteristics problems to obtain integral solution. Furthermore, holding pressure could be regarded as an adjustment factor to the process mean. From the result of analysis of variance, material temperature, holding pressure and injection location have significant impact on size of finished product.

2 - Optimum process mean, specification limits, and manufacturing quantity based on quadratic loss function and rectifying inspection plan with perfect and imperfect reworks

Muhammad Al-Salamah, Systems Engineering, King Fahd University, Box 5067, KFUPM, 31261, Dhahran, Western, salamah@kfupm.edu.sa, *Ashraf El-ga'aly*

In this paper, a modified economic manufacturing quantity (EMQ) model under the imperfect product quality is developed. Taguchi's quadratic quality loss function is integrated into the model to evaluate the product quality. The imperfect reworks of product are considered in the modified EMQ model. By solving the modified model, we can obtain the optimum combination of the production quantity, process mean and the specification limits that lead to the maximized profit. A numerical example and sensitivity analysis of parameters of the model are provided for illustration.

3 - Ordering Policy For Spare Preventive Replacement

Jih-An Chen, Department of Business Administration, Kao-Yuan University, NO.1821, Jhongsan Rd., Lujhu Township, 82151, Kaohsiung County, Taiwan, jachen@cc.kyu.edu.tw

We develop a preventive replacement policy of spare ordering under cost effectiveness criterion. The spare unit for replacement is available only by order and the lead time for delivery the spare due to regular or expedited ordering follows general distributions. Introducing costs due to ordering, repairs, downtime and replacements, as well as the salvage value of system, we derive the expected cost effectiveness per unit time in the long run as a criterion of optimality. There exists a finite and unique optimum policy of ordering time which maximizes the expected cost effectiveness.

4 - Redundancy Allocation for Serial Systems

Kurtulus Baris Oner, Industrial Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB, Eindhoven, Netherlands, k.b.oner@tue.nl, *Geert-Jan van Houtum*, *Alan Scheller-Wolf*

We consider a situation in which a user buys a number of units of a serial system. The systems are supported by a single spare parts inventory stock point. A predetermined emergency procedure is performed on stock-out events. Three policies, which are different combinations of applying the emergency procedure and having a cold-standby unit, can be implemented per subsystem. We formulate a model to minimize the Total Cost of Ownership of the systems under a minimum availability constraint. Next, we conduct exact analysis and derive results on the optimality of the policies.

■ WB-12

Wednesday, 10:40 - 12:00
8.2.39

AHP 06

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Ahmet Kandakoglu*, Department of Industrial Engineering, Istanbul Technical University, Macka, 34367, Istanbul, Turkey, kandakoglu@itu.edu.tr

1 - Developing an Organizational Performance Model for Community Empowerment in Taiwan

Pin-Ju Juan, Department of Tourism and Hospitality, Tamkang University, 180 Linwei Road., Chiao-hsi Shiang., 26247, I-lan County, Taiwan, pj@ocu.edu.tw, *Shin-Yi Lin*, *Benjamin J.C. Yuan*

This study intends to explore an evaluation model for effectiveness and satisfaction of the community empowerment. This study will also use focus groups approach to construct an assessment model. The purpose of this paper is to construct a performance measurement model combine balance scorecard (BSC) and Analytical Hierarchy Process (AHP). By applying the AHP to obtain factors and criteria weights, this model can assist decision makers or administrators of Community Development in assessing the performance and improving applicability for future use.

2 - Development and Application of an Analytic Hierarchy Process Model for Assessing Airport Advanced Surface Movement Guidance and Control Systems

Konstantinos Zografos, Department of Management Science and Technology, Athens University of Economics and Business, Evelpidon 47A & Lefkados 33, 11362, Athens, Greece, kostas.zografos@aueb.gr, *Konstantinos Androutsopoulos*

This paper presents an AHP based methodology for the assessment of an Advanced Surface Movement Guidance and Control System (A-SMGCS). A-SMGCS provide ground traffic management services for the improvement of the efficiency and safety of airport operations. The proposed methodology involves an AHP model that takes into account multiple tangible and intangible criteria and indicators associated to the A-SMGCS assessment. The AHP model identifies the relative importance of the assessment criteria and indicators and provides a comparative assessment of the A-SMGCS against a baseline system.

3 - The Evaluation Analysis of RFID Adoption for Taiwan Logistic Industry

Ling-Lang Tang, School of Management, Yuan Ze University,
135 Yuan-tung road., 320, Chung-Li, Taoyuan, Taiwan,
balltang@saturn.yzu.edu.tw, Cheng-Chuang Hon

This study adopts TOE as the framework that included four dimensions and 33 criteria in assisting logistic managers evaluating RFID adoption. Firstly, 18 evaluation criteria were selected by experts from 33 decision criteria of RFID implementation. The selected criteria include four dimensions: environment, technology, organization, and cost. Secondly, the FAHP weights evaluate and judge the key success factors of RFID adoption. Finally, it explores the importance factors affecting RFID implementation among three phases.

■ WB-13

Wednesday, 10:40 - 12:00

2.2.21

Heuristics in location

Stream: Location Analysis

Invited session

Chair: *Said Salhi*, Kent Business School, University of Kent, Centre for Heuristic Optimisation., Canterbury, Kent, CT2 7PE, United Kingdom, s.salhi@kent.ac.uk

1 - Evaluation of an Ant Based Hybrid Metaheuristic to solve the Capacitated Facility Location Problem

Harry Venables, Business School, University of Sunderland, Reg Vardy Centre, St Peter's Campus, SR6 0DD, Sunderland, United Kingdom, harry.venables@sunderland.ac.uk, *Alfredo Moscardini*

Hybrid metaheuristics belong to an emerging area that makes use of integrating exact and/or approximate techniques. Although this approach has been attempted before for the capacitated facility location problem, previous attempts suffered from excessive run-times. A hybrid ant colony optimisation algorithm that integrates a pheromone based model with an exact solution technique is proposed. Also, a simple binary flip local search mechanism which makes use of the same exact solver is integrated within the design. Run-time distributions are generated and compared with other algorithms.

2 - Goal Programming in Location Problems

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

Solving the location problems often involves the preference of locality that is based on certain criteria (largeness of a node, population density, waste concentration etc.). For that reason it seems to be effective to use the modification that is based on multi-criteria decision analysis, concrete the goal programming. Via goal programming it is possible to specify such variant that comes close to real needs. Provided that the considered problems are equally structured, constructed problem might be of their combination.

3 - Formulation space search for Location-Allocation problem

Nenad Mladenovic, Faculty of Organizational, University of Belgrade, 11000, Belgrade, Serbia, nenad.mladenovic@gerad.ca, *Jack Brimberg*

For solving the multi-source Weber problem we suggest heuristic method based on the recent Formulation space search approach. In our new local search we explore the fact that continuous and discrete formulations of the problem (i.e., the p-median) tend to be the same if the number of possible location points in p-median tends to infinity. So, in each iteration we switch from continuous formulation to discrete, adding new (non-occupied) Weber facilities to the set of potential p-median sites. Encouraging computational results are reported.

■ WB-14

Wednesday, 10:40 - 12:00

2.2.15

Pension funds

Stream: Actuarial Sciences and Stochastic Calculus

Invited session

Chair: *Elena Vigna*, Dipartimento di Statistica e Matematica Applicata, Università di Torino and Collegio Carlo Alberto, corso Unione Sovietica 218 bis, 10135, Torino, Italy, elena.vigna@econ.unito.it

1 - Optimal asset allocation and sharing rule for pension funds in DC and DB frameworks

Francesco Menoncin, Economics, Brescia University, Via S. Faustino, 74/B, 25122, Brescia, Italy, menoncin@eco.unibs.it

We study both the optimal asset allocation and the optimal share of performances for a pension fund which operates in a complete financial market where the prices of risky assets are driven by a set of stochastic variables. Furthermore, we take into account a stochastic force of mortality whose risk (i.e. both mortality and longevity risk) can be hedged through a demographic asset as a derivative on this force of mortality. The framework is useful for both a defined contribution and a defined benefit pension scheme. We demonstrate that it is optimal to share all the wealth exceeding the prospective mathematical reserve and that the optimal portfolio must contain a component which hedges against the changes in such a reserve due to the changes in the values of the stochastic state variables.

2 - Demographic Risk Sharing in Defined Contribution Pension Funds

Martino Grasselli, Dipartimento di Matematica Pura ed Applicata, Università degli Studi di Padova and ESILV, via Trieste 63, 35121, Padova, grassell@math.unipd.it, *Daniel Gabay*

We consider the problem of a defined contribution fund manager looking for a fair remuneration rule for all the retirees by smoothing the fluctuations arising from the non stationarity of the fund population. We find that the optimal remuneration policy consists in delivering the guarantee plus a surplus, which is a (positive) random amount depending on market performance. In this case the benefits turn out to be volatile.

3 - Constrained portfolio choices in the decumulation phase of a pension plan

Fausto Gozzi, Dipartimento di Scienze Economiche e Aziendali, Luiss University - Roma - Italy, viale Romania 32, 00197, Roma, RM, Italy, fgozzi@luiss.it, *Salvatore Federico, Marina Di Giacinto, Elena Vigna*

We deal with a constrained investment problem for a DC pension fund in the decumulation phase. We consider the basic model of GHV (2004) with fixed consumption and annuitization time. Firstly, we require no short-selling. Secondly, we impose a final capital requirement, implying no ruin. We approach the constrained stochastic control problem with dynamic programming. We give a general result of existence and uniqueness of regular solutions of HJB equation. In a special case we explicitly compute value function and optimal policy and show a numerical application.

4 - Stochastic pension funding when benefits follow a jump diffusion process

Juan Pablo Rincon-Zapatero, Economia, Universidad Carlos III de Madrid, c/ Madrid, 126, 28903, Getafe, Madrid, Spain, jrincon@eco.uc3m.es, *Ricardo Josa-Fombellida*

We consider a defined benefit stochastic pension fund where benefits follow a jump diffusion process. The fund manager invests in a risky portfolio and selects an amortization rate to keep stable the fund evolution within prescribed targets. The problem is solved analytically by means of the dynamic programming approach and the technical interest rate is selected in order to attain a neutral risk valuation of the liabilities.

■ WB-15

Wednesday, 10:40 - 12:00

2.2.12

Vehicle Routing Applications III

Stream: Vehicle Routing

Invited session

Chair: *Joaquín Pacheco*, Applied Economy, University of Burgos, Plaza Infanta Elena s/n, 09001, Burgos, Spain, jpacheco@ubu.es

1 - Solving a Stochastic Bi-Objective Covering Tour Problem

Fabien Tricoire, Department of Business Administration, University of Vienna, Chair for Production and Operations Management, Brünner Straße 72, 1210, Vienna, fabien.tricoire@univie.ac.at, *Walter Gutjahr*

In a disaster relief mission, the population of the affected region is to be provided with emergency supplies. These supplies are delivered to distribution centers (DCs), where people can pick them up. The percentage of inhabitants of a village going to the next DC depends on the distance between the village and the DC. We therefore have to solve an extended bi-objective covering tour problem. The decisions concern both the DCs to open and the tours to deliver the goods to them. Pareto fronts for the two objectives "cost" and "coverage" are determined under sampled stochastic demand.

2 - Vehicle routing: A case study for laundry services

Azmin Azliza Aziz, Warwick Business School, University of Warwick, Warwick, Warwick Business School, The University of Warwick, CV4 7AL, Coventry, United Kingdom, A.A.Aziz@warwick.ac.uk

This case study focuses on laundry service in Coventry which can be modelled as a vehicle routing problem. At present, the daily routing activities are done manually. Therefore improvement of current system is necessary by performing rescheduling exercise using different approaches whilst satisfying related constraints. Comparison amongst approaches is conducted to investigate potential cost savings to the problem. Experimental results reveal that the optimization software significantly improve the manual implementation. The next interest would be to perform robustness checks on the solutions.

3 - Optimizing vehicle routes in a bakery company

Joaquín Pacheco, Applied Economy, University of Burgos, Plaza Infanta Elena s/n, 09001, Burgos, Spain, jpacheco@ubu.es, *Ada Alvarez*, *Irma García*, *Francisco R. Angel-Bello*

The work is motivated from a real problem of a bakery company in Northern Spain. The objective is to minimize the total distance traveled for the daily routes over the week. In order to reduce this total distance, some flexibility in the dates of delivery is introduced. A two-phase method based in GRASP and Path Relinking metaheuristics is proposed. Computational experiments show that the method performs very well, obtaining high quality solutions in short computational times. When it is applied to real-data-based instances the obtained solutions considerably reduce transportation costs

■ WB-16

Wednesday, 10:40 - 12:00

2.2.14

OR models in Public Transport

Stream: Public Transport [c]

Contributed session

Chair: *Leo Kroon*, Rotterdam School of Management, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, lkroon@rsm.nl

1 - Route of New High-speed Line Which Minimizes Total Travel Time of Railway Users

Takamori Ukai, Nanzan university, 27, Seirei-cho, 4890863, Seto, Aichi, Japan, ukai@nanzan-u.ac.jp

In this presentation, we discuss the route of new high-speed railway which minimizes total travel time of users. High-speed mass transit, like bullet train, decreases travel time drastically, and it affects the economy of the regions where the stations are located. By this reason, many alternatives are suggested to select the locations of stations. We formulate the problem as a mathematical programming problem and propose the route minimizing the total travel time under the assumption that individuals take the route of which their travel time is shortest.

2 - Conflict Avoidance for Air Traffic Flow Management Problem, pure and MIP models

Pablo Olaso, Department of Statistics and Operations Research, Universidad Rey Juan Carlos, c Tulipán s/n, 28933, Móstoles, pablo.olaso@urjc.es, *Celeste Pizarro Romero*, *Laureano Fernando Escudero*

Two linear optimization models for conflict avoidance between any number of aircrafts in the airspace are proposed, the first one a pure 0—1 LP which avoid conflicts by means of altitude changes, and the second one a Mixed 0—1 LP whose strategy is based on velocity and altitude changes. Several objective functions are established and some extensions to improve both models are proposed. Due to the small computational time for solving both problems, this approach can be used in real time by using standard optimization software.

3 - An Ant Colony Optimisation algorithm for simulating hyper-path choices on real-scale networks

Luca D'Acerno, Dipartimento di Ingegneria dei Trasporti, Università degli Studi di Napoli "Federico II", Via Claudio, 21, 80125, Napoli, Italy, dacierno@unina.it, *Mariano Gallo*, *Bruno Montella*

In this paper, we propose an ACO-based algorithm to imitate the behaviour of public transport users. In particular, we show that the proposed algorithm allows transit systems to be simulated in less time but with the same accuracy compared with traditional assignment algorithms. Moreover, we state the equivalence in terms of hyperpath choice behaviour between artificial ants (simulated with the proposed algorithm) and transit users (simulated with traditional assignment algorithms). Finally, we apply the proposed algorithm on a real-scale network highlighting performances of the ACO approach.

4 - A Column Generation Approach to the Vehicle Positioning Problem

Carlos Cardonha, Optimization, Zuse Institute Berlin, Takustrasse 7, Berlin-Dahlem, D-14195, Berlin, Berlin, Germany, carlos.cardonha@gmail.com, *Ralf Borndörfer*

The Vehicle Positioning Problem consists of assigning the vehicles of a public transport company to parking positions in a depot. We propose a set partitioning model approach for the basic and for the integrated versions of the problem and an associated column generation solution approach for them. The proposed models provide tight linear descriptions of the problems and the pricing routines for some versions can be solved in pseudo-polynomial time. The computational results of these methods show that they provide satisfactory solutions to large-scale instances of the problem."

■ WB-17

Wednesday, 10:40 - 12:00

1.3.14

Financial Mathematics and Stochastic Modelling

Stream: Computational Statistics

Invited session

Chair: *Efsun Kürüm*, Financial Mathematics, Institute of Applied Mathematics, METU, Institute of Applied Mathematics, 06531, Ankara, Turkey, efsun.kurum@gmail.com

1 - Economical applications of Almost Stochastic Dominance

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

In this work we study some classical methods to compare options. First, Stochastic Dominance (SD) and Mean Variance (MV) rules with their principal applications are commented. In the situations in which we can rank the options using these rules, we need other criteria, in particular Almost Stochastic Dominance (ASD) rules. We also study examples in which ASD rules let us to make a choice between different options.

2 - Optimal control of a finite-capacity stochastic inventory system with setup cost and lost sales

Xiuli Chao, IOE, University of Michigan, 1205 Beal Ave, 48109, Ann Arbor, MI, United States, xchao@umich.edu, *Yifan Xu*

One of the most fundamental results in inventory theory is the optimality of (s, S) policy for inventory systems with setup cost. This result is established based on a key assumption of infinite production/ordering capacity. Several studies have shown that, when there is a finite production/ordering capacity, the optimal policy for the inventory system is very complicated. We consider a continuous review inventory system with finite production/ordering capacity and setup cost, and show that the optimal control policy for this system has a very simple structure.

3 - Modelling Predecisional Bias in a Speculative Financial Market

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*

Predecisional bias, where individuals evaluate attributes to favour the leading option, has been observed in laboratory studies. We investigate this phenomenon in a real world environment, using logistic regression to model decisions made in a horserace betting market. We find that bettors do alter their probability judgements and prefer a leading option when it is sufficiently more favoured than the other choices available. In addition, we find that the bias is unaffected by alternative-based complexity but is stronger in situations involving high attribute-based complexity.

4 - Testing for breaks in stochastic volatility model

Carlos Rivero, Statistics and Operations Research, University Complutense of Madrid, Campus de Somosaguas, 28223, Madrid, Spain, crivero@estad.ucm.es

Volatility plays an important role in economics and finance. Deciding whether volatility models have constant coefficients or exhibit breaks is an important issue in applied works. The statistical properties of the volatility models introduce some complexity to test for breaks. This paper proposes a method to test for constant parameters in Stochastic Volatility Models. The method can be applied to any SVM with autoregressive structure in the conditional variance. The proposed test adds a useful tool to financial econometrics and applied finance. Simulations confirm the good performance of the method.

■ WB-18

Wednesday, 10:40 - 12:00

1.3.15

Stochastic Models and Queueing Systems

Stream: Stochastic Modeling and Simulation

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

Chair: *Zeev (Vladimir) Volkovich*, Ort Braude Academic College, Yehiam 6, 21823, Karmiel, Israel, zeev@actcom.co.il

1 - Equilibrium and socially optimal strategies in the M/G/1 queue with vacations

Antonio Gomez-Corral, Department of Statistics and OR, Complutense University of Madrid, Faculty of Mathematics, Plaza de Ciencias, 3, 28040, Madrid, Spain, antonio_gomez@mat.ucm.es

We study the balking behavior of customers in the single-server queue with vacations. Arriving customers decide whether to enter the system or balk, based on a natural reward-cost structure that incorporates their desire for service, as well as their unwillingness to wait. We identify equilibrium strategies and socially optimal strategies under two information assumptions. In a first case, customers make individual decisions without knowing the system state. In a second case, they are informed about the server's current status.

2 - Nonparametric Estimation for a Numerical Evaluation of the Proximity of G/G/1 and G/M/1 Systems

Aïcha Bareche, Laboratory of Modelisation and Optimization of Systems, University of Bejaia, Algeria, 06000, Bejaia, Algeria, aicha_bareche@yahoo.fr, *Djamil Aïssani*

We study strong stability of the G/M/1 queueing system after perturbation of the service times. We are interested in the determination of the proximity error between the corresponding service time distributions of the G/G/1 and G/M/1 systems and the approximation error on their stationary distributions in the stationary state, when the general distribution of service times G in the G/G/1 system is unknown and must be estimated by the means of a nonparametric estimation method. The boundary effects are taken into consideration. Simulation studies are realized to support the results.

3 - An M/G/1 retrial queue with exhaustive service and multiple vacation policy

Mohamed Boualem, RO, University of Bejaia, LAMOS, University of Bejaia, 06000 Bejaia, Algeria, Bejaia, Algeria, robertt15dz@yahoo.fr, *Djamil Aïssani*, *Djellab Natalia*

In this paper, we consider an M/G/1 retrial queue with server vacations, when service times and vacation times are arbitrary distributed. The distribution of the number of customers in the system in stationary regime is obtained in terms of generating function. Next, we show that the system size can be decomposed into two random variables, one of which corresponds to the system size of the ordinary M/G/1 FIFO queue without vacation. Such a stochastic decomposition property is useful for the computation of performance measures of interest.

4 - Stochastic inequalities for MX/G/1 retrial queue with impatient customers with high retrial rate

Nawel Arrar, Mathematics, Annaba university, BP.12, 23000, Annaba, Algeria, nawel.arrar@univ-annaba.org

We carry out a stochastic analysis of the M/G/1 retrial queue with batch arrivals and impatient customers. This includes steady state joint distribution of the server state and the number of customers in retrial group, embedded Markov chain and stochastic decomposition for the number of customers. Under high retrial intensity, the steady state distribution of a retrial queue converges to a limit. In our case, it is intuitive that it is the classical M/G/1 queue with batch arrivals and impatience phenomenon. We prove this heuristic argument with stochastic decomposition property.

■ WB-19

Wednesday, 10:40 - 12:00

1.3.20

Nonsmooth Optimization and Its Applications

Stream: Nonsmooth Optimization

Invited session

Chair: *Antonio Fuduli*, Department of Mathematics, Università della Calabria, Via P. Bucci, CUBO 31B, 87036, Rende, Italy, antonio.fuduli@unical.it

Chair: *Annabella Astorino*, ICAR, CNR, C/0 DEIS - UNICAL, CUBO 41 C, 87036, RENDE, Italy, astorino@icar.cnr.it

1 - Generalized Bundle Methods for Decomposable Functions with "Easy" Components

Enrico Gorgone, DEIS - Dipartimento di Elettronica Informatica e Sistemistica, Università della Calabria, Via Bucci, CUBO 41c, VI piano, 87036, Rende, Cosenza, Italy, egorgone@deis.unical.it, *Antonio Frangioni*

Many large-scale optimization problems exhibit a block-structure that can be algorithmically exploited by means of decomposition approaches. We propose a modification to the (generalized) bundle scheme for minimization of a decomposable nonsmooth convex function, where some components are easy convex programs. We show how to construct, for this case, a suitably modified representation of the original convex subproblem, providing it with "exact" information about "easy" components of the function to be minimized. We report numerical results for Network Design problem.

2 - Analysis of optimization algorithms for clustering

Zorana Luzanin, Department of Mathematics and Informatics, University of Novi Sad, Trg Dositeja Obradovica 4, 21000, Novi Sad, Serbia, zorana@dmi.uns.ac.rs

Two main issues in cluster analysis are considered in this paper. The first one is the weighting of attributes while the second is application of nonsmooth optimization. The effectiveness of algorithms is demonstrated on real data sets. Cluster analysis was used on the results of the poll organized by the Ministry of Health which pertains to the health of the population in Serbia. The basic features included in this cluster analysis are socio-economic status, hygienic habits, diet, leisure, knowledge of health topics, subjective life satisfaction, and mental health.

3 - Heuristic algorithm for clustering large data sets based on nonsmooth optimization approach

Adil Bagirov, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

The k-means algorithm is known to be fast clustering algorithm. However, it is sensitive to the choice of starting points and is inefficient for clustering large datasets. Recently, incremental approaches have been developed to resolve difficulties with the choice of starting points. The global and modified global k-means algorithms are based on such an approach. However, they are not suitable for clustering very large data sets. We propose a new version of the modified global k-means algorithm which is based on nonsmooth optimization approach and is suitable for clustering large datasets.

4 - Nonsmooth Convex Optimization via Piecewise Quadratic Approximations

Annabella Astorino, ICAR, CNR, C/0 DEIS - UNICAL, CUBO 41 C, 87036, RENDE, Italy, astorino@icar.cnr.it, *Antonio Frangioni*, *Manlio Gaudioso*, *Enrico Gorgone*

We present a numerical method, of bundle type, for minimization of a real convex function of several variables, not necessarily differentiable. Differently from standard methods, based on the cutting plane approach, in our method we approximate the objective function via a piecewise quadratic model of max type. It retains the property of interpolating the original objective function at the "bundle" points. Termination at an approximate optimal solution is proved and numerical results are reported.

■ WB-20

Wednesday, 10:40 - 12:00

1.3.33A

Data Mining and Decision Making II

Stream: Data Mining and Decision Making

Invited session

Chair: *Hsin-Vonn Seow*, Business School, University of Nottingham-Malaysia Campus, Jalan Broga, Selangor Darul Ehsan, 43500, Semenyih, Selangor, Malaysia, Hsin-Vonn.Seow@nottingham.edu.my

Chair: *Lai-Soon Lee*, UPM Serdang, 43400, Selangor Darul Ehsan, Malaysia, lslee@math.upm.edu.my

1 - Rule Based Predictive Models, Decision Table and Tree: An Empirical Evaluation on Comprehensibility

Karel Dejaeger, Faculty of Business and economics, Katholieke Universiteit Leuven, Naamsestraat 69, 3000, Leuven, Belgium, Karel.dejaeger@econ.kuleuven.be, *Wouter Verbeke*, *Johan Huysmans*, *Christophe Mues*, *Jan Vanthienen*, *Bart Baesens*

Little research has been performed to assess the comprehensibility to the end-user of predictive data mining models. In this paper, an empirical study is presented which investigates the comprehensibility of a number of alternative representation formats for classification. An end-user experiment is designed to test the accuracy, response time and answer confidence for a set of problem-solving tasks involving different representation formats. The formats under consideration are decision tables, decision trees, propositional and oblique rules.

■ WB-21

Wednesday, 10:40 - 12:00

6.2.47

Optimization Algorithms II

Stream: Software for OR/MS

Invited session

Chair: *Tamas Kis*, Computer and Automation Research Institute, Hungarian Academy of Sciences, P.O.Box 63, 1518, Budapest, Hungary, kistamas@sztaki.hu

1 - Strengthening split cuts by lift-and-project

Tamas Kis, Computer and Automation Research Institute, Kende str. 13-17, 1111, Budapest, Hungary, tamas.kis@sztaki.hu, *Egon Balas*

We propose a procedure for improving arbitrary split cuts by pivoting in the LP tableau based on the lift-and-project reduced costs. We show how this procedure, successfully used in the last few years to improve mixed integer Gomory cuts, can be applied to other split cuts by creating a new source row specific to the family of cuts in question. The starting point of the new procedure is any split disjunction which can be obtained by combining integer variables using integer multipliers. Computational experience will be discussed.

2 - A hybrid algorithm for global optimization problems

Leticia Velazquez, Mathematical Sciences, The University of Texas at El Paso, 500 West University Avenue, 79968-0514, El Paso, Texas, United States, leti@utep.edu, *Miguel Argaez*, *Miguel Hernandez*, *Carlos Ramirez*, *Reinaldo Sanchez*

We are developing a hybrid algorithm for solving global optimization problems that is based on the coupling of a stochastic global method (Simultaneous Perturbation Stochastic Approximation, Simulated Annealing, Genetic Algorithms) and a local method (Newton-Krylov Interior-Point) via a surrogate model. There exist verified algorithms for finding approximate global solutions, but our technique will further guarantee that such solutions satisfy physical bounds of the problem. First, the SPSA algorithm conjectures regions where a global solution may exist. Next, some data points from the regions are selected to generate a continuously differentiable surrogate model that approximates the original function. Finally, the interior-point Newton algorithm is applied to the surrogate model subject to bound constraints for obtaining a feasible approximate global solution. We present some encouraging numerical results of small to large scale parameter estimation problems. The authors acknowledge the support from the Department of the Army Grant No. W911NF-07-02-0027.

3 - Some experimental results measuring the complexity of the B&B algorithm versus the geometry of the polyhedron

Ivan Derpich, Industrial Engineering Department, University of Santiago of Chile, Av. Ecuador 3769, Estacion Central, Volcan Lanin 205, las Condes, 0000, Santiago, Region metropolitana, Chile, ivan.derpich@usach.cl

In this presentation we show first a new bound for the width of the polyhedron based in the eigenvalue of the polyhedron. Then we use this bound for estimate the maximum number of nodes to branch in the B&B algorithm. Finally we compare this maximum number of nodes with the number of nodes obtained in a set of instances taken from a set of test problem.

■ WB-22

Wednesday, 10:40 - 12:00

3.1.10

Maritime transportation

Stream: Maritime Logistics

Invited session

Chair: *Marielle Christiansen*, Norwegian University of Science and Technology, N-7291, Trondheim, Norway, marielle.christiansen@iot.ntnu.no

1 - Integrated cargo routing and ship scheduling in liner shipping

Karina Kjeldsen, CORAL, Department of Business Studies, Aarhus School of Business, Fuglesangs Alle 4, 8210, Aarhus V, Denmark, kahk@asb.dk, *Oguz Solyalı*

The problem consists of creating routes and schedules for a heterogeneous fleet of ships while determining the cargo routing and the speed for all relevant port pair/ship combinations. Transshipment is allowed in ports with transshipment capabilities. The service frequency is fixed at one week. Since the speed of the ships is a decision variable, the developed model is nonlinear. The model is made linear by means of variable redefinition. Using decomposition the linearized model is split into a master problem and a sub problem per ship, and solved by a column generation algorithm.

2 - A Branch-and-Price-and-Cut Method for a Maritime Pickup and Delivery Problem with Time Windows and Split Loads

Magnus Stålhane, Industrial Economics and Technology Management, NTNU, Alfred Getz veg 3, 7491, Trondheim, Norway, stalham@iot.ntnu.no, *Henrik Andersson*, *Marielle Christiansen*, *Jean-François Cordeau*, *Guy Desaulniers*

We present a branch-and-price-and-cut method for a maritime pickup and delivery problem with time windows and split loads. The fleet is heterogeneous with each ship having a different load capacity, speed and cost structure. There are both mandatory and optional cargoes to transport. Each cargo has a time window both at the pickup and the delivery ports, and earns revenue for transporting it. Each cargo may be transported by one or more ships, potentially giving substantial savings compared to solutions where splitting of cargoes is not allowed. Computational results will be presented.

3 - A medium-term short sea fuel oil distribution problem

Alexandrino Duarte Delgado, Matemática, Universidade de Aveiro, Campus Universitário de Santiago, 3810 - 193, Aveiro, Portugal, alexandrino.delgado@univcv.edu.cv, *Agostinho Agra*, *Marielle Christiansen*

We consider a medium-term short-sea fuel oil distribution problem occurring in the archipelago of Cape Verde. Here, an oil company is responsible for the inventory management and for the routing of ships between the islands such that the demand for various products is satisfied during the planning horizon of several weeks. Inventory capacities are considered and a constant demand rate at each port is assumed.

We present a mathematical model of the problem and discuss different strategies to improve the proposed model, such as the use of an extended formulation and the inclusion of valid inequalities. Computational results based on real data will be reported.

4 - Recent research and trends in maritime cargo and inventory routing

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

We present the current status of models and solution methods for tactical planning problems in tramp and industrial shipping. Problems including both ship routing and inventory management considerations will be discussed, as well as routing and scheduling problems where specified cargoes are transported from given loading ports to discharge ports. Maritime transportation problems are rich and we discuss several important real life aspects. A brief overview of both exact methods and heuristics used for solving maritime cargo and inventory routing problems will be given. Finally, we present some trends regarding the research within maritime cargo and inventory routing.

■ WB-23

Wednesday, 10:40 - 12:00

6.2.49

Price and Risk Forecasting in the Financial Sector

Stream: Data Mining in the Financial Sector

Invited session

Chair: *Marcus Hildmann*, Swissquant Group AG, Kuttelgasse 7, 8001, Zürich, Switzerland, hildmann@swissquant.ch

Chair: *Vadim Strijov*, Computing Center of the Russian Academy of Sciences, Klara Zetkin 13-79A, 127299, Moscow, Russian Federation, strijov@ccas.ru

1 - Conditional Bootstrapping and Price Forecasting

Marcus Hildmann, Swissquant Group AG, Kuttelgasse 7, 8001, Zürich, Switzerland, hildmann@swissquant.ch, *Dejan Stokic*, *Florian Herzog*

We propose a bootstrapping concept of simulating the future prices, without a need for a priori setting specific data distribution, since assuming a data distribution in order to test the empirical data is potential source of errors. However, using simple bootstrapping destroys the path information of a time series. We present a bootstrapping based data mining method to simulate future electrical hourly price paths, which have the empirically observed path properties, calibrated by a nonlinear underlying process. Resulting simulated time series also include external seasonality information.

2 - Neural network based search for mispriced options

Dejan Stokic, Swissquant Group, Kuttelgasse 7, 8001, Zürich, Switzerland, stokic@swissquant.ch, *Marcus Hildmann*

There are two general ways of speculating on financial options: by forecasting the future implied volatility or by searching for options that are heavily mispriced. We address the latter approach by developing a neural-network based data mining algorithm, which given the option price, price of the underlying, strike and moneyness, searches for options which are under- or over-priced. We train our model on the data collected in last 3 years. By using this nonparametric approach, none of the assumptions about the dynamics of underlying processes have to be specified.

3 - Nonparametric method for economic indices construction. Application to analysis of capital and financial markets

Ivan Kondrakov, Moscow Institute of Physics and Technology, 9, Institutskii per., 141700, Dolgoprudny, Moscow Region, Russian Federation, ivankondrakov@mail.ru, *Alexander Shaninin*

A nonparametric method for construction of the Konus-Divisia indices is considered. The method is based on the Afriat-Varian theorem and takes into account changes in the demand structure when the structure of prices is changing. The construction of indices is reduced to solving a linear inequalities system of a special type, for which a solution method of polynomial computational complexity is known. This nonparametric method can be used for analysis of market segmentation and prediction of demand. We discuss also the possibility of its using for analysis of capital and financial markets.

4 - Estimation of investment project profitability in the modified Cantor-Lipman model

Mikhail Vashchenko, Computing Center of the Russian Academy of Sciences, Vavilov St. 40, 119333, Moscow, Russian Federation, m_vashchenko@mail.ru

The paper covers the methods for assessing the yield of investment projects, namely, considers the modified Cantor-Lipman model, which takes into account the probability of a crisis in the investments market and its impact on investor behavior. In such a formulation, the problem is reduced to the Bellman equation. We investigate the case when a cautious investment strategy avoiding bankruptcy is the optimum strategy, and concentrate on estimation of the investor's capital growth in the dynamic system based on a cautious strategy.

■ WB-24

Wednesday, 10:40 - 12:00

6.2.50

Automated Nurse Rostering

Stream: Timetabling and Rostering

Invited session

Chair: *Greet Vanden Berghe*, Industriële Ingenieur, KaHo Sint-Lieven, Gebr. Desmetstraat 1, 9000, Gent, Belgium, greet.vandenbergh@kahosl.be

1 - Design and Implementation of Operational Research Techniques for Making Schedules of Nurses

Lakhdar Djeflal, Universit Hadj-lakhdar, 05000, Batna, Algeria, lakdar_djeflal@yahoo.fr, *Elamir Djeflal*, *Gilles Goncalves*

Scheduling the nursing staff is based on finding solutions to combinatorial nature, responding to multiple constraints. In this paper we describe an advanced method for finding a solution very close to the mathematical model of type Constraint Satisfaction Problem CSP with objective function. This method combines techniques from operations research with heuristics which allows it to be done at each node of the search tree. Our results show that the tool developed is effective in terms memory usage, decision support based on the preferences and wishes of assignment.

2 - On Solving Real Nurse Rostering Problems

Margarida Pato, ISEG (Technical University of Lisbon), CIO (University of Lisbon) and ISEG (Technical University of Lisbon), Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, mpato@iseg.utl.pt, *Margarida Moz*, *Pedro Caldeira*

We present a recently improved computational decision support system developed to determine rosters for nurses working in hospital units. The system includes input and output modules as well as an engine. Both input and output respect all the practical rostering issues of a real public hospital context and the engine is a standard exact algorithm used to solve the mixed binary linear programming model for the specific purpose. Some applications of the system with real data will be given.

3 - Robust Optimization Approach to Scheduling Interns at Hospitals

Maryam Ghotbaddini, Apt 4, No. 15, Tous Alley, Valiasr St., Tajrish Sq., Tehran, Tehran, Iran, Tehran, Iran, Islamic Republic Of, ghotbaddini@gmail.com, *Mohammad Javad Feyzollahi*, *Mohammad Modarres*

Scheduling interns at hospitals is an important problem which affects the utilization of interns, satisfactory of patients and hospital costs. In most of developed models for this problem, researchers neglected data uncertainty or their efforts resulted to complicated models, which are difficult to compute. It is obvious that in a real-world problem the exact number of daily patients is not known precisely. In this paper, we use a robust optimization method to address data uncertainty in scheduling interns at hospitals.

4 - Constraint and precondition definitions for nurse rostering problems

Greet Vanden Berghe, Industriële Ingenieur, KaHo Sint-Lieven, Gebr. Desmetstraat 1, 9000, Gent, Belgium, greet.vandenbergh@kahosl.be, *Burak Bilgin*

Many different variants of the nurse rostering problem exist. The difference mainly constitutes personnel and work characteristics, the objectives, and the hard and soft constraints.

We concentrate on two particular modelling issues that require attention in order to make nurse rostering approaches re-usable in different settings. The first one considers precondition definitions. It deals with constraint evaluation across planning periods. Secondly, we present a model for dealing differently with idle days and absence requests. It offers an extension to existing constraint definitions.

■ WB-25

Wednesday, 10:40 - 12:00

6.2.48

ROADEF/EURO challenge senior session 1

Stream: ROADEF/EURO challenge

Invited session

Chair: *H. Murat Afsar*, Industrial Systems, University of Technology of Troyes, 12 rue Marie Curie, BP 2060, 10010, Troyes, France, murat.afsar@utt.fr

1 - A Guided-Construction approach to large scale power plant scheduling

Cor Hurkens, Mathematics and Computer Science, Eindhoven University of Technology, POBox 513, 5600MB, Eindhoven, Netherlands, wscor@win.tue.nl

We tackle the power plant scheduling problem of the 2010 ROADEF Challenge by a mixture of OR techniques: - tightening the outage opportunities; - optimizing a single plant schedule by means of dynamic programming; - enforcing feasibility by multi-plant scheduling via a time-index MIP formulation; - balancing production cost per scenario by a flow formulation. Solution variants are found by random sequencing of plants, as well as by varying the impact of modulation. We use CPLEX for solving the various subproblems.

2 - A solution approach to the ROADEF/EURO challenge based on Benders decomposition

Laurent Flindt Muller, DTU Management Engineering, Technical University of Denmark, Produktionstorvet, DTU — Bygning 424, 2800, Kgs. Lyngby, Denmark, lafm@man.dtu.dk, *Richard Lusby*, *Bjørn Petersen*

A stochastic large-scale energy management problem is considered, which consists of planning refuelling and production levels for a set of power plants, such that demands are met across a set of scenarios at minimum cost. The algorithm is based on Benders Decomposition (BD), where the master problem entails finding shutdown dates and reload amounts, while each subproblem involves finding an optimal production plan for a scenario. Because of the nature of the constraints, the normal BD-algorithm is adapted to handle these. Effective preprocessing removes large parts of the solution space.

3 - Matheuristic methods for large-scale energy management problems

Mauro Dell'Amico, ICOOR, Italy, dellamico@icoor.it, *José Carlos Díaz Díaz*

The algorithm we propose has an heuristic nature, but it makes use of sophisticated mathematical models and applies exact optimal solution approaches. Our method works in phases. - In the first phase, preprocessing techniques are used to strengthen and propagate the constraints. - In the second phase, a constructive heuristic schedules the outages and finds an admissible production asset. - The third phase is devoted to improve the incumbent solution through local search methods. - In the fourth phase, a MIP model which catches some of the most important constraints of the problem is solved through an iterative procedure which adds "dual cutting planes". - The last phase is a refinement of the best solution found.

4 - Team S21: Using Integer Linear Model for Scheduling Outages

Vincent Jost, Laboratoire d'Informatique, CNRS - Ecole Polytechnique, route de Saclay, 91128, Palaiseau, France, vjost@lix.polytechnique.fr, *David Savourey*, *Nora Touati Mouncla*

We split the problem into scheduling the outages and power affectation (for a given schedule). Currently, we use a 0-1 linear formulation for the scheduling of the outages taking into account CT 13 to 21. We heuristically add other constraints to ensure that enough fuel can be spent between two consecutive outages (constraint on min refueling and Amax). Starting with maximum production for type 2 power plants, we deal with modulation to avoid overproduction. We still need to find ways to evaluate the quality of a schedule. We discuss the relevance of the model, especially the stochastic part.

WB-26

Wednesday, 10:40 - 12:00

3.1.11

New Achievements in Game Theory I (cooperative and noncooperative)

Stream: Cooperative Game Theory

Invited session

Chair: *Mariana Rodica Branzei*, Faculty of Computer Science, "Alexandru Ioan Cuza" University, 16, Berthelot St., 700483, Iasi, Romania, branzeir@info.uaic.ro

Chair: *Sirma Zeynep Alparslan Gok*, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and Sciences, Suleyman Demirel University, 322260, Isparta, Turkey, zeynepalparslan@yahoo.com

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - A smuggling game with incomplete information

Ryusuke Hohzaki, Dep. of Computer Science, National Defense Academy, 1-10-20 Hashirimizu, 239-8686, Yokosuka, Kanagawa, Japan, hozaki@cc.nda.ac.jp, *Ryuichi Masuda*

Since the Dresher's work, there have been many researches on the so-called inspection game or smuggling game. This report deals with a smuggling game of Customs and a smuggler by considering asymmetric information which the players obtain. We model the game as a game with incomplete information, which has not been studied so far. We derive a perfect Bayesian equilibrium for the game and analyze optimal decisions of the players by comparing with another model with complete information.

2 - New results on rendezvous search on the interval

John Howard, Operational Research, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, j.v.howard@lse.ac.uk, *Marco Timmer*

Two people are placed on a finite stretch of road (using independent draws from the same distribution), and must try to meet each other in the least possible expected time. This is a rendezvous search problem for which some optimal solutions are known when the players have to use identical strategies and the distribution is uniform. In this paper we characterise the complete set of solutions for the uniform case.

Further, we derive a recurrence relation for solutions to this symmetric rendezvous problem for any initial distribution, so that all such problems can be solved by computer.

3 - A Modified Beer Game with Two Decision-Makers at Each Stage

Özlem Çoban, Industrial Engineering, Sabanci University, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, ozlemcoban@su.sabanciuniv.edu, *Murat Kaya*, *Gurdal Ertek*

We conduct a modified version of the well-known beer game in which, at each stage, the order decision is jointly given by two subjects: the sales manager whose performance measure is the back order cost, and the production manager whose performance measure is the inventory holding cost. We analyze if this change in the decision structure will dampen the bullwhip effect. We also run regression analysis to determine the factors (such as the inventory on hand and pipeline inventory) that affect the subjects' order quantity decisions.

WB-27

Wednesday, 10:40 - 12:00

8.2.06

URBAN TRANSPORT SYSTEMS

Stream: Transportation and Logistics

Invited session

Chair: *Maurizio Bruglieri*, INDACO, Politecnico di Milano, Via Durando, 38/a, Milano, Italy, maurizio.bruglieri@polimi.it

1 - Data Provision For Attended Home Delivery In Urban Areas

Dirk Christian Mattfeld, Business Information Systems, Universitaet Braunschweig, Decision Support Group, Mühlenpfordtstraße 23, 38106, Braunschweig, Germany, d.mattfeld@tu-bs.de, *Jan Fabian Ehmke*

Fast and reliable delivery of goods is a crucial part of service quality. In order to provide a high service quality in attended home delivery, customers expect a choice of narrow delivery time slots. Confirmed time slots have to be realized within cost efficient delivery tours. We demonstrate efficient and reliable vehicle routing in urban areas, which is based on empirical traffic data that can be utilized in time-dependent problem formulations. Computational experiments underline the benefits of time-dependent heuristics for the travelling salesman problem considering customer time windows.

2 - Centralized Versus Decentralized Control - A Solvable Stylized Model in Transportation Logistics

Olivier Gally, STI-IMT-LPM, Ecole Polytechnique Fédérale de Lausanne (EPFL), Station 17, CH-1015, Lausanne, Vaud, Switzerland, olivier.gally@epfl.ch, *Max-Olivier Hongler*, *Michael Hülsmann*, *Philip Cordes*, *Richard Colmorn*

To analyze the potential outcomes resulting from interaction between autonomous decision-making "smart parts" in logistics networks, we propose here an exactly solvable stylized model that is able to quantify how much the dynamics can be enhanced by (fully decentralized) agent-based mechanisms. Cost functions are introduced in order to compare the performances of centralized versus decentralized organization and we are able to conclude that for time horizons shorter than a critical value, multi-agent interactions generate smaller costs than an optimal effective central controller.

3 - Improved probe vehicle measurements with point data

Livia Mannini, Dep. of Civil Engineering, Roma Tre University, Italy, lmannini@uniroma3.it, *Ernesto Cipriani*, *Stefano Gori*

This study deals with the problem of urban travel time forecast. In order to achieve this objective a procedure that combines micro and macro approaches is proposed: micro approach deals with microsimulation models fed with micro (GPS probe vehicle) data; then, a macro approach is adopted to integrate micro data with aggregate measurements supported by fixed detectors.

4 - A web-based carpooling service for universities: a case study in Milan

Maurizio Bruglieri, INDACO, Politecnico di Milano, Via Durando, 38/a, Milano, Italy, maurizio.bruglieri@polimi.it, *Alessandro Luè*, *Alberto Colorni*

Carpooling is a transport system based on a shared use of private cars. The mobility managers of the Università Statale and Politecnico di Milano universities are interested in promoting the use of such system among their students and employees. The paper presents an ongoing project to design, implement and test a car pooling service for such universities. The design will take into account how to introduce and promote the service, identifying regulation, incentives, modalities, and marketing actions. A web-based software tool will be implemented to manage the matching of the users.

WB-28

Wednesday, 10:40 - 12:00

8.2.10

Scheduling with Due Dates

Stream: Scheduling

Invited session

Chair: *Igor Karpov*, Laboratory 20, Institute of Control Sciences of the Russian Academy of Sciences, Russia, Russia, Moscow, Profsoyuznaya, 65, Moscow, Russian Federation, karpov_sh33_yar@mail.ru

1 - Heuristics for the single machine weighted squared tardiness scheduling problem

Jorge Valente, Faculdade de Economia - LIAAD - INESC Porto L.A., Universidade do Porto, Rua Dr. Roberto Frias, 4200-464, Porto, Portugal, jvalente@fep.up.pt, *Jeffrey Schaller*

This paper considers the single machine scheduling problem with a weighted squared tardiness objective function. Several dispatching rules are proposed. These heuristics are tested on a set of randomly generated problems. The performance of the proposed dispatching rules is analysed, and for the smaller instances the heuristics are compared with optimum results.

2 - Evaluation of Job Shop Scheduling Rules in Due Date Performance Optimization

Fabio Pereira, Industrial Engineering Post Graduation Program, Nove de Julho University (Uninove), Francisco Matarazzo Av., 612 São Paulo-Brasil, 05001100, São Paulo, São Paulo, Brazil, fabio.pea@gmail.com, *Edna Barbosa, Michele Gonçalves, Marilda Fátima*

Job shop is small manufacturing operations environments which the production scheduling are characterized by, for example, the need to promise a competitive completion date estimate to the customer. In these conditions, the choice of the proper production schedule is healthy. This paper evaluates the effect of the main scheduling rules on due date performance in a job shop for optimization of both number of tardy jobs and the total tardiness. The optimization approach is based on the OptQuest tool for Arena, which allows searching for optimal solutions within simulation models.

3 - A Preemption-Based Heuristic for the Single-Machine Total Weighted Tardiness Problem

Halil Şen, Industrial Engineering, Sabanci University, Sabanci University, Orhanlı/Tuzla, 34956, Istanbul, Turkey, halilsen@sabanciuniv.edu, *Kerem Bulbul*

We consider the non-preemptive single-machine total weighted tardiness (TWT) problem with general weights, processing times, and due dates. We first develop a family of preemptive lower bounds for this problem and explore their structural properties. Then, we show that the solution corresponding to the least tight lower bound features some desirable properties that can be exploited to build excellent feasible solutions to the original non-preemptive problem in short computational times. We present results on standard benchmark instances from the literature.

4 - Polynomially solvable case of the NP-hard problem $1|r_j|L_{max}$

Igor Karpov, Laboratory 20, Institute of Control Sciences of the Russian Academy of Sciences, Russia, Russia, Moscow, Profsoyuznaya, 65, Moscow, Russian Federation, karpov_sh33_yar@mail.ru, *Alexander Lazarev*

We consider the classical NP-hard scheduling problem in strong sense $1|r_j|L_{max}$. New properties of optimal schedules are found. Polynomially case is selected when the release times (r_j), the processing time (p_j) and due dates (d_j) of jobs satisfy the relationships: $d_j = \alpha p_j + \beta r_j + C$, $p_j \geq 0$, $\alpha \in [0, 1]$, $\beta \in [1, +\infty)$, C - constant. An algorithm finds Pareto-optimal sets of schedules for objective functions L_{max} and C_{max} that contains no more than n schedules.

Paragraphs of the report:

1. Properties of the problem.
2. Makespan problem under a constraint on the maximum lateness. Algorithm and its evaluation.
3. Pareto-optimal schedules for the objective functions C_{max} and L_{max} . Algorithm and its evaluation.

24040, Milano, Italy, daniele.felletti@tiscali.it, *Silvana Stefani, Paolo Falbo*

A risk averse energy producer can switch production between two kinds of plants with different CO2 impact. We suppose he can partly transfer price shocks in production factors to the final price of electricity. The market power of the producer is modelled as a coefficient influencing the multivariate distribution of cost factors and energy prices. By simulation we analyse several market scenarios. Optimal production policies are obtained as efficient combinations of mean-variance of the profit function.

2 - New Solution Tools to Unit Commitment in Power Production Planning

Joao Pedro Pedrosa, DCC - FC, Universidade do Porto and INESC Porto, Portugal, jpp@fc.up.pt, *Ana Viana, Abdur Rais*

Unit Commitment is a classical problem in power production planning, consisting of deciding which electric generators must be committed to production in each period, and defining the production level at which each generator should operate. We present a branch-and-bound strategy for solving the problem, taking advantage of the specific structure of the problem: branch propagation is allowed only for children that, after look ahead, are found to satisfy all constraints. Careful bounding based on the quadratic structure of the problem is applied.

3 - Emission markets: dynamics of market prices and a "fair" price for CO2

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, *Daniele Felletti, Paolo Falbo*

A power producer can switch production between a polluting and a renewable plant. After a description of CO2 emission market in the first trading period, we propose an equation by which a CO2 "fair" threshold price is found below which it is not convenient switching production from polluting to renewable. We show evidence for Germany and Italy.

4 - Does speculation drive oil prices? A new evidence

Cristina Bencivenga, Teoria Economica e Metodi Quantitativi, Università di Roma "La Sapienza", Piazza Aldo Moro 5, 00155, Rome, Italy, Italy, c.bencivenga@dtc.uniroma1.it, *Umberto Triulzi, Rita D'Ecclesia*

Crude oil prices have been showing exceptional volatility with oil price moving from \$ 50 per barrel to \$ 147 per barrel (June 2005 - July 2008) to drop to \$ 50/bd on November 21, 2008. Oil price fluctuation really affects consumers, producers and marketers especially in terms of costs, incentives to invest in technology and trading strategies. At present the price of crude oil does not seem to be provided by the traditional relationship between supply and demand but it is affected by others factors as a dynamic financial market and changing political forces (Stevens L. K., Sessions D. N. (2008)). We assume that active financial traders operating in the oil market may cause large deviations of prices from fundamentals. In particular some "speculators" i.e. large banks and hedge funds, not directly interested in the delivery of oil, may strongly affect this market. The recent rise in oil prices may be generated by both changes in market fundamentals and speculation (Kaufmann R. K., Ullman B. (2009)). Other economists (i.e., Krugman P. (2008)) sustain that the "oil bubble" is not due to speculation but it may be a result of other variables linked to the growing consumption of emerging countries (i.e., China) and the increasing cost of exploration and drilling activities. This paper aims to identify the various factors that affect the dynamics of West Texas Intermediate (WTI) crude oil spot prices and empirically assess their role. The role of the speculative factor is investigated together with macroeconomic variable. Given the non-stationarity of the examined variables a VECM is adopted. The analysis is performed over the period 1993-2009 in order to capture possible changes in the dynamic. Over the entire period one cointegrating vector, i.e., a long run equilibrium is found while over the sub period 2001-2009 two long run equilibrium are detected. The results show that in the period 2001-2009 the variables chosen to measure the speculative factor seem to affect the price dynamic.

WB-29

Wednesday, 10:40 - 12:00

8.2.11

Energy and Environmental Finance

Stream: Financial 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 - Market power and optimal energy production under the EU ETS system

Daniele Felletti, Metodi Quantitativi, Università di Milano-Bicocca, via Bicocca degli Arcimboldi 8, Edificio U7,

■ WB-30

Wednesday, 10:40 - 12:00

8.2.13

Risk Models in Finance

Stream: Operational Research and Quantitative Models in Banking

Invited session

Chair: *João Oliveira Soares*, Engineering and Management, IST, Av. Rovisco Pais, 1049-001, Lisboa, Portugal, joaosoares@ist.utl.pt

1 - Quantitative vs. Qualitative Criteria for Credit Risk Assessment*

João Oliveira Soares, Engineering and Management, IST, Av. Rovisco Pais, 1049-001, Lisboa, Portugal, joaosoares@ist.utl.pt,
Joaquim Pina, *Margarida Catalão-Lopes*

The existing vast literature on credit risk assessment and default prediction provides models building mostly in quantitative indicators. We present the results of a survey carried out of experts from the main banks in Portugal, conveying evidence on the dominant procedures undertaken by the Portuguese banking system. Our analysis concludes on the relevance of qualitative criteria, particularly management's experience and reliability, and on their significant negative correlation with banks' default records. Within this context the paper reflects on the role of multi-criteria decision analysis (MCDA) models as a way to process credit risk assessment integrating qualitative and quantitative aspects.

2 - Consolidation in the European Pharmaceutical Industry

Alain Chevalier, FINANCE, ESCP-EAP, 79, Avenue de la République-PARIS-75011-FRANCE, 75011, PARIS, PARIS, France, chevalier@escp-eap.net

The paper analyses questions related to M&A activity in the European pharmaceutical sector: (a) consolidation forces in the industry, (b) factors which affect the sector's profitability, (c) potential evolutions in the R&D policies. Three M&A cases (Bayer-Schering, Sanofi-Aventis, several Novartis operations) are presented. An attempt is made to assess whether value was created by the acquisition and to identify the existence of abnormal returns. The results will be compared with those of the financial industry.

3 - Incorporating Risk and Uncertainty into MCDM in practice

Brendan O'Brien, University College Dublin, Sheheree, Loreto Road, 1111, Killarney, Co Kerry, Ireland, brendan.obrien@ucd.ie, *Cathal Brugha*

Risk and uncertainty is incorporated in to a structured MCDM method using Direct-Interactive Structured-Criteria (DISC) Multi-Criteria Decision-Making (MCDM). This method specifically combines both financial and non financial aspects of a large decision into a single usable methodology that provides an optimal result even when there are very close alternatives and scores. We propose a method that is robust, usable and uses real criteria structures. The method is implemented in a real case, with actual criteria, actual scores, actual decision makers in a manner that is interactive and refines as the decision progresses.

4 - The information content of option-based forecasts of volatility

Silvia Muzzioli, Economics, University of Modena and Reggio Emilia, V.le Berengario 51, 41100, Modena, Italy, sylvia.muzzioli@unimore.it

The aim of this paper is to investigate and empirically test with market data the information content of option based forecasts of volatility. In particular we examine the predictive power of three different forecasts: Black-Scholes implied volatility, model free implied volatility proposed by Britten-Jones and Neuberger (2000), and corridor implied volatility introduced by Carr and Madan (1998). Moreover we compare the three option-based forecasts with historical volatility in order to see if they subsume all the information contained in the latter.

■ WB-31

Wednesday, 10:40 - 12:00

8.2.15

Industrial applications of scheduling and routing II

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 - Scheduling and routing of harvesting resources

Mikael Rönnqvist, Department of Finance and Management Science, Norwegian School of Economics and Business Administration, NO-5045, Bergen, Norway, mikael.ronnqvist@nhh.no, *David Bredström*, *Petrus Jönsson*

We describe an integrated scheduling and routing problem. Harvesting operations at forest harvest areas are done by harvesters and forwarders. Each team (a harvester and a forwarder) is assigned to a set of harvest areas. Each machine in a team and each harvest area have very different characteristics. The planning problem is complex and we propose a two phase solution method where we in the first we solve an assignment problem (teams to harvest areas) and in a second, the scheduling of each team over its assigned areas. We report results from a case with 46 machines and 968 harvest areas.

2 - Solving The Dynamic Pickup and Delivery Problem with Time Windows Using Hybrid Local Search Metaheuristics

Jawad Omari, Programmes, KADDB, Amman, Amman, Jordan, jawad82@batelco.jo

A local courier firm offers same-day pickup and delivery services of small parcels using its own fleet. The service is booked in advance or requested during the day; each request has specific time periods to perform the service. The firm aims to minimize the total distance traveled by all vehicles. To do so the Dynamic Pickup and Delivery Problem with Time Windows model is used, and an online hybrid metaheuristic based on Variable Neighborhood Search, Tabu Search, and Guided Local Search is created to search for feasible solutions. The hybrid is tested on instances spanning over 30 days.

3 - A Decision Support System for Cruise Yacht Scheduling and Routing

Dimitris Paraskevopoulos, Management Science and Technology, Athens University of Economics and Business, Evelpidon 47A & Lefkados 33, Athens, Athens, Greece, dparaskevop@aueb.gr, *Panagiotis Repoussis*, *Christos Tarantilis*, *George Ioannou*

This study presents a Decision Support System for cruise yacht scheduling and routing. The proposed DSS enables users to generate cruise plans (i.e. sequence of visits, arrival/departure dates and times) according to particular preferences. The latter constitutes a hard combinatorial optimization problem. To this end, the problem is mathematically depicted and a metaheuristic algorithm is designed and developed for solving it. Computational experiments illustrate the performance of the proposed methodology, while the deployment and operation of the DSS on a Greek company is also discussed.

4 - Integrated Crew Pairing and Assignment by Column Generation and Dynamic Constraint Aggregation

Issmail Elhallaoui, Math., Polytechnique, cp. 6079 succ. centre-ville, H3C 3A7, Montreal, Qué., Canada, issmail.elhallaoui@gerad.ca, *Francois Soumis*, *Mohamed Sadoune*, *Guy Desaulniers*

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.

■ WB-32

Wednesday, 10:40 - 12:00

8.2.17

Energy and technological system issues

Stream: Long Term Planning in Energy, Environment and Climate

Invited session

Chair: *Vincent Mazauric*, Strategy & Technology, Schneider Electric, 38TEC/T3 Building, 37 Quai Paul-Louis Merlin, 38050, Grenoble, France, vincent.mazauric@schneider-electric.com

1 - Energy transmission in electrical engineering: A multi-scale approach

Vincent Mazauric, Strategy & Technology, Schneider Electric, 38TEC/T3 Building, 37 Quai Paul-Louis Merlin, 38050, Grenoble, France, vincent.mazauric@schneider-electric.com,
Nadia Maïzi

In order to address the abysmal lack of efficiency of the electrical system (73% of losses, 45% of CO₂ emissions worldwide...!), the laws of electromagnetism are addressed through a thermodynamic-based optimal problem. This approach is shown supporting a multi-scale analysis where the brute minimization condition is replaced by embedded minimizations on the various scales excited by the power electrical system. Following the previous thermodynamic viewpoint, these various scales are reviewed from deep within the material to the whole electrical system.

2 - Optimisation of a multi sources district heating network using Floyd and Moore algorithms

Ghanassia Elie, EDF R&D, 75, Paris, elieghan@yahoo.fr

District heating systems are usually designed for the distribution of centralised heat generation. However, mutualisation fits better to an urban network operating mainly from distributed renewable energies.

This paper deals with multi sources network optimization. A mathematical model, using Moore algorithm in graph theory to optimize the energy transmitted per linear meter has been developed. It implies the utilization of a geographic system of information for a better acquisition of inputs and visualisation of outputs. The results are presented for a real case of a French city district.

3 - Optimization of future power systems focusing on reliability of supply

Mathilde Drouineau, Center for Applied Mathematics, Mines Paristech, 1 rue Claude Daunesse, BP N207, F-06904, Sophia Antipolis Cedex, France, mathilde.drouineau@mines-paristech.fr, *Nadia Maïzi*, *Vincent Mazauric*

The overall efficiency of future power systems is expected to improve with renewable and distributed energy sources, as the level of losses induced by the Carnot cycles are decreased. However these sources challenge reliability of supply and may induce extra-losses. In this work, we apply variational principles, deduced from thermodynamics, to take reliability into account and assess the overall amount of losses. It appears that centralized power systems are disadvantaged by the efficiency of the Carnot cycles, whereas distributed systems are penalized by the losses induced by reliability.

4 - The diversity of Canadian energy policies: an illustration of emerging opportunities using the new model TIMES-Canada

Jean-Philippe Waaub, Geography, UQAM, CP 8888 succ. Centre-Ville, H3C 3P8, Montreal, Quebec, Canada, waaub.jean-philippe@uqam.ca, *Kathleen Vaillancourt*, *Olivier Bahn*, *Richard Loulou*

Regarding energy production, Canada is an important player on the world scene while energy security represents a major challenge for non-producing provinces. Provincial energy systems are diversified and a national energy strategy is missing to optimize the conception of energy policies. Our objective is to analyze the role of renewable electricity using the new technology-rich model TIMES-Canada in two economic scenarios up to 2030. We perform sensitivity analyses on interesting matters for policy making such as electricity exports, oil sands development, liquefied natural gas imports, etc.

■ WB-33

Wednesday, 10:40 - 12:00

8.2.19

Carbon markets

Stream: Energy, Environment and Climate

Invited session

Chair: *Pauline Barrieu*, Statistics, London School of Economics, Houghton street, WC2A 2AE, London, United Kingdom, p.m.barrieu@lse.ac.uk

Chair: *Max Fehr*, Statistics department, LSE, WC2A2AE, London, United Kingdom, m.w.fehr@lse.ac.uk

1 - Existence of a supply function equilibrium for electricity markets

Edward Anderson, Faculty of Economics and Business, University of Sydney, NSW 2006, Sydney, NSW, Australia, edward.anderson@sydney.edu.au

Electricity markets can be modelled using supply function equilibrium (SFE). Often there are asymmetric SFE that are independent of the demand distribution, called 'Strong SFE'. We consider an asymmetric duopoly with fixed marginal costs and capacity constraints. When at low demand scenarios only the cheaper firm is used, and at high demand scenarios the more expensive firm is at its capacity, then a strong SFE may not exist. We demonstrate an equilibrium involving a vertical segment, which is not a strong SFE. In very general circumstances there is exactly one SFE in pure strategies.

2 - Option Pricing in the European Unions Emission Trading Scheme

Max Fehr, Statistics department, LSE, WC2A2AE, London, United Kingdom, m.w.fehr@lse.ac.uk

We propose a model for risk neutral futures price dynamics in the European Unions Emissions Trading Scheme (EU ETS). Historical price dynamics suggests that both allowance prices for different compliance periods and CER prices for different compliance periods are significantly related. To obtain a realistic price dynamics we take into account the specific details of the EU ETS compliance regulations, such as banking and the link to the Clean Development Mechanism (CDM), and exploit arbitrage relationships between futures on EU allowances and Certified Emission Reductions.

3 - On fair pricing of emission-related derivatives

Juri Hinz, Logistics, Zurich University of Applied Sciences, IDP, Rosenstrasse 3, CH-8401, Winterthur, Switzerland, hizr@zhaw.ch

Tackling climate change is at the top of many agendas. In this context, emission trading schemes are considered as promising tools. The regulatory framework of an emission trading scheme introduces a market for emission allowances and creates need for risk management by appropriate financial contracts. In this work, we address logical principles underlying their valuation.

4 - Pricing CO₂ permits using approximation approaches

Rudiger Kiesel, University Duisburg Essen, 47048, Duisburg, Germany, Ruediger.Kiesel@uni-due.de

Equilibrium models have been widely used in literature with the aim of showing theoretical properties of emission trading systems. This paper derives first a new equilibrium model. Second, it is shown that the theoretical permit price is related to changes in the expectation about how long regulated companies will need to exhaust the remaining permits. Third, by application to real data it demonstrates that emission trading systems are inherently prone to jumps.

■ WB-34

Wednesday, 10:40 - 12:00

8.2.23

Fast algorithms for large matrix optimization problems

Stream: Convex Optimization

Invited session

Chair: *Michel Baes*, IFOR, ETH, HG.G.22.1, Ramistrasse 101., 8092, Zurich, Switzerland, michel.baes@ifor.math.ethz.ch

1 - Smoothing techniques for solving structured semidefinite programs

Michael Bürgisser, IFOR, ETH, HG G 22.4, Rämistrasse 101, 8092, Zürich, Switzerland,
michael.buergisser@ifor.math.ethz.ch, Michel Baes

We use smoothing techniques to solve approximately mildly structured semidefinite programs with many constraints. As smoothing techniques require a specific problem format, we introduce an alternative problem formulation that fulfills the structural assumptions. The resulting algorithm has a complexity that depends linearly both on the number of constraints and on the inverse of the accuracy. In the numerical experiments we performed, smoothing techniques compare favorably with interior-point methods for very large-scale instances.

2 - Randomised first-order algorithms for large semidefinite optimization

Michel Baes, IFOR, ETH, HG.G.22.1, Ramistrasse 101., 8092, Zurich, Switzerland, michel.baes@ifor.math.ethz.ch

Solving large-scale and dense semidefinite optimization problems is an extremely difficult task: the size of the problem rules out standard first-order schemes, let alone interior-point methods. Pursuing a research direction initiated by Arkadi Nemirovski, we develop and study some first-order methods where subgradient computations can be accelerated by randomization. We report some numerical experiments on this line.

3 - An alternating direction algorithm for finding jointly sparse extremal eigenvectors

Peter Richtarik, University of Edinburgh, United Kingdom,
peter.richtarik@ed.ac.uk

In this paper we consider the problem of finding jointly sparse minimal and maximal eigenvectors of a symmetric matrix. We first formulate the problem as a nonconvex optimization program with a sparsity-inducing penalty term and then propose and analyze a simple alternating direction algorithm for solving it. It turns out that the emergence of sparsity in the iterates of the method can be explained in geometrical terms. We finish the discussion by giving some preliminary computational results on random matrices and outline an application to compressed sensing.

4 - Kernel-Based Interior-Point Methods for Monotone LCP over Symmetric Cones

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

We present a generic interior-point method for monotone LCP over symmetric cones that is based on barrier functions which are defined by a large class of univariate functions called eligible kernel functions. Furthermore, the method uses Nesterov-Todd search directions. We provide a unified analysis of the method and give a general scheme on how to calculate the iteration bounds for the entire class. For some specific eligible kernel functions we match the best known iteration bound for large-step methods while for short-step methods the best iteration bound is matched for all cases.

We consider a critical path network problem, where a project is completed only after a series of dependent tasks are finished. Task durations are uncertain, but can be insured a priori to mitigate potential delays. One must balance costs incurred in insuring arcs with penalties associated with late project completion times, where lateness penalties are assumed to be lower semi-continuous non-decreasing functions of completion time. We employ RLT to make the problem amenable to solution via Benders decomposition, and demonstrate the efficacy of our approach by testing on a test-set of problems.

2 - Robust formulations for Mixed Integer Non-Linear Programs: uncertainty in routing problems

Hassan Hijazi, Orange Labs & LIF, Orange Labs
R&D/CORE-TPN, 38-40 rue du General Leclerc cedex 9, 92794, Issy-Les-Moulineaux, France,
hassan.hijazi@orange-ftgroup.com, Pierre Bonami, Adam Ouorou

In Telecommunications, operators usually use market surveys and statistical models in order to estimate the evolution of networks' traffic, which often leads to weak management planning decisions. Motivated by this reality, we introduce elements of Robust Optimization theory for Mixed Integer Non-Linear Programs modeling multi-flow delay constrained routing problems. We write and compare different robust formulations offering different protection levels. Computational experiments are developed in order to evaluate the "price of robustness" and to assess the quality of proposed models.

3 - The signomial global optimization algorithm — some recent advances

Andreas Lundell, Process Design and Systems Engineering, Åbo Akademi University, Biskopsgatan 8, FIN-20500, Turku, Finland, andreas.lundell@abo.fi, Tapio Westerlund

The signomial global optimization (SGO) algorithm can be used to solve MINLP problems containing nonconvex signomial functions to global optimality. In the algorithm, convex underestimators for the nonconvex signomial terms are obtained using single-variable power and exponential transformations approximated with piecewise linear functions. In this presentation, some recent advances in regard to this method are discussed, including how it is possible to solve problems where variables with nonpositive bounds need to be transformed using translations in regards

4 - Reduced Reformulation-Linearization Technique for Polynomial Programs

Sonia Cafieri, LOTA, Ecole Nationale d'Aviation Civile, 31055, Toulouse, France, sonia.cafieri@recherche.enac.fr, Pierre Hansen, Lucas Létocart, Leo Liberti, Frederic Messine

Reduced RLT (rRLT) is a special class of Reformulation-Linearization Technique (RLT). This reformulation was originally defined for nonconvex, both continuous and mixed-integer, quadratic programming problems subject to linear equality constraints. It is obtained by replacing some of the quadratic terms with suitable linear constraints, called rRLT constraints. We present an extension of the rRLT theory to the case of general polynomial programs. We also show a strategy to choose the basis of a matrix involved in the rRLT constraints generation so as to improve the chances of tightening the lower bound of the associated convex relaxation. This allows to improve the performance of a spatial Branch-and-Bound algorithm applied to nonconvex NLP and MINLP problems where such convex relaxation is exploited.

■ WB-35

Wednesday, 10:40 - 12:00
6.2.46

MINLP Reformulations and Applications

Stream: Mixed-Integer Non Linear Programming
Invited session

Chair: Leo Liberti, LIX, Ecole Polytechnique, LIX, Ecole Polytechnique, 91128, Palaiseau, France, leoliberti@gmail.com

1 - Expectation and Chance-constrained Models and Algorithms for Insuring Critical Paths

Cole Smith, Industrial and Systems Engineering, University of Florida, PO Box 116595, 32611, Gainesville, FL, United States, cole@ise.ufl.edu, Siqian Shen, Shabbir Ahmed

■ WB-36

Wednesday, 10:40 - 12:00
3.1.05

News from Commercial MIP Solvers

Stream: OR and Real Implementations
Invited session

Chair: Daniel Junglas, CPLEX Development, IBM Deutschland, An den Frankengrääbern 1, 55129, Mainz, Germany, daniel.junglas@de.ibm.com

1 - Recent improvements to ILOG IBM CPLEX

Daniel Junglas, CPLEX Development, IBM Deutschland, An den Frankengrääbern 1, 55129, Mainz, Germany, daniel.junglas@de.ibm.com

We report on features recently added to ILOG IBM CPLEX. This includes performance improvements in particular for parallel algorithms (MIP, barrier) and solvers for quadratic problems as well as improved stability analysis tools. We also present some of the improved interoperability features introduced in the latest versions of ILOG IBM CPLEX.

2 - Recent improvements to FICO Xpress

Oliver Bastert, FICO, Maximilianstr. 35a, 80539, Munich, Germany, oliverbastert@fico.com, *Richard Laundry*

In this talk we take a look at some of the recent improvements to FICO Xpress. We discuss the addition of new modeling constructs to handle logical constraints and describe the new features for handling multiple solutions. On the performance side we present computational results showing the improvements to the Xpress parallel MIP solver and quadratic simplex solvers

3 - Primal Heuristics and Related Features of the SAS/OR MILP solver

Philipp Christophel, Operations Research R&D, SAS Institute, 100 SAS Campus Drive, 27513, Cary, NC, Germany, Philipp.Christophel@sas.com

This talk discusses new features and performance improvements of the SAS/OR MILP solver. It focuses on current research and development in the area of primal heuristics. This includes a discussion about concepts like heuristic strategies, types of primal heuristics, and solution pools. Furthermore it demonstrates how the implementation of these concepts influences the performance of the SAS/OR MILP solver and how it leads to new possibilities for SAS/OR users.

4 - Preprocessing in Linear-Fractional Programming

Anett Racz, Applied Mathematics and probability theory, University of Debrecen, Egyetem tér 1, 4032, Debrecen, Hungary, racz.anett@inf.unideb.hu

Most of the professionally developed solvers automatically use preprocessing techniques to maintain numerical stability and improve performance. In this paper we describe the main results of our investigations connected with preprocessing techniques in Linear-Fractional Programming (LFP), which are based on the use of well-known preprocessing techniques ([Mészáros, Shul (2003)], [Andersen (1995)]) of linear programming and we adapt them to LFP Problems.

■ WB-37

Wednesday, 10:40 - 12:00

3.1.09

MCDA and Public Administration

Stream: MCDA I: New Approaches and Applications

Invited session

Chair: *Norese Maria Franca*, DSPEA, Politecnico di Torino, C.so Duca degli Abruzzi nr. 24, 10129, Torino, Italy, Italy, mariafranca.norese@polito.it

1 - Using a MCDA methodology for evaluating social acceptance of hydrogen technology in France: from collective perceptions to criteria

Sébastien Damart, M-Lab (DRM) - Université Paris Dauphine / CNAM (Chaire EGSS), Université Paris Dauphine Place du Mal de Lattre de Tassigny, 75775, Paris, France, sebastien.damart@cnam.fr, *Amidou Kpoumie*, *Benjamin Rousval*, *Alexis Tsoukiàs*

A MCDA methodology has been used within a research project on the evaluation of the social acceptance of hydrogen (H2) technology in France. At a first stage we collected shared beliefs of citizens about implications of the use of H2 technology. For that purpose focus groups have been organised leading to the construction of collective causal maps. During this stage, scenarios of what would be the evolution of H2 technology use in the next decades have been identified using mainly expert reports and results of already performed forecasts. In the second stage, the causal maps have been synthesised in order to highlight the underlying values and a set of criteria upon which the scenarios could be assessed.

2 - An integrated use of cognitive mapping and multi criteria models to support communication and innovation

Maria Franca Norese, DISPEA Production Systems and Economics, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129, Torino, Italy, mariafranca.norese@polito.it, *Simone Griffa*, *Chiara Novello*

Land monitoring, to plan or control activities, is one of the main functions of the public administration. A new technology, which includes Unmanned Aerial Vehicle platforms, could be an interesting proposal but also a critical situation because several public and private organisations should be involved in the innovation process and different decisional uncertainties and complexities are present and could negatively impact the process. An integrated use of cognitive maps and multicriteria models allowed us to identify the key actors, orient the inquiry and organize all the information elements towards a global definition of some system alternatives and their evaluation and selection.

3 - The Strategic Choice Approach (SCA) for structuring decisional problems in the context of public projects. The Turin East Ring Road case study.

Diana Rolando, Casa Città, Turin Polytechnic, Istituto Galileo Ferraris, Corso Massimo d'Azeglio, 10125, Turin, Italy, diana.rolando@polito.it

During the first phase of complex plans it is necessary to analyse uncertainties and risks associated with the project, to define strategic decisions as well as concrete solutions. SCA is a methodology that adopts a multicriteria approach to shape decision problems, design and compare solutions and control uncertainties, in order to assist decision makers from the involved organizations. Recently SCA has been tested on a complex public project in Turin, to support the decisions to be taken, the criteria for an ELECTRE application and the uncertainties to be analyzed by all the stakeholders.

4 - Real Option Analysis as a Decision Aiding tool

Giulia Lucertini, Università degli Studi di Padova, via venezia 1, 35131, Padova, Italy, Italy, giulialucertini@hotmail.com, *Chiara D'Alpaos*, *Alexis Tsoukiàs*

In our research we propose to use Real Options Analysis (ROA) as a decision aiding tool. In the presentation we first compare customary Cost Benefit Analysis (CBA) to ROA and we focus on the dynamic dimension of ROA which is missing to CBA. We then compare ROA to decision under risk and uncertainty emphasising the concept of information value as options value. We then explore the possibility of using ROA as a tool for generating alternatives in public policy evaluation.

■ WB-38

Wednesday, 10:40 - 12:00

6.2.44

Lot-sizing models

Stream: Inventory Management

Invited session

Chair: *Wilco van den Heuvel*, Econometric Institute, Erasmus University Rotterdam, Burg. Oudlaan 50, P.O. Box 1738, 3000DR, Rotterdam, Netherlands, wvandenheuvel@ese.eur.nl

1 - Reformulations of the economic lot-sizing problem with remanufacturing

Mathijn Retel Helmrich, Erasmus School of Economics, Erasmus University Rotterdam, Postbus 1738, 3000 DR, Rotterdam, Netherlands, retelhelmrich@ese.eur.nl, *Wilco van den Heuvel*, *Raf Jans*, *Albert Wagelmans*

The classic lot-sizing problem has been extended with a remanufacturing option. In each period, we can choose to set up a process to remanufacture returned products or produce new items. These processes can have separate or joint set-up costs. We show that both cases are NP-hard. A "natural" MIP formulation contains big M constraints. Therefore, we propose several alternative formulations, inspired by reformulations of the classic problem, namely Eppen & Martin's shortest path reformulation, Van Vyve & Wolsey's partial shortest path reformulation and the (L,S,WW) valid inequalities.

2 - Gray Markets and All Units Discounts

Mengze Shi, rotman school of management, university of toronto, 105 st george street, m5s 3e6, toronto, ontario, Canada, mshi@rotman.utoronto.ca

Gray market is the unauthorized channel of distribution for a supplier's authentic products. This paper studies the gray market caused by a reseller responding to the supplier's all-unit quantity discount offerings. We perform closed form analysis of the reseller's dynamic optimal lot-size decisions in response to supplier policies. A novel feature of our solution is the precisely expressed relationship between holding costs and the supply of goods to the gray market. We also identify conditions under which a profit maximizing supplier is more likely to accommodate the gray market.

3 - Effective replenishment policies for the multi-item dynamic lot-sizing problem with inventory limited

Jose M Gutierrez, Estadística, Investigación Operativa y Computación, Universidad de La Laguna, Facultad de Matemáticas, Av. Astrofísico Fco. Sánchez s/n., 38271, La Laguna, Tenerife, Spain, jmgrrz@ull.es, *Marcos Colebrook*, *Beatriz Abdul-Jalbar*, *Joaquín Sicilia*

We address the dynamic lot-sizing problem considering multiple items and storage capacity. Despite we can easily characterize a subset of optimal solutions just extending the properties of the single-item case, these results are not helpful to design an efficient algorithm. Accordingly, heuristics are appropriate approaches to obtain near-optimal solutions for this NP-hard problem. Thus, we propose a heuristic procedure based on the smoothing technique, which is tested on a large set of randomly generated instances.

4 - Some lot-sizing models with perishable items

Wilco van den Heuvel, Econometric Institute, Erasmus University Rotterdam, Burg. Oudlaan 50, P.O. Box 1738, 3000DR, Rotterdam, Netherlands, wvandenheuvel@ese.eur.nl, *Mehmet Onal*, *Edwin Romeijn*

We consider a lot-sizing model with perishable items. We assume that items deteriorate completely after a deterministic lifetime and can not be sold thereafter. Furthermore, the order in which items are distributed to the customer depends on the customer preference and the way items are exposed to the customer by the store manager. In this way items may be consumed in four different manners: (i) Last-Expired, First-Out, (ii) First-Expired, First-Out, (iii) First-In, First-Out, or (iv) Last-In, First-Out. We consider the complexity and propose algorithms for the different models.

■ WB-39

Wednesday, 10:40 - 12:00
6.2.45

Scheduling and Pricing

Stream: Scheduling under Resource Constraints
Invited session

Chair: *Wieslaw Kubiak*, Faculty of Business Administration, Memorial University, Prince Philip Drive, A1B 3X5, St. John's, NL, Canada, wkubiak@mun.ca

1 - Dynamic resource scheduling

Joanna Jozefowska, Institute of Computing Science, Poznań University of Technology, Piotrowo 2, 60-965, Poznań, Wielkopolska, Poland, jjozefowska@cs.put.poznan.pl, *Lukasz Jozefowski*, *Wieslaw Kubiak*

A scheduling problem is considered where multiple users with various importance compete for a scarce resource and the resource allocation should guarantee appropriate service rate objectives for the users. We consider so called dynamic environment in which the parameters describing instances of the problem may change in an unpredictable way. The problem occurs within a broad spectrum of systems, including databases, mediabased applications, and networks. In this paper a scheduling algorithm based on the divisor methods of apportionment is presented for solving the problem.

2 - An overview on shop scheduling with minimum time lags

Djamel Rebaine, Informatique et mathématique, Université du Québec à Chicoutimi, 555, boul. de l'Université, G7H 2B1, Chicoutimi, Québec, Canada, drebaine@uqac.ca

We consider the two-machine shop problems with unit-time operations and minimum time lags. The goal is to seek a schedule with a minimum makespan. In this talk we give an overview for the flow shop, open shop, single machine with coupled operations, and generalizations with parallel machines. We start with preliminary results. Then, for each of the mentioned models, we present results on well solvable cases and worst-case analysis.

3 - Makespan Minimization of Multi-Slot Just-In-Time Scheduling on Single and Parallel Machines

Dariusz Dereniowski, Algorithms and System Modeling, Gdańsk University of Technology, ul. Gabriela Narutowicza 11/12, 80-233, Gdańsk, Poland, deren@eti.pg.gda.pl, *Wieslaw Kubiak*

In this talk we address the problem of minimizing the number of slots and makespan of multi-slot just-in-time schedules. We are interested in the latter (more general) optimization criterion. Several algorithmic results are presented, including efficient optimal algorithms for the single machine problem and for a multiple machine case when the processing time of each job does not exceed its due date; and a polynomial-time approximation algorithm for a general case on parallel machines.

An interesting application of this task scheduling model is a routing problem in a slotted ring network.

4 - Bullwhip effect emergence into an after-sales spare part service supply chain in Telecom firms - A complex system approach

Mauricio Flores, Systems, Instituto Politecnico Nacional, Petirrojo #9, Las Alamedas, 52970, Atizapan de Zaragoza, Estado de Mexico, Mexico, fcmauricio@yahoo.com, *Oswaldo Morales Matamoros*, *Ricardo Tejeida Padilla*, *Isaias Badillo Piña*

Telecom Equipment Manufacturers have a great opportunity to capture revenue and profit from telecommunications service providers by provide them after-sales spare part services of repairable units. The challenge is to match the supply process and demand process in order to support 99.999% of availability of the telecom network. Unfortunately these two processes cannot match perfectly, and the effect is the bullwhip effect. In order to cope with this problem, this paper studies the bullwhip effect emergence under a complex system approach.

■ WB-40

Wednesday, 10:40 - 12:00
6.2.52

Optimal Control and Design in Applications

Stream: Engineering Optimization
Invited session

Chair: *Volker Schulz*, University of Trier, 54296, Trier, Germany, Volker.Schulz@uni-trier.de

Chair: *Moritz Diehl*, ESAT, K. U. Leuven, Kasteelpark Arenberg 10, 3001, Leuven, Belgium, moritz.diehl@esat.kuleuven.be

1 - Aerodynamic Shape Optimization under Uncertainty

Claudia Schillings, University of Trier, Germany, claudia.schillings@uni-trier.de, *Volker Schulz*

A novel approach towards stochastic distributed uncertainties is discussed for the specific application of shape uncertainties in aerodynamic design. While the random field of uncertainties is approximated by a goal-oriented Karhunen-Loeve expansion, an adaptively refined sparse grid is used to discretize the resulting probability space. Algorithmic approaches based on multiple-setpoint ideas in combination with one-shot methods will be presented as well as numerical results.

2 - Large Scale Aerodynamic Shape Optimization

Stephan Schmidt, University of Trier, Universitätsring 15, FB IV - Mathematics, 54296, Trier, Germany, Stephan.Schmidt@uni-trier.de, *Volker Schulz*

Shape calculus techniques for aerodynamic shape optimization are presented that result in a shape derivative existing only on the surface of the aircraft. Thus, this adjoint based sensitivity can be computed very efficiently and a large deformation of the aircraft shape is possible using every CFD mesh node position as a design parameter. The resulting loss of regularity is treated by considering the shape Hessian, which is derived for Stokes and Navier-Stokes flows using operator symbols.

3 - Double Smoothing Algorithm for a class of Optimal Control problems

Olivier Devolder, CORE, Université catholique de Louvain (UCL), Louvain-la-Neuve, Belgium,
olivier.devolder@uclouvain.be, François Glineur, Yurii Nesterov

We consider an optimal control problem governed by a linear differential system. The constraints are formed by some convex bounds on the states at finite number of instants, and by point-wise convex constraints on the control. We tackle this class of problems by a dual approach, without preliminary discretization. Dualization of the state constraints leads to a non-smooth convex problem in finite dimension. We apply a double smoothing. Our strategy is supported by a worst-case complexity analysis.

■ WB-41

Wednesday, 10:40 - 12:00
3.1.06

Long Term Financial Decisions

Stream: Long Term Financial Decisions

Invited session

Chair: Ursula Walther, Frankfurt School of Finance and Management, Sonnemannstrasse 9-11, 60314, Frankfurt/M, Germany, u.walther@frankfurt-school.de

1 - Is Timing Money? The Return Shaping Effect of Technical Trading Systems

Peter Scholz, Frankfurt School of Finance and Management, 60314, Frankfurt am Main, Germany,
p.scholz@frankfurt-school.de

The success of technical trading systems still seems puzzling. Previous research is mainly based on historical backtests. This work investigates the hypothesis that trend following systems should profit from autocorrelated returns. Therefore, we test trading systems on asset returns which were simulated by different parameterized stochastic processes. To evaluate the performance, the return distribution is compared to the buy-and-hold strategy, applying concepts of stochastic dominance and expected utility.

2 - Development of Service Quality (SQ) reference model in Private Banking (PB)

Erkan Sengün, Institut für Management, Universität Koblenz-Landau, 56070, Koblenz,
erkansenguen@uni-koblenz.de

Is the high level of service quality the right way of success for the PB Market? Or is "good" Service quality far enough? The purpose of this research is to construct a measurement instrument to capture sustainable and optimal SQ in the German PB market. It allows to achieve competitive advantage and a better understanding of the subject perception (customer satisfaction, trust, commitment and customer loyalty, etc.). Due to the banker's discretion there are almost no representative data about the wealth PB clients available.

3 - Diversification effects of asset price process parameters — an empirical investigation

Ursula Walther, Frankfurt School of Finance and Management, Sonnemannstrasse 9-11, 60314, Frankfurt/M, Germany,
u.walther@frankfurt-school.de, Andriy Fetsun

Higher moments of asset price distributions — especially skewness — have long been recognized as important characteristics in asset pricing and risk management. However, it is less well known that portfolio characteristics other than variance may not diversify on a portfolio level but even accumulate. We study this behavior based on a parameterized description of asset price processes using GARCH-type models and non-normal increments. We analyze historical buy-and-hold-portfolios of German stocks and also study aggregation effects of simulated returns.

■ WB-42

Wednesday, 10:40 - 12:00
3.1.07

Decision Making 4

Stream: Decision Making

Contributed session

Chair: Ali Eshragh Jahromi, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, 5095, Adelaide, South Australia, Australia,
Ali.EshraghJahromi@unisa.edu.au

1 - The impact of uncertainty in Decision Support for waste management organizations

Ali Eshragh Jahromi, School of Mathematics and Statistics, University of South Australia, Mawson Lakes Campus, 5095, Adelaide, South Australia, Australia,
Ali.EshraghJahromi@unisa.edu.au, Jerzy Filar

By directive of the EU existing substances like plastics or glass waste have to be collected, recycled and commercialized as secondary raw materials. While the value of these substances is small, the expenses for recycling and transportation are considerable. Therefore waste management organizations are interested in minimizing their expenses for this process. For the case of deterministic input data a generalized two-stage assignment and transportation model for this real-world problem has been presented before. This model has been integrated into a custom-made DSS, and generates substantial savings for the waste management organization. In this talk we highlight the impact of uncertainty in input data for the problem under consideration. Furthermore we present an adaptation of the previous model, which is able to cope with this kind of uncertainty. Finally we present computational results for the new model, and discuss the benefits of considering uncertainty.

2 - A combined method to deal with conflicting software requirements

Catarina Gomes, Uninova-CA3, Casa Emilio Cebola, Casal das Figueiras, 2970-261, Sesimbra, Portugal,
catarina.alex.gomes@gmail.com, Rita Ribeiro

The objective of this work is to contribute to the resolution of conflicting situations between software requirements (e.g security requirement may affect negatively the performance requirement) that may appear during software development life cycle. Thus, it is important to provide support regarding the decision of which requirements are more relevant and the priority order in its implementation. To this aim we used a search graph algorithm, called BFS (Best First Search), which seems appropriate for finding the ideal solution, i.e. the one responsible for satisfying or implementing all conflicting requirements, with the lower cost and pointing the ideal implementation path ordering.

■ WB-43

Wednesday, 10:40 - 12:00
8.2.02

Sustainable Construction Processes

Stream: OR for Sustainable Development

Invited session

Chair: Jana Šelih, Faculty of Civil and Geodetic, University of Ljubljana, Jamova 2, 1000, Ljubljana, Slovenia, jselih@fgg.uni-lj.si

1 - Sustainability assessment of construction processes

Jana Šelih, Faculty of Civil and Geodetic, University of Ljubljana, Jamova 2, 1000, Ljubljana, Slovenia,
jselih@fgg.uni-lj.si, Aleksander Srdic

Recently the definition of quality has been extended to a more comprehensive level, which also includes sustainable performance of products and processes. This is especially valid for construction. The purpose of the paper is to develop a rational and unambiguous method to assess the sustainable performance of the complete construction production chain. The developed multi-criteria decision method is robust and easy-to-use to facilitate the implementation of the method in practice. It is based on Life Cycle Assessment (LCA). A case study analysis is presented.

2 - New Classification of Construction Companies: Overhead Costs Aspect

Rasa Apanaviciene, Dept of Civil Engineering Technologies, Kaunas University of Technology, Studentu str. 48-401, LT-51367, Kaunas, Lithuania, rasa.apanaviciene@ktu.lt, *Ala Daugeliene*

The traditional classification of construction companies depending on the number of employees is not appropriate when analysing the competitiveness of construction companies. The collected data of Lithuanian construction companies was analysed by applying statistical methods and the construction companies were classified into competitiveness classes according to the relative value of the overhead costs. The new classification provides the basis for economical evaluation of the construction companies and modelling of their competitiveness in regard to the value of overhead costs as well as applying the competitive advantages for the estimation of construction bidding price.

3 - ERP system implementation in Latvian construction company

Andrejs Tambovcevs, Riga Technical university, Latvia, ata2000@inbox.lv

ERP systems have the potential to integrate seamlessly organizational processes using common shared information and data flows. The purpose of the study is to investigate ERP system implementation process in the construction company in Latvia. The study briefly described the business processes involved in the company and illustrated how ERP systems could be implemented and the efficiency of management system consequently enhanced. This study also argues that ERP systems are important source of organizational change with major implications for the organization and management of work.

4 - Environmental Management Systems Experience among Latvian Construction Companies

Tatjana Tambovceva, Faculty of Engineering Economics and Management, Riga Technical University, Mezha street 1/7- 213, LV-1048, Riga, Latvia, tatjana.tambovceva@rtu.lv, *Ineta Geipele*

The concept of sustainable development has become widespread amongst government agencies, politicians, corporations and other organizations around the world. The purpose of this study is to investigate experiences and effects of ISO 14001 in Latvian construction companies. Our results show that the companies primarily expect an external recognition of the EMS activities. ISO 14001 often leads to reduced environmental impact, especially in the area of waste. The authors conclude that it is necessary to let all personnel to participate in work with the EMS as early as possible.

■ WB-44

Wednesday, 10:40 - 12:00

8.2.03

Vector and Set-Valued Optimization III

Stream: Vector and Set-Valued Optimization

Invited session

Chair: *Enrico Miglierina*, Dipartimento di Economia, Università dell'Insubria, via Monte Generoso 71, 21100, varese, Italy, enrico.miglierina@uninsubria.it

1 - Characterizations of Calmness and Subregularity of Constraint Set Mappings

Helmut Gfrerer, Institute for Computational Mathematics, Johannes Kepler University Linz, Altenbergerstr 69, A-4040, Linz, Austria, gfrerer@numa.uni-linz.ac.at

The existence of nondegenerate multipliers in first-order necessary conditions at a local minimizer is related to the validity of some constraint qualification condition, for instance the property of metric subregularity of the constraint set mapping or equivalently, the calmness property of the solution mapping. In this talk we present characterizations of calmness/subregularity. We will see that there are some limitations when using exclusively first-order analysis, which can be bypassed assuming some part of the constraint mapping to be known subregular or by using second-order analysis.

2 - Generalized convexity for multiobjective problems with conic constraints

Beatriz Hernández, Economics, University Pablo de Olavide, Edificio N° 3, José Moñino - 2ª planta-despacho26, Ctra. de

Utrera, Km. 1- 41013 Sevilla, 41013, SEVILLA, Spain, mbherjim@upo.es, *Marko A. Rojas-Medar, Rafaela Osuna-Gómez, Antonio Rufián-Lizana*

Taking in mind Craven's notion of K-invexity function and Martin's notion of Karush-Kuhn-Tucker-invexity, we give a new notion of generalized convexity that is both necessary and sufficient to ensure every vector Karush-Kuhn-Tucker point is a weakly efficient solution for multiobjective problems with conic constraints. Moreover, it is the weakest to characterize the set of weakly efficient solutions. The notions and results that exist in the literature up to now are particular instances of the ones presented here.

3 - Mountain Pass-type Theorem for Vector-Valued Functions

Enrico Miglierina, Dipartimento di Economia, Università dell'Insubria, via Monte Generoso 71, 21100, varese, Italy, enrico.miglierina@uninsubria.it, *Ewa Bednarczuk, Elena Molho*

The mountain pass theorem for scalar functions is a fundamental result of the minimax methods in variational analysis. Here we give a result that extends this approach to vector valued functions. Under suitable geometrical assumptions, we prove a theorem that ensures the existence of a critical point of the considered function f and we localize this point as a solution of a minimax problem for the function f . We remark that the considered minimax problem consists of an inner vector optimization problem and of an outer set-valued optimization problem.

■ WB-45

Wednesday, 10:40 - 12:00

8.2.12

New Trends of Facility Logistics

Stream: Facility Logistics

Invited session

Chair: *Yugang Yu*, Rotterdam School of Management, Erasmus University, T10-38, Burg. Oudlaan 50., P.O. Box 1738, 3000 DR, Rotterdam, Netherlands, yugang@rsm.nl

1 - A Location Problem in Construction Management

Huseyin Guden, Industrial Engineering, Baskent University, 06531, Ankara, Turkey, hsyngdn@yahoo.com, *Haldun Sural*

In construction projects (im)mobile concrete plants are located to build viaducts and tunnels on a line over a time horizon. There are costs of opening and moving a plant and transporting concrete to sites. The problem is to determine the number, type, and movement of the plants and to make the concrete production - allocation decisions so that the total cost is minimized. We develop two strong integer models for the problem. Using a real project data, we are able to solve the models to optimality. We also perform a sensitivity analysis on the solution and provide computational results.

2 - Optimal Dislocation of Transport Junctions

Vaclav Cempirek, Transport Technology and Control, Univerzita Pardubice, Studentska 95, 53201, Pardubice, Czech Republic, hana.cisarova@upce.cz

Optimization of transport junctions in Hub and Spoke system is very timely in the context of growing demands for quality and the speed of transport. The current trend of concentration of traffic flows into larger and economically less demanding transport session, it entails the issue of distribution hubs. There are many possible algorithms. Majority, these algorithms are heuristic. This contribution provides a detailed description of genetic algorithm that is suitable for solving the optimal location of transmission junctions.

3 - Material handling systems - the future is now

Dominik Berbig, Institut für Fördertechnik und Logistiksysteme, KIT, Gotthard-Franz-Straße 8, 76131, Karlsruhe, Germany, berbig@kit.edu, *Christian Huber, Frank Schönung, Christoph Nobbe, Kai Furmans*

Requirements for material flow systems have undergone a great change. Flexibility, modularity and energy efficiency have become key aspects. There is a need for reconfigurable material flow systems and, consequently, adequate as well as compatible analysis. This paper deals twofold with this circumstance: In a first step, innovative (but close to industrial application) technologies to render manufacturing systems flexible are presented. In a second step, both, well-suited analysing techniques to quantify the benefits and recently developed simulative and analytical tools are illustrated.

■ WB-46

Wednesday, 10:40 - 12:00

8.2.14

Stochastic Optimization Models

Stream: Stochastic Programming 2 [c]

Contributed session

Chair: *Marta Kostrzewska*, Institute of Mathematics, University of Silesia, ul. Bankowa 14, Katowice, 40-007, Katowice, Poland, marta.kostrzewska83@gmail.com

1 - Strategic Capacity Planning under Dynamic Probabilistic Demand

Ashis Chatterjee, Operations Management, Indian Institute of Management Calcutta, Joka, DH Road, 700104, Kolkata, West Bengal, India, ac@iimcal.ac.in, *Dipankar Bose*

The existing single period models in Strategic Capacity Planning under demand uncertainty have been extended in this paper to a two period multi product model to capture seasonality of demand. Models have been developed for both Flexible and Dedicated Plant. While deciding on first period production, the actual demand is assumed as not known and demand for period 1 is known at the start of period 2. The resulting two-stage stochastic linear program has been solved by simulated data based optimization. Solutions have been examined to study the economics of Flexible and Dedicated plant.

2 - The Problem of Minimum Cost Flow on Dynamic Generative Network Flows

Seyed Ahmad Hosseini, Computer Science, University of Tehran, Tehran, University of Tehran, 0098, Tehran, Tehran, Iran, Islamic Republic Of, ahmad.s.hosseini@gmail.com

This paper is concerned with a new class of network flows called dynamic generative network flows in which the flow commodity is dynamically generated at source nodes and dynamically consumed at sink nodes. It is assumed that the source nodes produce the flow according to time generative functions and the sink nodes absorb the flow according to time consumption functions. The minimum cost dynamic flow problem for a pre-specified time horizon T is defined and mathematically formulated and some methods are developed to solve the problem.

3 - Stochastic single product network design model with lead time and safety stock considerations

Mehdi Sharif Yazdi, Department of Industrial Engineering, University of Science and Culture, 's Gravendijkwal 83, 3021 EG, Rotterdam, Netherlands, mehdi.sharif@gmail.com, *Leyla Ozsen*, *Behzad Bagheri*

The stochastic single product network design model with lead time and safety stock considerations (SSPNLDS) performs a tradeoff between capacity utilization and flexibility in long run. SSPNLDS simultaneously decides on locating DCs, selecting their capacity and allocating retailers to DCs regarding capacity and coverage constraints as well as demand and lead time uncertainty. The paper presents a nonlinear program minimizing total expected cost of location, pipeline inventory, and safety stock over a set of discrete scenarios and proposes a Lagrangian-relaxation-based algorithm.

4 - Optimization methods for stochastic cost flow problem

Marta Kostrzewska, Institute of Mathematics, University of Silesia, ul. Bankowa 14, Katowice, 40-007, Katowice, Poland, marta.kostrzewska83@gmail.com, *Leslaw Socha*

The minimum cost flow problem in stochastic network is considered. The costs per unit of flow on the arcs of the network are assumed to be independent random variables and the criteria of minimization are the expected value and the second moment of the total cost of flow. This problem is transformed to the bi-criteria minimum cost flow problem with the linear and the quadratic objective functions. Two sandwich methods for approximation of the efficient frontier of considered problem with the convergence proofs are proposed. Moreover, the approximate methods for the determination of the distribution of the total cost are studied.

■ WB-47

Wednesday, 10:40 - 12:00

8.2.16

Activities for Popularization of Science

Stream: Young People for System Theory, Optimization and Education

Invited session

Chair: *Kateryna Pereverza*, Students Science Association, National Technical University of Ukraine, Kyiv, Revutskogo, 19/1, app. 282, 02091, Kyiv, Ukraine, pereverza.kate@gmail.com

1 - Promoting and Disseminating Science among Youth: Peculiarities and Perspectives

Ielyzaveta Korotchenko, National Technical University of Ukraine "Kyiv Polytechnic Institute", prospect Peremohy 37, 03056, Kyiv, Ukraine, Korotchenko.liza@gmail.com

The paper considers the role of promoting of science in Ukraine due to its significant role in the development of the country. Talented youth, involved into science, can make a breakthrough using new technologies and inventions. The affective ways of disseminating science, encouraging young people for scientific research, intellectual endeavors in general are viewed. Based on the experience of Students' Science Association and real-life examples, different approaches, measures, agents, programs and initiatives for promoting of science, particularly OR, among youth are presented in this talk.

2 - Organizing of Scientific and Educational Projects as a Way to Integrating Students into Scientific Community

Alexej Orlov, Students Science Association, Institute for applied system analysis of National Technical University of Ukraine "KPI", Peremohy ave., 37, build. 1, room 299(15), 03056, Kyiv, Ukraine, orlov.alexej@gmail.com, *Kateryna Pereverza*

In this report we will consider participation of young people in organization of scientific and educational projects as a way to integrating them into scientific community and motivating them to build academic careers. Usefulness of such approach would be demonstrated in example of projects of Students Science Association of NTUU KPI. Organizing team of SSA projects consist totally from KPI students. Their motivations to participate in project organizing, opportunities that open up for students and project management approach which is used at SSA are presented in this paper.

3 - Activity of Student's Organizations for Popularization of Science: Russian Experience

Oleg Tumanov, Biology and soil, Kazan state university, Kremlevskaya st., 18, 420008, Kazan, Russian Federation, leick@inbox.ru

Different student's organizations and associations play a significant role in popularization of science especially among youth. Organization of scientific conferences and competitions by these institutions has a success in involving youth into science. A Russian experience of promoting science among youth will be presented. It will be illustrated with the examples of organizing projects aimed on science population and educational actions which have already demonstrated their effectiveness.

4 - Leadership style and organizations' strategic orientation

Gabrijela Leskovar-Špacapan, Faculty of Economics and Business, University of Maribor, Razlagova 20, 2000, maribor, Slovenia, gabrijela.leskovar-spacapan@uni-mb.si

The paper analyses whether strategic orientations of Slovenian organizations are supported by leadership style that influence employees' perception of support for innovation. It is hypothesized that organizations with different strategic orientations exhibit different levels of employees' perception of support for innovation as caused by differences in leadership style. Hypotheses were tested using variables measured through multiple items based on data from 195 organizations. The results confirm that leaders have significant impact on employees' perception of support for innovation and thus on creativity and innovation.

■ WB-48

Wednesday, 10:40 - 12:00

8.2.04

Iterative Methods for Economic Models: Related Topics

Stream: Iterative Methods for Economic Models

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

1 - Complex Dynamic Multi-level Networks

Patrizia Daniele, Department of Mathematics and Computer Science, University of Catania, Viale A. Doria, 6, 95125, Catania, Italy, daniele@dmf.unict.it

We shall consider a supply chain network model with three tiers of decision-makers (manufacturers, retailers, and consumers) in the case when prices and shipments are evolving on time. Moreover, we assume that excesses of production and excesses of demand of the commodity are present. For such a framework we furnish, using the infinite dimensional duality theory, the equilibrium conditions for the representatives of each tier of the supernetwork, the time-dependent variational formulation governing the complete supply chain supernetwork, and we provide some existence theorems.

Wednesday, 12:20 - 13:40

■ WC-02

Wednesday, 12:20 - 13:40

3.2.14

Keynote Talk 11

Stream: Keynote Speakers

Invited session

Chair: *Jacek Blazewicz*, Instytut Informatyki, Politechnika Poznańska, ul. Piotrowo 2, 60-965, Poznań, Poland, jblazewicz@cs.put.poznan.pl

1 - The Discretizable Molecular Distance Geometry Problem

Nelson Maculan Filho, COPPE / PESC, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil, maculan@cos.ufrj.br

The function of a protein is determined by its 3D structure. Nuclear Magnetic Resonance (NMR) experiments provide distances between some pairs of atoms of a protein. The Molecular Distance Geometry Problem (MDGP) consists in finding all the atomic positions of the molecule by exploiting the distances generated by the NMR experiments. In practice, the MDGP is solved by continuous optimization methods. We show that under a few realistic assumptions, the MDGP can be formulated as a search in a discrete space, where we call this MDGP subclass the Discretizable MDGP (DMDGP). We prove that the DMDGP is also NP-hard and we propose a Branch-and-Prune (BP). The BP algorithm performs remarkably well in practice in terms of speed and solution accuracy. We present computational results on several artificial and real-life instances.

■ WC-04

Wednesday, 12:20 - 13:40

3.2.13

Facilities planning, design and management

Stream: Metaheuristics

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: *Eric Taillard*, HEIG-Vd, Route de Cheseaux 1, Case Postale, 1401, Yverdon-les-Bains, Vaud, eric.taillard@heig-vd.ch

1 - An Estimation of Distribution Algorithm for Machine Part Cell Formation Problem

Ibrahim Saber, Quantitative methods, FSEG, sfax, sfax, Tunisia, saber.ibrahim@gmail.com, *Bassem Jarboui*, *Rebai Abdelwaheb*

We propose to apply a novel evolutionary algorithm called Estimation of Distribution Algorithm for the first time to the Part Cell Formation Problem. To improve solution, we added the Variable Neighborhood Search as a local search. Furthermore, we present two evaluation criteria called the Grouping Efficacy and the Percentage of Exceptional Elements to quantify the goodness of the obtained solutions. An extensive comparative study was elaborated with the existing literature. The obtained results have shown that the proposed EDA is very competitive against the previously best results.

2 - A particle swarm optimization algorithm for a pick and place robotic system

Slim Daoud, LOSI, university of technology of Troyes, 12 rue marie curie, 10000, troyes, France, slim.daoud@utt.fr, *Farouk Yalaoui*, *Lionel Amodeo*, *Hicham Chehade*, *Thierry Girard*

In this work, we are interested in a robotic system which realizes pick and place operations. The robots must seize the products on a conveyor and deposit them on fixed points. This system was studied in 2000 by Mattone et al who developed different queuing strategies. To optimize the system, we have developed a particle swarm optimization algorithm which defines the suitable scheduling rules for each robot. The objective is to maximize the gripping rate. The obtained results are compared to an exact method and the results are promising. The developed method is applied on an industrial case.

3 - Electromagnetic Meta-Heuristic Method for Solving Floorplanning Problem

Seyyed Hassan Taheri, Mathematics, Khayyam University, Fallahi 1 - Shahrak Lashkar, 91775-1159, Mashhad, Iran, Islamic Republic Of, s_h_taheri@yahoo.com, *Eric Taillard*

The floorplanning problem consists in finding the optimal positions for a given set of departments of fixed area within a facility such that the sum of distances between pairs of department that have a positive connection cost is minimized. This is a NP-hard combinatorial optimization problem. This paper applies the Electromagnetism-like Meta-Heuristic method with some local search to the floorplanning problem. We provide results from several test problems that demonstrate the robustness of this approach across different problems and parameter setting.

4 - Minimizing Working Time in the Straight Assembly Line with Deteriorating Tasks

E. Maneshi, industrial engineering, iran university of science and technology, no. 2, 9.7 alley, 9 st, Sheikh-e-Bahai, Tehran, Tehran, Iran, Islamic Republic Of, ershad505@gmail.com, *M.b. Aryanezhad*, *U. Bahalke*, *M. Karimi-Nasab*, *A.m. Yolmeh*

Assembly line scheduling is a category of assembly line balancing problems (ALBP), where the optimal schedule of the tasks and their assignments to different workstations should be determined simultaneously. Total working time of a product in the most industrial factories dealing with a set of deteriorating tasks is important because of its costs. So this paper introduces the effect of task deterioration in to the total working time of a product in a straight assembly line. Task deterioration means that a task processed later consumes more time than the same task when it is processed earlier. The following assumptions are considered in this research: - there are a fixed number of workstations in a simple straight assembly line, - there are a set of dependent tasks that should be assigned and scheduled to each workstation while considering the precedence relations between the tasks, - every task should be performed only one time in each cycle, - at each workstation, there is a multi-skilled machine able to perform all of the tasks assigned to that workstation, - there is a single product to be processed, - it is assumed that no machine breaks down when performing each task assigned to it. In other words, interruption is not allowed. On the other hand, pre-emption is not allowed, - setups are assumed to be negligible, - planned machine idleness is not allowed, but idleness could occur for the difference of the station time and the cycle time, - performance time of each task consists of two main parts: a fixed part, and a variable part which depends on the delay in the start time of the task and its deterioration coefficient, - production manager desires to obtain the optimal tasks' schedule corresponding to minimum value of the total working time (because of tasks' deterioration) while suggesting a virtual value for the worst cycle time. In other words, production manager does not accept tasks' schedules and assignments with larger cycle time than what he proposes based on his previous experiences (as an upper bound for cycle time).

Then the problem is formulated via a mathematical model. As the problem is strongly NP-Hard, a genetic algorithm is developed to solve the problem in large scales. Finally, several well-known test problems are solved for illustrating the proposed approach.

■ WC-05

Wednesday, 12:20 - 13:40

3.2.16

Matheuristics

Stream: Metaheuristics

Invited session

Chair: *Matteo Fischetti*, DEI, University of Padova, Italy, matteo.fischetti@unipd.it

Chair: *Filipe Alvelos*, Departamento de Produção e Sistemas, Universidade do Minho, Campus de Gualtar, 4710-057, Braga, Portugal, falvelos@dps.uminho.pt

1 - A hybrid Multiple Particle Collision Algorithm applied to a source estimation inverse problem

Eduardo Luz, Applied Computing Grad. School, National Institute for Space Research, Av. Astronautas 1758, CAP/LAC, 12227010, Sao Jose dos Campos, SP, Afghanistan, eduardofpl@gmail.com, *José Carlos Becceneri*, *Haroldo F. Campos Velho*

This work presents the application of the Multiple Particle Collision Algorithm (MPCA), hybridized with the SIMPLEX algorithm, for estimating the location and the strength of a polluting source. The MPCA is a Metropolis based algorithm, broadly inspired in the scattering and absorption of particles while in nuclear reaction. The source estimation inverse problem is a non-linear optimization problem, where the objective function is given by the square difference between the pollutant concentration measured and the pollutant concentration computed from a Lagrangian particle dispersion model.

2 - A Primal-Dual Local Search Heuristic for the Set Covering Problem

Belma Yelbay, Sabanci University, Sabanci University Tuzla Campus, Istanbul, Turkey, byelbay@su.sabanciuniv.edu, *S. Ilker Birbil*, *Kerem Bulbul*

We present a heuristic algorithm for solving the set covering problem effectively. It is based on the primal-dual approach which is commonly used for approximating NP-hard optimization problems. Unlike the traditional primal-dual algorithms, our algorithm uses a dual variable selection method which performs well for cost and coverage correlated problems. We improve the solution quality through a local search procedure based on primal and dual variable fixing. We show that the proposed heuristic is able to produce good results in terms of both the solution quality and time.

3 - A local search heuristic based on column generation

Filipe Alvelos, Departamento de Produção e Sistemas, Universidade do Minho, Campus de Gualtar, 4710-057, Braga, Portugal, falvelos@dps.uminho.pt, *Amaro de Sousa*, *Dorabella Santos*, *Carina Pimentel*, *Elsa Silva*, *J. M. Valério de Carvalho*

We propose a local search heuristic for integer programming models with a very large number of binary variables which has three main steps. In the first step, the problem is solved by column generation. In the second step, an initial solution is constructed by using primal and dual information from the restricted master problem. In the third step, based on the representation of a solution as a subset of columns, local search is applied. We illustrate the application of the heuristic in a multicommodity flow problem and in a two-dimensional bin packing problem.

■ WC-06

Wednesday, 12:20 - 13:40

8.2.30

DEA Applications XI

Stream: DEA and Performance Measurement

Invited session

Chair: *Mikulas Luptacik*, Economics, Vienna University of Economics and Business Administration, Augasse 2-6, A-1090, Vienna, mikulas@chello.at

1 - Changes in productivity of Spanish university libraries

Clara Simon de Blas, Statistics & Operations Research, Rey Juan Carlos University, Departmental II, Desp. 251, C/Tulipan s/n, 28933, Mostoles, Madrid, Spain, clara.simon@urjc.es, *Jose Simon Martin*, *Alicia Arias*

We analyze productivity growth, technical progress, and efficiency change in a sample of 34 Spanish university libraries between 2003 and 2007. DEA and a Malmquist Index are combined with a bootstrap method to provide statistical inference estimators of individual productivity, technical progress, and efficiency change scores. To calculate productivity, a three-stage service model has been developed. The results indicate a growth in the internal productivity of the libraries and in the productivity of the service.

2 - Initial Allocation of Emission Certificates Using Data Envelopment Analysis

Mikulas Luptacik, Economics, Vienna University of Economics and Business Administration, Augasse 2-6, A-1090, Vienna, mikulas@chello.at

In the paper we present a new approach for the initial allocation of the emission certificates. Using data envelopment analysis the amount of free allocated certificates to the plants is based on their eco-efficiency scores. We suppose that there is a centralized decision maker who supervises all the operating units. Applying and extending the centralized resource allocation model by Lozano-Villa (2004) the amount of free allocated certificates is based on their eco-efficiency such that the total amount of emissions is minimized.

3 - Academia and business world on bank performance: Are they on the same page? Developing a case for China

Necmi Avkiran, UQ Business School, The University of Queensland, St Lucia Campus, 4072, Brisbane, Queensland, n.avkiran@uq.edu.au

Majority of applications of DEA in banking do not test for the association of efficiency estimates with key performance indicators used by industry. As Chinese banks come under increasing scrutiny, identifying efficiency estimates' associations with accepted financial measures of performance could guide benchmarking activities, pricing decisions and regulatory monitoring. Following a systematic test of super-efficiency models, super SBM emerges as the most significant model explaining the variation in the two industry ratios post-tax profit/average total assets, and return on average equity.

4 - Evaluating mutual funds using robust nonparametric techniques

Amparo Soler-Dominguez, Universitat Jaume I, 12071, Castellon, adomingu@cofin.uji.es, *Juan Carlos Matallin-Saez*, *Emili Tortosa-Ausina*

Literature evaluating the performance of mutual funds using OR has evolved rapidly. The instruments applied (mostly DEA and FDH) have the ability of encompassing several dimensions of performance, but they have also some drawbacks that may have prevented a wider acceptance. In this article we apply not only the nonconvex counterpart of DEA, namely, FDH but also order- m and order- m partial frontiers to a sample of Spanish mutual funds. The results obtained for both order- m and order- m are quite useful, since a full ranking of performance is obtained. Although results hinge on the specified m and parameter.

■ WC-07

Wednesday, 12:20 - 13:40

8.2.47

Machine Scheduling

Stream: Project Management and Scheduling [c]

Contributed session

Chair: *Sinan Gürel*, Middle East Technical University, METU Department of Industrial Engineering, 06531, Ankara, Turkey, sgurel@ie.metu.edu.tr

1 - Single-machine scheduling with a general learning effect function

Wen-Chiung Lee, Statistics, Feng-Chia University, 100 Wenhua Road, 407, Taichung, Taiwan, wclee@fcu.edu.tw

Scheduling with learning effects has become a vivid area of research recently. However, it is assumed that the functions of the learning effects have specific forms in most of the existing models. In this paper, we propose a new model in which the actual job processing time is a general function of the processing time of jobs already processed and its scheduled position. It has the flexibility to describe different learning curves. Most of the models in the literature are special cases of our proposed model. We provide the optimal sequences for some single-machine problems.

2 - Scheduling of jobs in a parallel machine problem with eligibility and release and queue times

Manuel Mateo, Departament Business Administration, Universitat Politècnica Catalunya, Avda Diagonal, 647, 7th, E-08028, Barcelona, Spain, manel.mateo@upc.edu, *Xavier Garriga*, *Imma Ribas*

The problem dealt is the scheduling of parallel machines with eligibility, i.e. not all the jobs can be manufactured in any machine. The previous and the next operations also introduce release times and queue times. The three-step algorithm proposed solves the problem of a set of n jobs to be scheduled on m parallel machines distributed among p levels, particularly three levels are studied. A machine can produce jobs of the same or a lower level. Any machine has the same processing time for a job. The objective is to find a feasible schedule with minimum completion time C_{max} .

3 - Finite-capacity-based due date setting: A computational study for flowshops

Paz Perez Gonzalez, Industrial Management, University of Sevilla, Camino de los descubrimientos s/n, 41092, Sevilla, Spain, pazperez@esi.us.es, *Jose M Framinan*, *Jose M. Molina-Pariente*

In this work we analyse a dynamic permutation flowshop shop floor, where new jobs arrive while old jobs are already scheduled with a committed due date, which must be considered as a deadline. The problem is to schedule the new jobs in order to determine the tightest possible due dates. In our paper we analyse the different problems that may arise depending on whether the old jobs can be rescheduled, or not. The distribution of solution of these problems are analyzed in order to study their structure and to help selecting the more suitable solution procedures to be applied.

4 - Decompositions and conic formulations for railway design problems with convex congestions at yard locations

Sinan Gürel, Middle East Technical University, METU Department of Industrial Engineering, 06531, Ankara, Turkey, sgurel@ie.metu.edu.tr

Finding optimal yard and arc capacities are as critical as routing decisions in railway scheduling problems. Congestion realized at yard locations can be reduced by increased yard capacities which require high investment costs. Finding the yard locations at which the capacity should be increased simultaneously with routing decisions on railway network is a difficult problem. Nonlinear nature of congestion costs brings further difficulty in solving these problems. We propose using decomposition and conic formulation approaches for this problem and compare computational performance.

■ WC-08

Wednesday, 12:20 - 13:40

6.1.36

Various Advances on Management and Scheduling I

Stream: Project Management and Scheduling

Invited session

Chair: *Erwin Pesch*, FB 5 - Institute of Information Systems, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, pesch@fb5.uni-siegen.de

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Edmund Burke*, School of Computer Science & IT, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, ekb@cs.nott.ac.uk

1 - Monthly tour scheduling models with mixed skills considering weekend off requirements

Aiyng Rong, Cemapre (Center for Applied Mathematics and Economics), ISEG-Technical university of Lisbon, Rua do Quelhas 6, 1200-781, Lisbon, Portugal, arong@iseg.utl.pt

This paper deals with the monthly tour scheduling problem with mixed skills considering the weekend off requirements, in contrast to the weekly planning horizon that is typical in most literature. Two model formulations are developed based on implicit programming techniques. One model uses a general integer programming formulation while the other one adopts a binary integer programming formulation. The effectiveness and efficiency of the two model formulations are illustrated and compared by the numerical tests based on realistic data sets.

2 - Reducing schedule instability on the order level for the multi-item capacitated lot-size problem

Andreas Cardeneo, Logistics Systems Engineering, FZI Forschungszentrum Informatik, Haid-und-Neu-Strasse 10-14, 76131, Karlsruhe, Germany, cardeneo@fzi.de, *Sebastian Fiedler*

Schedule stability is of increasing importance as it reduces dispatching time and harmonizes shop floor logistics. It has been subject of quite some publications on different types of MRP problems. Here, schedule stability for the MLCLSP in a multi-period rolling horizon setting, where demand is given by customer orders that change throughout the planning horizon, is addressed. A new penalty term measuring schedule instability and experimental results showing the impact of a selected set of environmental and design factors on schedule instability are presented.

3 - Coordination of the branch closing times and scheduling the unloading operations in a parcel transfer center

Kadir Ertogral, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu cd. No:43, 06560, Ankara, Turkey, kertogral@etu.edu.tr, *Onur Dikmen*

Parcel transportation problems have received great deal of attention in the literature on different aspects, such as truck routing, network design, consolidation decisions, and operational planning in transfer centers. Our study deals with coordinating the branch closing times and scheduling the unloading operations of the trucks in a local transfer center of a national parcel carrier. The problem is modeled as an integer programming formulation. The formulation is based on a model for a parallel machine scheduling problem from the literature, with several modifications. Since the formulation of the problem is too big to solve to the optimality, we suggest a heuristic solution approach based on a linear programming relaxation of the model, and show the effectiveness of the heuristic approach through numerical experiments.

WC-09

Wednesday, 12:20 - 13:40
6.2.53

Advanced Applications 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: *Domingos Cardoso*, Departamento de Matematica, Universidade de Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, dcardoso@ua.pt

1 - Optimal Pricing, Marketing and Order Quantity for One Laptop Per Child

Mostafa Ghasem Esfahani, Iran University of Science and Technology, Iran, Islamic Republic Of, mesfehani2002@yahoo.com, *Seyed Jafar Sadjadi*

One of the primary concerns on One Laptop Per Child (OLPC) program is to find a suitable pricing strategy. The OLPC program provides various packages to penetrate different under developed countries. We present a mathematical model to determine the optimal price, marketing and ordering lot-size for this program. In this model, demand is considered as a function of price and marketing expenditure while the cost of production is a function of order size. The whole program is a kind of charity and the next goal is to maximize the total profit from the market. The resulted model is formulated as a Geometric Programming (GP). Therefore, we use the recent advances of optimization techniques called CVX to find the optimal solution.

2 - An Upper Bound for Quadratic Multiple Knapsack Problem

Tugba Saraç, Industrial Engineering Department, Eskisehir Osmangazi University, Meselik Kampüsü M3, 26480, Eskisehir, Turkey, tsarac@ogu.edu.tr

The Quadratic Multiple Knapsack Problem (QMKP) with k knapsacks, each with its own capacity ck , asks to maximize a quadratic objective function subject to $k+1$ inequality constraints. Finding an upper bound is important for this kind of problems because in most cases, inexact methods are used to solve them and upper bounds help to know what the quality of the obtained solution is. Upper bounds are also used in branch-and-bound algorithm. In this study, an upper bound is proposed for QMKP and its performance is evaluated by using test instances taken from the literature.

3 - An Entropy-based Solver for Multidimensional Nonlinear Knapsack Problems

Yuji Nakagawa, Department of Informatics, Kansai University, 2-1-1 Ryouzenji-Cho, 569-1095, Takatsuki, Japan, nakagawa@res.kutc.kansai-u.ac.jp, *Ross J. W. James*, *César Rego*, *Chanaka Edirisinghe*

We develop an implicit enumeration method for solving difficult linear and nonlinear multidimensional knapsack problems where branching is accomplished based on the sub-problem complexity. Using the concept of entropy in information theory, we develop a (sub)problem-difficulty metric that is used to devise decision rules for problem partitioning within implicit enumeration. Comparisons with state-of-the-art solvers show that our method is extremely efficient.

4 - A mathematical approach to seek the natural and practical piano fingering

Keisuke Hotta, Faculty of Information and Communication, Bunkyo University, 1100 Namegaya, 253-8550, Chigasaki, Kanagawa, Japan, khotta@shonan.bunkyo.ac.jp

Given a piano score, the piano fingering problem is to decide the natural and reasonable fingering for the piano performance. The problem is not only the allocation of fingers to notes in score, but also some kind of melody analysis of music. Considering several costs based on that, I modeled the problem as 0,1-IP, and tried to seek the practical fingering. The determination of the fingering is based on a lot of rules, which several piano players and researchers have mentioned. However, some of them seem like a contradiction. I also seek the useful and helpful rules for the fingering.

WC-11

Wednesday, 12:20 - 13:40
8.2.38

Advances in the Use of Information Technology III

Stream: Emerging Applications of OR

Invited session

Chair: *Sevgi Ozkan*, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, İsmet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Innovative Training Methodologies for Transport Trainers

Ivan Kolarov, Machine Design, HST, Geo Milev Str. N 158, 1574, Sofia, Bulgaria, ikolarov@vtu.bg

An investigation of the main ICT application for continuing training of drivers and transport specialists in accordance with Directive 2003/59/EC is presented. The best practices of innovative methods for training used by transport specialists in 6 European countries (ES, EL, IT, LT, UK and BG) are analyzed and the needs of trainers in the sector are determined. Perspective training methodologies with application for creation of Virtual Learning Community for the needs of sector are specified. Results of this investigation will be used for creation of a tool for transport trainers.

2 - Residual intelligibility estimation method on a safety area border

Elena Arkhypova, Institute of Physics and Technology, National Technical University of Ukraine 'Kyiv Polytechnic Institute', 37 Prospect Peremogy, Kiev 03056, Ukraine, str.Malyshko 21-b,ap.77 Kiev 02192, Ukraine, Kiev, Ukraine, leoo@zeos.net, *Vladimir Zhuravlev*

It is realized analytical and experimental researches which solve the task that consists in an objective estimation of one-dimensional speech masking efficiency parameter on a safety area border. This parameter estimation method is developed on the basis of the correlation coefficient statistical characteristics analysis. Articulation words tables are developed for the first time with regard to statistical parameters of the Ukrainian language phonetic structure. Articulation tests which confirm adequacy of the offered method are carried out.

3 - Optimization of time-triggered communication protocols by means of Resource Constrained Project Scheduling with Temporal Constraints

Zdenek Hanzalek, DCE, CTU, Karlovo nam 13, 121 35, Prague, Czech Republic, zdenek.hanzalek@fel.cvut.cz, Premysl Sucha

The objective is to choose schedule of the communication protocols and to minimize the makespan of time-triggered messages in order to maximize the space for other messages. Messages are characterized by release dates, deadlines, end-to-end deadlines, synchronisation and precedence relations. The resources can be characterized as one processor (single-channel Flexray) or dedicated processors (Profinet) or identical processors (two-channel TTP). In the case of wireless communications the message transmission occupies several collision domains and therefore it is a multiprocessor task.

4 - Evaluate Outsourcing Design Systems Performance based on GRA

Cheng-Ru Wu, Yuanpei University, Taiwan, alexru00@ms41.hinet.net, Chiu-Chin Chen, Che-Wei Chang

This study focused on using the grey relational analysis (GRA) decision support tools for the Taiwan bureau's control information systems (CIS) analysis the outsourcing design information systems performance case studies. GRA in the combination-based approach, this article provides decision-makers are doing outsourcing design, to more practical and accurate in line with the standard structure of domestic industries to enhance the control of outsourcing design the overall effectiveness of information systems.

WC-12

Wednesday, 12:20 - 13:40

8.2.39

AHP 07

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: Gulgun Kayakutlu, Industrial Engineering, Istanbul Technical University, Macka, 34367, Istanbul, Turkey, gkayakutlu@gmail.com

1 - Applying the Delphi and AHP for Selecting the Optimal International Exhibition Agency

Pi-Fang Hsu, Department of Communications Management, Shih Hsin University, No.1, Lane 17, Mu-Cha Road, Sec.1, 11604, Taipei, Taiwan, celina9@ms26.hinet.net, Hsin-Yu Chiang

This study develops a model for selecting international exhibition agency. First, the proposed model adopts the modified Delphi method to identify suitable criteria for evaluating exhibition agency. Next, the research model applies the analytic hierarchy process (AHP) to calculate and rank the optimal exhibition agency. Additionally, the example of a renowned Taiwanese bedding company is used to demonstrate the process of exhibition agency selection using this model. The proposed model helps enterprises effectively select media agency, making it highly applicable in academia and commerce.

2 - Influential Causes of Bullwhip Effect in Automotive Supply Chain

Fatih Tas, Industrial and Mechanical Engineering, Istanbul Technical University, Pasalimani Cad. Selehattin bey apt., 34/6 Uskudar, 34472, Istanbul, Turkey, tasfatih88@hotmail.com, Gulgun Kayakutlu

Bullwhip effect is an important obstacle for supply chain success. Researchers are focused on six causes of bullwhip effect: demand fluctuations, order batching, shortage gaming, price fluctuation, lead time, and level of echelons in the supply chain. This study aims to determine the sequence of importance of these causes in the automotive industry using Analytic Hierarchy Process (AHP) method. Supply chain managers of both spare parts chain and finished products chain are interviewed. The level of echelons is found to be the most important cause in this industry unlike other industries.

3 - Correction Approach for Solving the Pairwise Comparison Matrix Inconsistency

Dmitry Borodin, Business Information and ICT, University College of Ghent, Schoonmeersstraat 52, 9000, Ghent, Belgium, dmitriy.borodin@hogent.be, Viktor Gorelik

The work proposes a correction approach to solve the problem of the inconsistency of the pairwise comparison matrix. Two correction techniques forcing such matrices to the consistency are demonstrated together with the results of computations and their comparison with other different approaches. Pairwise comparisons are central in mathematics for the measurement of intangible factors, as proven in the AHP/ANP theory (T. Saaty). To recover the scale for decision making, it is necessary to solve the respective eigenvalue problem, which brings us to the pairwise comparison inconsistency.

4 - Interactive Comparison Support with Comparison Pattern Search for Analytic Hierarchy Process

Yumi Tadano, Graduate School of Information Science and Technology, Hokkaido University, North 14, West 9, Kita-ku, 060-0014, Sapporo, Hokkaido, Japan, yumi-hr@complex.eng.hokudai.ac.jp, Hidenori Kawamura, Keiji Suzuki

The analytic hierarchy process (AHP) is a method for decision making. The AHP calculate overall evaluations according to structure a hierarchy of the problem and compare two elements of the hierarchy's each level. Therefore, the comparisons of all pairs are difficult when evaluating many alternatives. We propose a comparison support method for evaluating many alternatives when decision maker needs to decide the highest priority alternative. The comparison support method stops pairwise comparisons when the highest priority alternative is found even if all comparisons aren't compared.

WC-13

Wednesday, 12:20 - 13:40

2.2.21

Location and Network Design

Stream: Location Analysis

Invited session

Chair: Ivana Ljubic, Department of Statistics and Decision Support Systems, University of Vienna, Bruennerstr. 72, 1210, Vienna, Austria, ivana.ljubic@univie.ac.at

1 - Lagrangean Decomposition for an Adaptive Location-Distribution Problem

Bernard Gendron, DIRO/CIRRELT, Université de Montréal, C.P. 6128, succ. Centre-ville, H3C 3J7, Montréal, Québec, Canada, gendron@iro.umontreal.ca, Paul-Virak Khuong, Frédéric Semet

We consider a location problem motivated by a case study for a multi-channel retailing company, which sells a wide variety of products via Internet, mail order catalogs, and stores. Since most items to deliver are small or medium-size parcels, consolidation is a major concern which is addressed by designing a multi-echelon distribution system. This system is adaptive, in the sense that terminals and satellites can be opened or closed easily according to demand fluctuations. We introduce a Lagrangean decomposition approach embedded in a branch-and-bound scheme, which can deliver provably optimal solutions to large-scale instances of the problem.

2 - The Hop-Constrained Connected Facility Location Problem

Stefan Gollowitz, Department of Statistics and Decision Support Systems, University of Vienna, Bruennerstraße 72, 1210, Vienna, Austria, stefan.gollowitz@univie.ac.at, Ivana Ljubic

The Connected Facility Location (ConFL) problem models the Fiber-To-The-Curb strategy for broadband local access networks. The problem generalizes the Uncapacitated Facility Location and the Steiner tree problem. We consider a variant of ConFL, in which the number of edges between a predefined root and each open facility is limited. We provide a theoretical and computational comparison of MIP models for this problem. Finally, we show how to model the problem on layered graphs. Our computational study shows the computational advantage of the latter approach over classical MIP models.

■ WC-14

Wednesday, 12:20 - 13:40

2.2.15

Stochastic Methods in Finance and Economics

Stream: Actuarial Sciences and Stochastic Calculus

Invited session

Chair: *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

Chair: *Juan Pablo Rincon-Zapatero*, Economía, Universidad Carlos III de Madrid, c/ Madrid, 126, 28903, Getafe, Madrid, Spain, jrincon@eco.uc3m.es

1 - Consumption, portfolio and life insurance rules for time-inconsistent decision makers

Jesús Marín-Solano, Matemàtica Econòmica, Financera i Actuarial, Universitat de Barcelona, Av. Diagonal, 690, Barcelona, Spain, jmarin@ub.edu, *Jorge Navas*, *Oriol Roch*

The assumption of a constant discount rate of time preference has been questioned by empirical findings about how agents change their preferences over time. However, the use of standard optimal control techniques for problems with other discount factors apart from the exponential function with a constant rate can lead to time inconsistent solutions. In this paper we solve a problem of consumption, portfolio and life insurance rules for a decision maker with a non-constant discount rate of time preference.

2 - Effect of Term Structure of Futures Price on Spot Procurement Policies

Ankur Goel, Operations, Case Western Reserve University, 10900 Euclid Avenue, Peter B Lewis Building, 44106, Cleveland, OH, ankur.goel2@case.edu, *Genaro Gutierrez*

We characterize optimal procurement policy of commodity from the spot market under the paradigm of fluctuating spot prices and stochastic demand. In particular, we explore the effect of additional term structure information of futures prices on the procurement policies from the spot market. In this regards, we compare one-factor stochastic price model with a two-factor model. In addition, we also explore the benefits of frequent calibration of stochastic price process on the procurement cost structure of a firm.

3 - Risk-Sensitive Discounted and Average Criteria in Finite State 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

The usual optimization criteria for Markov decision chains as total discounted or average costs cannot reflect variability-risk features of the problem. To this end, we focus attention on policies yielding minimal risk-sensitive costs, i.e., if the stream of discounted or undiscounted one-stage costs is evaluated, instead of linear by an exponential utility function. Necessary and sufficient optimality conditions for discounted and average risk-sensitive criteria as well as conditions guaranteeing independence of average costs on starting state will be discussed.

4 - Replacement Investment under Tax Uncertainty

Joao Zambujal-Oliveira, Engineering and Management, Technical University of Lisbon, Av. Rovisco Pais, Lisboa, 1049-001, Lisbon, Portugal, j.zambujal.oliveira@ist.utl.pt

This paper examines the asset replacement problem to investigate the optimal level under an uncertain tax environment and considering a depreciation policy. Based on the concept of equivalent annual cost, a minimization model, applied to the real options paradigm, allows innovative evaluations for flexibility in the replacement process analysis. This model improves previous ones since it considers a semi-autonomous process for salvage value. Assembled over a partial differential equation framework, the model integrates several processes (GBM, mean reversion and jump process), which are integrated in a cost function that supports replacement decisions under varying tax environment. The general analytical and particular numerical solutions differ significantly from those observed in previous models, providing evidences of over valued levels of replacement and corroborating that different types of uncertainties can produce non-monotonous effects on the optimal replacement level. The outcome is a new and stronger approach to the EAC literature, supplying an algorithm conditioned by a variable salvage value and changes on tax regime.

■ WC-15

Wednesday, 12:20 - 13:40

2.2.12

Arc Routing Problems

Stream: Vehicle Routing [c]

Contributed session

Chair: *Luis Gouveia*, DEIO, University of Lisbon, Campo Grande, Bloco C6, 1749-016, Lisbon, Portugal, legouveia@fc.ul.pt

1 - Rural Postman and related Arc Routing Problems

Ana Maria Rodrigues, INESC Porto/ ISCAP-IPP, INESC Porto, Campus da FEUP RuaDr. Roberto Frias, n 378, 4200-465, Porto, Portugal, amr@inescporto.pt, *José Soeiro Ferreira*

The presentation addresses the Rural Postman Problem (RPP) and related Arc Routing Problems (ARPs). The RPP (NP-Hard problem) has the objective of determining a minimum cost circuit traversing the required edges at least once (not all the edges of the graph are required). Applications appear in many contexts: mail delivery, garbage collection, street cleaning and cutting problems. The idea is to characterize, illustrate links and hierarchies and propose an organization to facilitate the understanding and integrate all the related ARPs. A reference to the solutions methods will also be made.

2 - Models for the Sectoring-Arc Routing Problem (SARP)

Ana Catarina Nunes, Dep. Métodos Quantitativos, ISCTE - IUL / Centro IO, Portugal, Av. das Forças Armadas, 1649-026, Lisbon, Portugal, catarina.nunes@iscte.pt, *Cândida Mourão*

The Sectoring-Arc Routing Problem (SARP) models the activities associated with the streets of large urban areas, such as waste collection. The SARP is defined over a mixed graph. Its aim is to identify a given number of similar sectors (sub-graphs) and to build a set of collecting trips in each sector, such that the total duration of the trips is minimized. Each sector is collected by one vehicle and each of its trips can not exceed a given load. Linear mixed integer programming formulations are presented for the SARP, and computational results over a set of benchmark problems are reported.

3 - Bounds for the Mixed Capacitated Arc Routing Problem

Cândida Mourão, Dep. Matemática, Instituto Superior de Economia e Gestão / Centro IO, Rua do Quelhas, 6, Gabinete 203, 1200-781, Lisboa, Portugal, cmourao@iseg.utl.pt, *Luis Gouveia*, *Leonor S.Pinto*

Mixed Capacitated Arc Routing (MCARP) models are widely used in distribution or collection problems where vehicles with limited capacity perform certain activities that are continuously distributed along some pre-defined links (routes, streets) of an associated mixed network. We present methods to obtain bounds for the problem. The quality of the methods is tested on some benchmark instances. We discuss and compare it with the best known method from the MCARP literature used for medium and large sized instances.

4 - A Lower Bound and a Hybrid ILS-VND for a Location Arc Routing Problem

Labadi Nacima, ROSAS, University of Troyes, 12, rue Marie Curie, BP2060, 10010, Troyes, France, nacima.labadi@utt.fr, *Jan Melechovsky*

This note deals with a variant of the Capacitated Location Arc Routing Problem (CLARP). The problem is defined on a two level undirected weighted graph, with plants, potential depots and customers (edges with positive demands). The goal is to determine the depots to open and for each depot, the plants from whose it would be provided to service the edges assigned to it; in order to minimize the total cost. An integer linear programming is developed and its linear relaxation is used to derive a valid lower bound. To solve the problem, A hybrid ILS VND is also designed.

■ WC-16

Wednesday, 12:20 - 13:40

2.2.14

Improving Real-time Railway Operations

Stream: Public Transport [c]

Contributed session

Chair: *Dennis Huisman*, Econometric Institute, Erasmus University, Rotterdam, Netherlands, huisman@ese.eur.nl

1 - Robust Train Scheduling based on the UK Network

Banafsheh Khosravi, School of Management, University of Southampton, Southampton, United Kingdom, B.Khosravi@soton.ac.uk, *Julia Bennell*, *Chris Potts*

We consider the computationally hard problem of scheduling trains for large or complicated networks. The problem can be formulated as a job shop scheduling problem subject to a set of operational and safety constraints. Our proposed model makes use of a modified disjunctive graph. The objective is to minimize the total weighted tardiness to avoid delay propagation in a passenger network which is based on the railway system in the UK. We develop a solution method inspired by the successful results of local search procedures to solve job shop scheduling problems.

2 - Dispatching and coordination in real-time railway traffic management

Francesco Corman, Department of Transport and Planning, Delft University of Technology, -, Delft, Netherlands, f.corman@tudelft.nl, *Andrea D'Ariano*, *Dario Pacciarelli*, *Marco Pranzo*

Train conflict resolution in multiple dispatching areas either requires to solve a large centralized problem or to solve and coordinate several smaller problems. This paper compares centralized and distributed approaches for dispatching trains in a large Dutch railway network. Computational experiments show that centralized control outperforms the distributed one when the timetable provides good guidance for dispatching. On the other hand, distributed control is the most effective approach when severe disruptions require deep modifications to the timetable in order to recover feasibility.

3 - Standardisation of service intention and interfaces for automatic train scheduling

Sabrina Wiedersheim, D-Math, ETH Zurich, Institute for Operation Research, ETH Zurich, HG G21.2, Raemistr. 101, 8092, Zurich, Zurich, Switzerland, wsabrina@ethz.ch, *Gabrio Curzio Caimi*, *Leo Kroon*, *Marco Laumanns*, *Dick Middelkoop*

In the last years, many train scheduling models and algorithms have been developed. However, the specification of input data and the interfaces between different scheduling steps often differ. In particular, the description of the commercial requirements of a timetable, the so-called service intention, varies from approach to approach. We present how to resolve this discrepancy by introducing standards for the specification of input and output data. This way, collaboration between different countries and research groups becomes easier and comparison between different methods is more meaningful.

4 - Delay Management with Passenger Re-Routing

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*

Delay management determines which connections should be maintained in case of a delayed feeder train. Current delay management models assume that the delay for a passenger who misses a connection equals the cycle time of the timetable. In reality, passengers will adjust their route when a connection is dropped. We propose a model that takes passenger re-routing into account explicitly. We have developed several methods that solve the resulting integer programs in a short amount of time. The quality of these methods is compared using real-life instances from Netherlands Railways.

■ WC-17

Wednesday, 12:20 - 13:40

1.3.14

Regression and Its Application

Stream: Computational Statistics

Invited session

Chair: *Pakize Taylan*, Mathematics, Dicle University, 21280, Diyarbakir, Diyarbakir, Turkey, ptaylan@dicle.edu.tr

1 - Time Series Forecasting Using Fuzzy Time Series Approach, Neural Network Models and Regression Splines

Akhlitdin Nizamitdinov, Statistics, Anadolu University, Anadolu University Faculty of Science, Department of Statistics, Eskisehir, Turkey, ahlidin@gmail.com, *Memmedaga Memmedli*, *Ozer Ozdemir*

Neural network models, regression splines and fuzzy time series approach have important affects to improve forecasting of time series. Hence, in this study, we aim to improve time series forecasting by using a fuzzy time series approach, regression splines such as P-Spline and Cubic Smoothing Splines and neural network models such as Generalized Regression Neural Networks (GRNN), Linear Network, Multi Layer Perceptron (MLP) and Radial Basis Function (RBF). All results are shown by using them for daily, weekly and monthly close prices of Istanbul Stock Exchange (ISE) national-100 index.

2 - Support Vector Machine for Time Series Regression

Ange-Michel Poli, Université de Corse, 20250, Corte, France, poli.ange-michel@wanadoo.fr

Support Vector Machines (SVMs) have been extensively used in classification and regression. In this talk we will show how SVMs can be used to predict specific aggregated values from a time series. Applications in finance will also be discussed.

■ WC-18

Wednesday, 12:20 - 13:40

1.3.15

Stochastic Models and Optimization

Stream: Stochastic Modeling and Simulation

Invited session

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Design and Planning of Green Supply Chains: A Fuzzy Approach

Tânia Pinto Varela, UMOSE-LNEG, Estrada do Paço do Lumiar, 1649-038, Lisbon, Portugal, Tania.pinto@ineti.pt, *Ana Paula Barbósa-Póvoa*, *Augusto Novais*

Green Supply Chains can be seen as logistic structures that guarantee production and distribution of products in an environmental friendly manner. To pursue this goal companies must invest on the optimal design/planning of their logistic structures, while considering the trade-off between profit and environmental impacts. This is addressed here using a generic and uniform mathematical framework (Resource-Task-Network). For this bi-level optimization a symmetric fuzzy linear programming approach is used, where those objectives are replaced by a new one embodying a compromise between them.

2 - On the Structural Analysis of Inventory Problems with Inventory-dependent Demand

Frank Y Chen, Department of Systems Engineering & Engineering Management, Chinese University of Hong Kong, Hong Kong, China, yhchen@se.cuhk.edu.hk

We consider how inventory should be managed when inventory affects sales in a periodic review setting. Models to be analyzed include those with a general demand function (by which demand varies with the stocking or displayed quantity) and a general cost structure. Capitalizing on our prior experience gained in related inventory-pricing control problems, we are able to establish structural results for these models.

■ WC-19

Wednesday, 12:20 - 13:40

1.3.20

Large-scale Mixed Optimization Problems

Stream: Nonsmooth Optimization

Invited session

Chair: *F-Javier Heredia*, Statistics and Operations Research, Universitat Politècnica de Catalunya, Jordi Girona 1-3, Campus Nord, C5, 08034, Barcelona, Catalunya, Spain, f.javier.heredia@upc.edu

1 - Solving tough instances of the controlled tabular adjustment problem

José Antonio González Alastrué, Dept. Estadística e Investigación Operativa, UPC, Edificio C5, Campus Nord, Jordi Girona 1-3, 08034, Barcelona, Spain, Jose.A.Gonzalez@upc.edu, *Jordi Castro*

Controlled tabular adjustment (CTA) is an efficient method for disclosure control of tabular data released by national statistical agencies (NSA). CTA results in mixed integer linear problems which are difficult to be solved by generic solvers; in some instances, it is even difficult to find a feasible solution. In this work we present several techniques (e.g., block coordinate descent, SAT procedures for initial feasible points, etc) that may drive a difficult instance towards a quality solution within a reasonable time limit (required by NSAs in the real world).

2 - Perspective cuts for solving the optimal electricity market bid problem with bilateral contracts

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, *F-Javier Heredia*

The electric market regulation in Spain (MIBEL) establishes the rules for bilateral contracts in the day-ahead optimal bid problem. Our model allows a price-taker generation company to decide the unit commitment of the thermal units, the economic dispatch of the bilateral contracts and the optimal sale bids observing the MIBEL. The uncertainty of the spot prices is represented through scenario sets. We solve this model as a deterministic MIQP problem by using perspective cuts to improve the performance of Branch and Cut approach. Numerical results are reported.

3 - On the use of Probabilistic Algorithms in Nonsmooth Optimization

Angel A. Juan, Computer Science, Open University of Catalonia, Rambla Poblenou, 156, 08018, Barcelona, Spain, ajuanp@gmail.com, *Bernardo Ruiz*, *Helena Ramalhinho Lourenço*, *Javier Faulin*, *Carlos Mendez*

This presentation discusses the use of probabilistic or randomized algorithms for solving nonsmooth optimization problems. We then propose the use of probability distributions, such as the Geometric or the Triangular ones, to add a biased random behavior to classical heuristics such as the Clarke and Wright Savings heuristic for the Vehicle Routing Problem or the NEH heuristic for the Flow Shop Scheduling Problem. By randomizing these heuristics, a large set of alternative good solutions can be quickly obtained in a natural way. Some specific examples of this technique are analyzed to illustrate the main ideas behind this approach.

4 - Endogenous model for medium-term electricity generation planning in liberalized mixed markets

Laura Mari, Statistics and Operations Research, Univ. Politecnica de Catalunya, C Jordi Girona 1-3, Campus Nord - Ed C5, Dptx 201, 08034, Barcelona, Spain, laura.mari@upc.edu, *Narcis Nabona*

Mixed electricity markets have pool auction and bilateral contracts. In the medium term stochastic parameters and the probabilistic matching of load have to be modeled. The maximization of revenue by participant generation companies leads to the minimization of the difference of positive definite quadratics subject to many linear inequality and equality constraints. The equilibrium situation of the market is obtained by using the Nikaido-Isoda relaxation algorithm of successive optimizations, where reverse convex constraints are employed to deal with non convex objective function.

■ WC-20

Wednesday, 12:20 - 13:40

1.3.33A

Discrete and Global Optimization

Stream: Discrete and Global Optimization

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Valentin Weber*, G-SCOP, 46 avenue Félix Viallet, 38000, GRENOBLE, France, valentin.weber@g-scop.grenoble-inp.fr

1 - Robust Quadratic Assignment Problem and a Heuristic to Solve It

Mohammad Javad Feyzollahi, Industrial Engineering dept., Sharif University of Technology, Industrial Eng. Dept., University of Technology, Azadi Ave., Tehran, Iran, 11365-8639, Tehran, Tehran, Iran, Islamic Republic Of, feyzollahi@gmail.com, *Maryam Ghotbaddini*, *Mohammad Modarres*

The Quadratic Assignment Problem models many real-world problems. The TSP, maximal clique and graph partitioning can be formulated as a QAP. It is obvious that in a real-world problem the exact amount of workflow among facilities, traffic in computing process and data transferring and distances between cities in the TSP model are not known precisely. We use a robust discrete optimization method to address data uncertainty in QAP, present a heuristic method to solve it and analyze the result by simulation.

2 - Optimal adjust of continuous and discrete variables in non-linear programming problems

Edilaine Soler, Escola de Engenharia de São Carlos, Universidade de São Paulo, Av. Trabalhador São-Carlense, 400, Centro, 13560-970, São Carlos, SP, Brazil, edilaine@sc.usp.br, *Geraldo R. M. da Costa*

In this work a method is proposed for solving non-linear programming problems containing continuous and discrete variables. A penalty function, which penalizes the objective function when discrete variables assume non-discrete values, is presented. By including this penalty function into the objective function, a non-linear programming problem with only continuous variables is obtained and the solution of this problem is equivalent to the solution of the initial problem that contains discrete and continuous variables. The proposed algorithm was applied to the Optimal Power Flow problem.

3 - A method for approximating general pairwise comparison matrices by consistent matrices

Janos Fulop, Research Group of Operations Research and Decision Systems, Computer and Automation Research Institute, Hungarian Academy of Sciences, Kende u. 13-17, H-1111, Budapest, Hungary, fulop@sztaki.hu

In multiattribute decision making, pairwise comparison (PC) matrices are applied to derive implicit weights for a given set of decision alternatives. A class of the approaches is based on the approximation of the PC matrix by a consistent matrix. We consider PC matrices without the reciprocity condition, and approximate them by consistent matrices in the least-squares sense. We transform the problem into the form of separable programming, and give sufficient conditions of the convexity of the objective function over the feasible set. For the general case, we propose a branch-and-bound method.

4 - Challenging instances for discrete optimization problems

Valentin Weber, G-SCOP, 46 avenue Félix Viallet, 38000, GRENOBLE, France, valentin.weber@g-scop.grenoble-inp.fr, *Nadia Brauner*, *Yann Kieffer*

Difficulty in complexity theory reflects worst case performances. However the practice of benchmarking for NP-hard problem is usually based on libraries of sample instances or random generators. We can question the relevance of such instances, in particular, whether they illustrate the actual difficulty of the problem. In our study, we look into some of these sample instances, analyze their hardness and suggest more challenging instances. This leads us to define several criteria to approach the informal concept of instance difficulty.

5 - Effective Branching Rules for Linear Integer Programming Models

Elias Munapo, Decision Sciences, UNISA (SOUTH AFRICA), Preller Street, Pretoria, P. O. Box 392, UNISA 0003, 27, Pretoria, Gauteng, South Africa, munape@unisa.ac.za

The paper presents an effective branching on constraint technique for linear integer programming models. In this technique a combination of two or more basic variables are used in branching rather than the usual single variable that is common in the available branch and bound related schemes. The proposed procedure has the advantage that it accelerates convergence if used within the context of the branch and cut algorithm. Searches on massive sub-problems that are usually associated with integer problems are minimized.

■ WC-21

Wednesday, 12:20 - 13:40

6.2.47

Optimization Algorithms III

Stream: Software for OR/MS

Invited session

Chair: *Tatiana Tchemisova*, Departamento de Matemáticas, University of Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, tatiana@ua.pt

1 - A Hierarchical Segmentation Algorithm for Image Processing

Edwin Zarragoza, Estadística e Investigación Operativa, Universidad Complutense de Madrid, Facultad de Ciencias Matemáticas, Plaza de Ciencias 3, 28040, Madrid, ezarrazo@mat.ucm.es, *Daniel Gomez Gonzalez*, *Javier Montero*, *Javier Yannez*

Segmentation algorithms are well known in the field of image processing. In this work we propose an efficient and polynomial algorithm for image segmentation based on the coloring of an associated network to the digital image. The main difference with the classical segmentation algorithms is in the output given by the segmentation process. Since the classical output for segmentation algorithms give us the homogeneous regions in the image, our proposal is to produce a hierarchical information (in a similar way as a dendrogram does in classical clustering methods) of how the groups are formed in the image, from the initial situation in which all pixels are in the same group to the final situation in which the whole image is divided in the minimal information units.

2 - Efficient direct-search solvers for single and multiobjective derivative-free optimization

Ana Luisa Custodio, Dept. Mathematics, New University of Lisbon, Quinta da Torre, 2829-516, Caparica, Portugal, alcustodio@fct.unl.pt, *Jose Aguilar Madeira*, *Humberto Rocha*, *A. Ismael F. Vaz*, *Luís Nunes Vicente*

Many practical optimization problems involve expensive functions for which derivatives are unavailable or unreliable.

We describe two solvers for such type of problems, based on direct-search methods organized around a search and a poll step. The first solver (sid-psm) applies to the single objective case and incorporates model-based techniques in both steps. The second solver (dms) is designed to compute the Pareto front in the multiobjective case without any function aggregation.

Extensive numerical results show that both solvers are efficient.

3 - An agent-based model of an eco-product market with social interactions and dynamic game pricing schemes

Edward Thommes, University of Guelph, N1G 2WQ1, Guelph, Ontario, ethommes@uoguelph.ca

We present an AB model of an eco-product market from a system design perspective, to investigate ways in which such a market can be made to emerge and develop. The model extends a static formulation of differentiated product markets to include social interactions among consumer classes. We study changes in response to influences such as new product introduction. Analysis of the model is conducted with multiple "personalities" of consumers. We also consider a dynamic game analysis perspective for pricing schemes of eco-products on markets simulated as above.

4 - Optimization methods and software in study of billiard aerodynamics and reverse Magnus effect in free molecular flow

Tatiana Tchemisova, Departamento de Matemáticas, University of Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, tatiana@ua.pt

We study Magnus effect for a spinning disc moving in a very rarified medium. We proposed a new approach that is based on examining the shape of the body's cavities and numerical simulation of optimal mass distribution for any particular case of a shape, as well as for the general case. On the base of the results we conclude that the reverse Magnus effect is more common phenomenon and is due to two factors: lateral friction to the particles, and multiple collisions of particles with the body originating from the fact that the body's surface is not convex but contains microscopic cavities.

■ WC-22

Wednesday, 12:20 - 13:40

3.1.10

LNG transportation

Stream: Maritime Logistics

Invited session

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 - Branch-and-Price for creating an Annual Delivery Program (ADP) of Multi-Product Liquefied Natural Gas

Jørgen Glomvik Rakke, IØT, NTNU, Alfred Getz veg 3, Sentralbygg I, 7491, Trondheim, Sør-Trøndelag, Norway, jorgen.rakke@iot.ntnu.no, *Marielle Christiansen*, *Henrik Andersson*, *Guy Desaulniers*

We consider a ship routing and inventory management problem for one of the world's largest producers of LNG. The problem is to manage the producer's inventory and fleet of ships to create an ADP that respects the long-term contracts. A MIP formulation, the Basic Voyage Model (BVM), based on pre-generation of all scheduled voyages will be presented. The LP-relaxation of the BVM is weak. To reduce the gap, the BVM is reformulated using contract delivery patterns generated by column generation. The sub-problems do not possess the integrality property, which might help raise the bound.

2 - Long term planning in the LNG value chain

Kristin Tolstad Uggen, Applied economics and operations research, SINTEF Technology and society, S.P. Andersens v 5, 7465, Trondheim, Norway, ktu@sintef.no, *Adrian Werner*, *Marte Fodstad*, *Arnt-Gunnar Lium*

We will present a strategic planning tool for the LNG business with planning horizons of 10-20 years. The model has a company focus, and makes decisions on how to expand the existing portfolio with potential investment opportunities in new LNG terminals, vessels and different types of purchase- and sales-contracts. Since future energy prices are uncertain, the model has stochastic natural gas and LNG prices both in contracts and on spot markets. Different modeling issues (especially transportation and contracts) and first results will be presented.

3 - A branch-and-price-and-cut algorithm for a maritime liquefied natural gas inventory routing problem

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, *Marielle Christiansen*, *Guy Desaulniers*

A branch-and-price-and-cut algorithm for a maritime liquefied natural gas (LNG) inventory routing problem will be presented. A heterogeneous fleet of ships is used to transport LNG from liquefaction plants to regasification terminals. The production at the plants and the sale at the terminals are decisions. A decomposition of the problem is done where voyages are used to describe the movement of the ships. The proposed valid inequalities are derived using the heterogeneity of the fleet, only full loading and unloading of ship tanks and the variable production and consumption.

■ WC-23

Wednesday, 12:20 - 13:40

6.2.49

Data Mining in Portfolio Analysis 1

Stream: Data Mining in the Financial Sector

Invited session

Chair: *Vadim Mottl*, Intelligent Systems, Computing Center of the Russian Academy of Sciences, Vavilov St. 40, 119333, Moscow, Russian Federation, vmottl@yandex.ru

Chair: *Evgeny Bauman*, Markov Processes International, 25 Maple ave, 07901, Summit, New Jersey, United States, evbauman@markovprocesses.com

1 - A mathematical and algorithmic framework for dynamic returns-based style analysis of investment portfolios

Vadim Mottl, Intelligent Systems, Computing Center of the Russian Academy of Sciences, Vavilov St. 40, 119333, Moscow, Russian Federation, vmottl@yandex.ru, *Olga Krasotkina*, *Michael Markov*, *Ilya Muchnik*

Transactions of an investment portfolio are, as a rule, hidden from public. The only available information is the time series of its daily or monthly returns. The idea of Dynamic Investment Style Analysis is monitoring the hidden capital sharing in a portfolio as estimating a time-varying regression model of its periodic returns with respect to those of asset classes the portfolio might contain. Under a natural Markov assumption on the trading process, the sweep method, pair-wise separable quadratic programming and Kalman-Bucy filter-smoother are equivalent means of solving the problem.

2 - Machine-learning for dynamic style analysis of hedge funds

Olga Krasotkina, Tula State University, 300600, Tula, Russian Federation, ko180177@yandex.ru, *Vadim Mottl*, *Michael Markov*, *Ilya Muchnik*

Immediate application of Dynamic Investment Style Analysis to a time series of periodic returns on the portfolio under monitoring is inevitably concerned with making additional decisions on, first, the active subset in the assumed set of asset classes the portfolio might contain, and, second, partitioning it into two further subsets of really traded assets and buy-and-hold ones. This necessity turns the statistical problem of time-varying regression estimation into that of Machine Learning, which implies finding the most appropriate data model among a priori models of growing complexity.

3 - Downside Risk Optimization via Quasi-Gradient Algorithm

Evgeny Bauman, Markov Processes International, 25 Maple ave, 07901, Summit, New Jersey, United States, evbauman@markovprocesses.com, *Michael Markov*

H. M. Markowitz introduced the mean-variance analysis as an instrument for forming well diversified portfolios. He concluded that the most theoretically robust measure was semi-variance. Semi-variance (downside risk) is the expected value of the squared negative deviations about a specified "target" rate of return. There are a lot heuristic algorithms to optimize downside risk. G. M. de Athayde suggested a quasi-gradient algorithm but there is no theoretical proof of its convergence. We developed a modification of his algorithm and proved its convergence.

4 - Peer group analysis as a clustering problem of portfolio trackers

Marcus Hildmann, Swissquant Group AG, Kuttelgasse 7, 8001, Zürich, Switzerland, hildmann@swissquant.ch

In this work we are combining two very important notions in risk management: peer group analysis of portfolio managers and index or portfolio tracking. First, we introduce an optimization method based on minimizing the tracking error, which given the initial set of assets, finds the minimal number of assets needed for portfolio return time-series reconstruction. Based on these results, we search further for an optimal clustering of portfolios into different peer groups. The latter is used for objective evaluation of a selection of portfolio managers.

■ WC-24

Wednesday, 12:20 - 13:40

6.2.50

Crew Scheduling

Stream: Timetabling and Rostering

Invited session

Chair: *Silke Jütte*, Supply Chain Management and Management Science, University of Cologne, Albertus-Magnus-Platz, 50923, Cologne, Germany, silke.juette@uni-koeln.de

1 - Integrated airline crew scheduling by a dynamic constraint aggregation method

Mohammed Saddoune, École Polytechnique de Montréal and GERAD, 700 cremazie Est, Appt 1A, h2p-1g2, montréal, QC, Canada, mohammed.saddoune@polymtl.ca, *Guy Desaulniers*, *Issmail Elhallaoui*, *Francois Soumis*

The bidline airline crew scheduling has been traditionally decomposed into two stages (crew pairing and crew assignment) that are sequentially solved. We propose a model that completely integrates both stages and solve it in a single step using a combined column generation/dynamic constraint aggregation method. Tested on real data, the proposed approach reduces the total cost by 4.76% compared to the sequential approach with an increase of computational time by a mean factor of 3.8 which is much smaller than that obtained with column generation solely (around 200 for the smallest instances).

2 - Pricing by Local Search for the Airline Crew Pairing Problem

Nimet Aksoy, Industrial Engineering, Sabanci University, Sabanci University, Orhanli Tuzla, 34956, Istanbul, Turkey, nimetaksoy@su.sabanciuniv.edu, *S. Ilker Birbil*, *Kerem Bulbul*, *Husnu Yenigun*

Traditional column generation (CG) approaches to the airline crew pairing problem formulate the pricing subproblem as a multi-label shortest path problem (MLSP) typically solved over a flight network. The MLSP suffers from an exponential complexity even for moderate size flight networks. We propose a CG method, where we first look for negatively priced pairings by a local search (LS) mechanism in a (partial) duty network. We resort to the MLSP when the LS fails and also generate new duties in the process. Numerical results are presented that attest to the efficiency of our approach.

3 - Ground Crew Rostering with Work Patterns at a Major European Airline

Richard Lusby, Department of Management Engineering, Technical University of Denmark, 2800, Kgs Lyngby, Denmark, rmlu@man.dtu.dk, *Anders Dohn*, *Troels Martin Range*, *Jesper Larsen*

We consider an important staff rostering problem arising in the ground operations of a major European airline. The so-called Ground Crew Rostering Problem with Work Patterns, entails assigning a set of employees to a set of shifts spaced over a given daily time horizon so that the robustness of the final roster is maximized. We present a cutting stock based formulation and propose a column generation solution approach that utilizes a rolling time horizon to find an efficient set of roster lines. Encouraging numerical results are given for real-life data supplied by a major European Airline.

4 - "Divide-and-Price": A Decomposition Algorithm for Solving Huge Railway Crew Scheduling Problems

Silke Jütte, Department of Supply Chain Management and Management Science, University of Cologne, Albertus-Magnus-Platz, 50923, Köln, Germany, silke.juette@uni-koeln.de, *Ulrich Thonemann*

The railway crew scheduling problem consists of generating crew duties to operate a set of trains at minimal cost. Typically, schedules covering thousands of trains need to be generated in very short time to allow for disruptions in the operations. We present an algorithm which has proven to significantly reduce runtimes of current solution approaches while providing schedules of reasonable quality. The planning problem is decomposed into overlapping regions which are optimized simultaneously. Trains belonging to several regions are assigned to the region where they are covered at lowest cost.

■ WC-25

Wednesday, 12:20 - 13:40

6.2.48

ROADEF/EURO challenge senior session 2

Stream: ROADEF/EURO challenge

Invited session

Chair: *Ender Ozcan*, Computer Science, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, exo@cs.nott.ac.uk

1 - A hybrid iterative decomposition approach to ROADEF 2010

Cristiano Nattero, DIST, University of Genova, Via all'Opera Pia 13, 16145, Genova, GE, Italy, cristiano.nattero@gmail.com,
Davide Anghinolfi, Luca Maria Gambardella, Roberto Montemanni, Massimo Paolucci, Nihat Engin Toklu

We propose a hybrid iterative decomposition approach based on mathematical programming and local search (LS) improvement. The decomposition separates the generation of schedules of the plant outages from the generation of optimal production plans. The approach consists of three phases. First a quality feasible starting solution is obtained solving a sequence of relaxed mixed integer programs, then this solution is improved by a LS where also a tabu list is used, and finally, the outage schedule selection and time step production plan is produced.

2 - A mathematical-programming-based solution approach for the EDF energy management problem

Francois Soumis, GERAD, 3000 Cote Ste-Catherine, H3T 2A7, Montreal, Québec, Canada, francois.soumis@gerad.ca, *Guy Desaulniers, Michel Gendreau, Louis-Martin Rousseau, François Lessard*

To solve this problem that involves nonlinear and disjunctive constraints, we propose a mathematical programming approach based on an integer linear multi-commodity network flow model with side constraints. In this model, different production cycle possibilities for the power plants of type 2 are represented by arcs. The expectation of the production cost of the type 1 power plants for a period is given by a piecewise linear convex function, yielding up to 50000 pieces. Starting with a small subset of these pieces, additional pieces are added as needed.

3 - High-performance local search for a large-scale energy management problem

Frédéric Gardi, e-lab, Bouygues SA, 40 rue Washington, 75008, PARIS, France, fgardi@bouygues.com, *Karim Nouioua*

We present the algorithm which we have implemented in the context of the ROADEF/EURO Challenge 2010, for solving a large-scale energy management problem addressed by EDF. This algorithm is a pure local-search heuristic, whose design and implementation follows the methodology presented in the past authors' works: no decomposition of the problem is done, and no particular metaheuristic is used. In this way, we have concentrated our work on the design of moves and on the algorithms which are behind their evaluation.

■ WC-26

Wednesday, 12:20 - 13:40

3.1.11

Models of Cooperative Games: Theory and Applications

Stream: Cooperative Game Theory

Invited session

Chair: *Mariana Rodica Branzei*, Faculty of Computer Science, "Alexandru Ioan Cuza" University, 16, Berthelot St., 700483, Iasi, Romania, branzeir@info.uaic.ro

1 - Cooperative Games under Interval Uncertainty: On the Convexity of the Interval Undominated Cores

Sirma Zeynep Alparlan Gok, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and

Sciences, Suleyman Demirel University, 322260, Isparta, Turkey, zeynepalparlan@yahoo.com, *Mariana Rodica Branzei, Oana Branzei*

This paper extends interval-type core solutions for cooperative interval games by discussing the set of undominated core solutions which consists of the interval nondominated core, the square interval dominance core, and the interval dominance core. The interval nondominated core is introduced and it is shown that it coincides with the interval core. A straightforward consequence of this result is the convexity of the interval nondominated core of any cooperative interval game.

2 - Application of cooperative TU-game solution concepts to a partition function form game

David Bartl, Department of Mathematics, University of Ostrava, 30.dubna 22, 701 03, Ostrava, Czech Republic, bartl@osu.cz

The classical cooperative TU-game solution concepts (core, bargaining set, ...) are defined for games the coalitional function form. We want to apply them to a cooperative TU-game which is given in the strategic or normal form. For that reason, contemplating the solution concepts, we extend their definition to the games in the partition function form (Lucas & Thrall, 1963), into which the strategic form game can be converted easily. The proposed methodology, apart from defining the gamma- or delta-core, which are known, enables to define, e.g., gamma- or delta-bargaining set etc.

3 - A value for interval games with multi-choice coalitions: Axiomatic characterizations and applications

Mariana Rodica Branzei, Faculty of Computer Science, "Alexandru Ioan Cuza" University, 16, Berthelot St., 700483, Iasi, Romania, branzeir@info.uaic.ro, *Hao Sun, Genjiu Xu*

We consider cooperative games arising from situations where agents can participate at several levels in a joint venture and where one can only predict upper and lower bounds for the outcome of agents' collaborative actions. This model of games fits many OR situations. To assist managers in scientific decision-making regarding reward/cost sharing problems with interval data and multiple levels of cooperation game-theoretic solution concepts are helpful. We propose an interval value based on multi-choice coalition payoffs, axiomatically characterize it and illustrate its use in practice.

■ WC-27

Wednesday, 12:20 - 13:40

8.2.06

TRANSPORTATION PLANNING

Stream: Transportation and Logistics

Invited session

Chair: *Jorge Freire de Sousa*, Industrial Management Unit, Faculty of Engineering University of Porto, Rua Roberto Frias, 4200-465, Porto, Portugal, jfsousa@fe.up.pt

1 - A New Model for Road Accident Prediction, Based on an Adaptive Neuro-fuzzy Inference System

Mario Mellano, Dept. of Roads and Transportation, Technical University of Bari, 70125 Bari, Bari, mmella@poliba.it, *Mauro Dell'Orco*

Due to the complexity of a road transportation system, studying either system decay, or crashes as its consequence, is not a simple task. Several road accident prediction models have been developed to investigate effects of many independent variables on crashes. In this paper, we have implemented a neuro-fuzzy inference engine to obtain crash prediction, and have tested the model on a four-lane median-divided Italian extra-urban road. The proposed algorithm has been tested through a simulation. Results have shown the goodness of the proposed model, and a remarkable significance of drivers' short-term memory on accidents.

2 - Discrete events simulation of a flexible service for people transportation

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, *Giovanni Storchi, Artem Serebriany*

The realization of innovative transport services, require increasingly greater flexibility and inexpensiveness of the service. In many cases the solution is to realize demand responsive transportation system. In this work, we address a Demand Responsive Transport Service able to manage incoming transport demand using a solution based on heuristics algorithm to solve a Dial-a-Ride Problem instance. The solutions provided by the heuristics are simulated in a discrete events environment in which it is possible to reproduce the programmed activities and evaluate some performance indicator.

3 - Using travel time predictions for planning and control at public transport companies

Jorge Freire de Sousa, Industrial Management Unit, Faculty of Engineering University of Porto, Rua Roberto Frias, 4200-465, Porto, Portugal, jfsousa@fe.up.pt, *João Mendes-Moreira*

In the last decade public transport companies (PTCs) made an important effort on gathering data about the actual work of their vehicles using Automatic Vehicle Location systems. PTCs have data about what happened but they are not being able yet to convert this data in useful information for the planning tasks, namely: trips definition, buses and drivers duties, and the assignment of duties. A major indicator used in these tasks is the expected travel time (TT). In this talk we explain how TT predictions can be used in the planning and control tasks for typified situations.

WC-28

Wednesday, 12:20 - 13:40

8.2.10

Scheduling with Lags and Setups

Stream: Scheduling

Invited session

Chair: *Alessandro Condotta*, University of Leeds, United Kingdom, scs6ac@leeds.ac.uk

1 - On the complexity of the hybrid flow shop with adjustment

Jan Pelikan, Econometrics, University of Economics Prague, W. Churchill sq. 4, 13067, Prague, Czech Republic, pelikan@vse.cz

The paper describes a case study of job scheduling in a mechanical-engineering production plant with a goal to minimise the overall processing time, or makespan. The production jobs are processed by machines, and each job is assigned to a certain machine for technological reasons. Before processing a job, the machine has to be adjusted; there is only one adjuster, who adjusts all of the machines as necessary. This problem is treated as a hybrid two-stage flow-shop: the first stage of the job processing is represented by the machine adjustment for the respective job, and the second stage by the processing of the job itself on the adjusted machine. A mathematical model is proposed, a heuristic method is formulated. Partition problem and 3-partition problem are reduced onto hybrid flow shop with adjustment so this is a proof that the flow shop with adjustment is NP hard in strong sense.

2 - On the complexity of scheduling with negative time lags

Adel Manaa, Operational Research, LIP6, 104 avenue du Président Kennedy, Bureau 538, 57016, Paris, France, adel.manaa@lip6.fr, *Claire Hanen*

We investigate the scheduling problems with negative time lags to minimise the makespan. Unlike an ordinary precedence constraint, a negative time lag l between two tasks i and j , means that j cannot start earlier than $-l$ time units before i . In such problems, the precedence graph may have cycles which may lead to unfeasibility. We identify polynomially solvable cases for different precedence graph structures on a single machine and on parallel machines. We also prove that for cyclic and star-like graphs, the problem with negative time lags is NP-complete.

3 - Real-Time Scheduling of Failure-Prone Manufacturing Systems with Setup Times and Costs

Fernando Tubilla, Mechanical Engineering Department, MIT, 23 Sidney Street 208, 02139, Cambridge, MA, United States, ftubilla@mit.edu, *Stan Gershwin*

We develop a new closed loop policy for scheduling manufacturing systems with setup times/costs and subject to random machine failures. The policy is exhaustive, prioritized, and easily tunable. After stating and motivating the policy, we use Lyapunov functions to obtain an easy-to-evaluate and not-too-conservative sufficient condition that ensures bounded cycle times for all items. We then show that the policy has very good performance with respect to long term average costs and transient costs. Finally, we discuss how our deterministic results apply to the failure-prone stochastic system.

4 - On scheduling multiple-operation jobs with time-lags

Alessandro Condotta, University of Leeds, United Kingdom, scs6ac@leeds.ac.uk, *Natalia Shakhlevich*

In many real-world scheduling problems, a job consists of multiple operations that are required to be processed with given time-lags in between. In this talk we review models and algorithms known in literature for scheduling multiple-operation with time-lags. We give an insight into the difficulties of finding efficient heuristics for NP-hard cases and present a new complexity result for the case with two operations per job where the sequence of all first operations is given. As example of a real-world application, we present an advanced model of scheduling patients in a chemotherapy clinic.

WC-29

Wednesday, 12:20 - 13:40

8.2.11

Portfolio Selection

Stream: Financial Modeling

Invited session

Chair: *David Wozabal*, Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, david.wozabal@univie.ac.at

1 - Set-Portfolio Selection with the Use of Market Stochastic Bounds

Sergio Ortobelli, MSIA, University of Bergamo, Via dei Caniana, 2, 24127, Bergamo, Italy, sol@unibg.it, *Enrico Angelelli*, *Daniele Toninelli*

This paper proposes an ex-post comparison of portfolio selection strategies applied to some preselected assets among more than 1300 stocks of the US Market. In particular, for any portfolio selection problem we preselect few assets that optimize the association with the market stochastic bounds and present the highest ex-ante reward-risk performance. Then we propose the comparison of the ex-post final wealth obtained with the optimization of reward-risk functionals that use the stochastic bounds of the preselected assets. We consider strategies where the investors recalibrate weekly their portfolios and we compare the wealth obtained under the assumption that returns follow a Markov chain.

2 - Mining financial time series: New insights from model-based clustering methods

José G. Dias, Quantitative Methods & UNIDE, ISCTE, Edifício ISCTE, Av. das Forças Armadas, 1649-026, Lisboa, Portugal, jose.dias@iscte.pt, *Jeroen K. Vermunt*, *Sofia B. Ramos*

In recent years large amounts of financial data have become available for analysis. We propose to explore returns from 21 stock markets by model-based clustering of regime switching models. These models allow the relaxation of traditional assumptions such as conditional Gaussian returns. The data mining approach handles simultaneously the heterogeneity across stock markets and time. The results show a clear distinction between groups of stock markets, each one characterized by different regime switching states that correspond to different expected return-risk patterns.

3 - Optimizing Value-at-Risk using the Difference of Convex Algorithm

David Wozabal, Business Administration, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, david.wozabal@univie.ac.at

Value-at-Risk (VaR) is an integral part of contemporary financial regulations. This paper treats a Value-at-Risk constrained Markowitz style portfolio selection problem when the distribution of returns are given in the form of finitely many scenarios. The problem is non-convex but can be reformulated as a difference of convex program. We apply the difference of convex algorithm to solve the problem. Numerical results comparing the solutions found by the DCA to the respective global optima for relatively small problems as well as numerical studies for large real life problems are discussed.

4 - Usage of Conditional CAPM method for explaining portfolio returns: An application for services, financial and industrial sectors' returns in Istanbul Stock Exchange

Serap Atbas, Social Sciences Institute, Turkey,
satbas@gmail.com, Melik Kamisli, Guven Sevil

In the light of studies in the literature it has been concluded that, the static CAPM can not fully explain portfolio returns, the beta coefficients of the assets do not remain constant over time. When it is taken into consideration that the expected return and beta that has changed over time, conditional CAPM method better explains the portfolio return. The aim of this study is to test whether it is better explained or not the return on services, financial and industrial sectors by using Conditional CAPM methods in Turkey between the years 03/01/2001 and 08/07/2009.

■ WC-30

Wednesday, 12:20 - 13:40
8.2.13

Advances in Quantitative Credit Risk Modeling: Change We Need

Stream: Operational Research and Quantitative Models in Banking

Invited session

Chair: *Bart Baesens*, Decision Sciences and Information Mangement, K.U.Leuven, Naamsestraat 69, B-3000, Leuven, Leuven, bart.baesens@econ.kuleuven.ac.be

Chair: *David Martens*, Decision Sciences and Information Management, Katholieke Universiteit Leuven, Naamsestraat 69, 3000, Leuven, Belgium, David.Martens@econ.kuleuven.be

Chair: *Christophe Mues*, School of Management, University of Southampton, SO17 1BJ, Southampton, United Kingdom, C.Mues@soton.ac.uk

1 - Modeling credit rating migrations dependent on the business cycle

Wouter Verbeke, Faculty of Economics and Business, K.U.Leuven, Naamsestraat 69, B-3000, Leuven, Belgium, wouter.verbeke@econ.kuleuven.be, *Koen Berteloot*, *David Martens*, *Gerd Castermans*, *Tony Van Gestel*, *Bart Baesens*

This study introduces a modeling methodology, based on standard ordinal logistic regression, to estimate the credit rating migration matrix as a function of rating dynamics and macroeconomic indices. This allows to stress test and analyze the impact of economical downturn conditions on credit ratings, and to assess the risk related to a credit portfolio. A formal evaluation methodology is proposed that permits to interpret intuitively the difference between estimated and historic migration matrices. The proposed methodology is applied to model US corporate rating migrations from 1984 to 2008.

2 - Rating Banks: a myth resolved

Elisabeth Van Laere, Accounting & Finance, Vlerick Leuven Gent Mgt School, Reep 1, 9000, Gent, Belgium, elisabeth.vanlaere@vlerick.be, *Bart Baesens*

One of the main challenges in developing bank regulation is the fact that risks taken in the process of financial intermediation are hard to observe. In order to reduce this lack of transparency CRAs provide information that can help to evaluate the risk. There is evidence of more split ratings over financial institutions suggesting that banks are more difficult to rate because of their opaqueness. In this paper the main research question is "What are the key determinants driving bank ratings and how robust are these?" This question will be addressed using new variables and techniques.

3 - Regression model development for Exposure at Default (EAD)

Iain Brown, School of Management, University of Southampton, University of Southampton, University Road, SO17 1BJ, Southampton, United Kingdom, I.Brown@soton.ac.uk, *Christophe Mues*, *Lyn Thomas*

In this presentation we propose a comprehensive and robust model for predicting the exposure at default (EAD). For off-balance-sheet (credit cards) to calculate the EAD one requires the committed but unused loan amount times a credit conversion factor (CCF). Ordinary least squares, logistic and cumulative logistic regression models are analysed with the main aim of finding the most robust and comprehensible model for the prediction of the CCF. A real-life data set with monthly balance amounts for clients over the period 2001-2004 is used in the building and testing of the regression models.

4 - Competing Risks Survival Model for Residential Mortgage Loans

Mindy Leow, School of Management, University of Southampton, University of Southampton, University Road, SO17 1BJ, Southampton, m.leow@soton.ac.uk, *Christophe Mues*, *Lyn Thomas*

With access to a dataset on defaulted mortgages kindly provided by a major UK bank, we develop a competing risk survival analysis model to predict the time taken for a defaulted mortgage loan to go to some event (repossession or closure), which would allow for a more accurate prediction of loss as these periods could vary from months to years depending on the health of the economy. Besides loan-related characteristics, we incorporate a time-dependent macroeconomic variable to track the year-on-year change in the national HPI.

■ WC-31

Wednesday, 12:20 - 13:40
8.2.15

Industrial applications of scheduling and routing III

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 - A Novel Heuristic for Sequencing Mixed-Model Assembly Lines

Rico Gujjula, Department of Production Management, TU Berlin, TU Berlin - H 95 - H 9155, Straße des 17. Juni 135, 10623, Berlin, Berlin, Germany, rico.gujjula@tu-berlin.de, *Sebastian Werk*, *Hans-Otto Guenther*

Many methods which were developed to sequence mixed-model assembly lines, e.g. in the automotive industry, fail to cope with real-life problem instances. We propose a novel heuristic solution procedure which is able to handle large and supposedly difficult problem instances. Test scenarios considering real-life aspects from car manufacturers were generated to evaluate the performance of the heuristic for realistic problem instances. It is shown that the proposed heuristic significantly outperforms simple priority rule-based methods and requires only reasonable computational effort.

2 - Production scheduling in a multi-page invoice printing system

Jiyin Liu, Business School, Loughborough University, Ashby Road, LE11 3TU, Loughborough, Leicestershire, United Kingdom, j.y.liu@lboro.ac.uk, *Yan Zhang*, *Zhili Zhou*

We study the production scheduling problem in a practical multi-page invoice printing system that comprises three stages: the stencil preparation stage, the page printing stage and the invoice assembly stage. The last two stages have parallel machines and the second stage involves two types of sequence-dependent setups. The objective is to minimize the makespan. We first formulate the problem into a mixed-integer linear programming model and then solve it using a hybrid genetic algorithm. Numerical experiment indicates that the algorithm can solve the problem efficiently and effectively.

3 - Self-Optimization Aspects for Dynamic Scheduling

Ivo Pereira, ISEP, Portugal, iasp@isep.ipp.pt, *Ana Madureira*

Scheduling is a critical function that is present throughout many industries and applications. A great need exists for developing scheduling approaches that can be applied to a number of different scheduling problems with significant impact on performance of business organizations. A challenge is emerging in the design of scheduling support systems for manufacturing environments where dynamic adaptation and optimization become increasingly important. At this scenario, self-optimizing arise as the ability of the agent to monitor its state and performance and proactively tune itself to respond to environmental stimuli.

■ WC-32

Wednesday, 12:20 - 13:40

8.2.17

Long-term modelling for agriculture and forestry

Stream: Long Term Planning in Energy, Environment and Climate

Invited session

Chair: *Nicklas Forsell*, CMA, CMA, France,
nicklas.forsell@cma.ensmp.fr

1 - Flexible potential of renewable energy sources in long-term energy planning models

Nicklas Forsell, CMA, CMA, France,
nicklas.forsell@cma.ensmp.fr

An approach is presented for considering renewable energy sources in long-term energy planning models such as MARKAL-TIMES. The proposed approach focuses on modeling of forest potentials, and specifically considers the development of periodic unused forest potentials. Instead of exogenously defining a single "business-as-usual" forest potential scenario, the model endogenously constructs a forest potential from a set of exogenously defined feasible forest potential scenarios. The proposed approach is demonstrated utilizing a case study of the future development of the Swedish energy system, specifically focusing on the future use of forest biomass.

2 - Retribution of carbon sinks in forest biomass Vs stimulation of timber consumption: what impacts on the French forest sector?

Philippe Delacote, INRA- LEF, France,
philippe.delacote@eui.eu, *Sylvain Cauria*

Forests contribute to climate change mitigation by sequestering carbon in forest biomass and in wood products and by substituting high energy products with wood products such as fuelwood instead of fossil fuel or construction wood instead of concrete, what we call substitution effect. Climate policies can thus focus on these effects. We assess potential impacts of substitution and stock policies on the French forest sector and on carbon accounting. Stock policies would be difficult to implement as long as carbon price does not reach levels comparable to timber prices.

3 - Large-Scale Modelling of Global Food Security under Extreme Weather Events

Sabine Fuss, Forestry, IIASA, Schlossplatz 1, -, 2361, Laxenburg, -, Austria, fuss@iiasa.ac.at, *Jana Szolgayova*, *Petr Havlik*, *Michael Obersteiner*

Climate change is supposed to impact food security more by increased frequency of extreme weather events than by changes in average temperature and precipitation. We adapt the GLOBIOM model to investigate the impact of yield stochasticity when ensuring food security is an explicit constraint. Under business as usual, there is a trade-off between the insurance of food security and the pressure on average prices. Rural development policies facilitating switches in management systems (rainfed/irrigated) and trade liberalization may improve this.

■ WC-33

Wednesday, 12:20 - 13:40

8.2.19

Risk and Uncertainty in Energy Models

Stream: Energy, Environment and Climate

Invited session

Chair: *Dominik Möst*, Universität Karlsruhe, Institut für Industrial Production (IIP), Hertzstraße 16, 76131, Karlsruhe, Germany,
Dominik.Moest@kit.edu

1 - Optimal gas procurement for a power producer using stochastic programming

Miguel Carrión, Electrical Engineering, University of Castilla - La Mancha, Avda Carlos III, s/n, Campus Fábrica de Armas, 45071, Toledo, miguel.carrión@uclm.es, *Antonio J. Conejo*

We consider the problem of a power producer that seeks to determine the monthly allocation of natural gas for its combined cycle gas turbines (CCGTs) within a planning horizon of one year. A stochastic programming model is used to address this problem where the pool price is characterized as a stochastic process using a set of scenarios. The monthly allocation of natural gas and the on/off status of the units are here-and-now decisions, whereas the pool trading is a wait-and-see decision. The performance of the proposed model is assessed by means of a realistic case study.

2 - The impact of renewable capacities on the conventional power plant system in 2030 in Germany

Dominik Möst, Universität Karlsruhe, Institut für Industrial Production (IIP), Hertzstraße 16, 76131, Karlsruhe, Germany,
Dominik.Moest@kit.edu, *Massimo Genoese*, *Wolf Fichtner*

One major contemporary strategic challenge for electricity supply systems is the integration of substantial amounts of renewable energy sources. Within the German sustainable energy strategy a target of 80% of renewables in electricity production is stipulated. This contribution therefore derives the residual load for the year 2030 and 2050 based on different correlations between the load and the renewable feed-in. This residual load is the starting point for a peak-load pricing model, which determines an optimal power plant mix under various renewable feed-in scenarios.

3 - Extending Dynamic Programming's Simulations and Regressions Approach to Value and Control a Hydropower System

Michel Denault, HEC Montréal, Canada,
michel.denault@hec.ca, *Jean-Guy Simonato*, *Lars Stentoft*

We investigate the control problem of managing a hydropower to optimize its value. Exogenous stochastic state variables taken into consideration are the power spot price, the water inflows and the power demand. One endogenous state variable is the water level in the dam. We model the problem as a dynamic program and solve it with a combination of simulations and value function approximations, generalizing the well-known American option pricing techniques that use simulation and regressions. The use of simulation paths for all state variables allows considerable flexibility.

4 - Extension Planning for Generation Units in a Hydrothermal Portfolio

Ulf Kasper, Institute of Power Systems and Power Economics, RWTH Aachen University, Schinkelstraße 6, 52062, Aachen, Germany, uk@iaew.rwth-aachen.de, *Albert Moser*

The increasing demand of system reserve and the development of spot prices in Europe motivate power generation and trading companies to consider an extension of their generation portfolios. In order to review the efficiency of such projects their effect on the company's entire hydrothermal portfolio has to be taken into account. The Institute of Power Systems and Power Economics of RWTH Aachen University has developed a practically approved program for optimizing power generation and trading on markets for scheduled energy and reserve to simulate such effects on generation portfolios.

■ WC-34

Wednesday, 12:20 - 13:40

8.2.23

Duality Problems

Stream: Convex Optimization

Invited session

Chair: *Iqbal Husain*, Mathematics, Jaypee College of Engineering and Technology, Dept. of Mathematics, Jaypee College of Engineering and Technology, A-B Road, Raghogarh, Guna, MP, 476-226, Bhopal, MadhyaPradesh, India, ihusain11@yahoo.com

1 - On weak conjugate maps, Fenchel and Fenchel Lagrange Duality, constructed by weak conjugate maps

Ilknur Atasever, Department of Mathematics, Anadolu University, Anadolu Universitesi Fen Fakultesi Matematik Bolumu, 26470, Eskisehir, Turkey, iatasever@anadolu.edu.tr, *Yalcin Kucuk*, *Mahide Kucuk*

Augmented Lagrangian dual problem, which is constructed by using weak conjugate maps, was studied by Azimov and Gasimov for nonconvex optimization problems. In this work, by using weak conjugate maps Fenchel, and Fenchel Lagrange dual problems are constructed. Definition of stability of primal problem with respect to Fenchel and Fenchel Lagrange duals are given and it is proved that stability of the primal problem implies the strong duality. Furthermore, necessary and sufficient conditions for stability of primal problem with respect to Fenchel and Fenchel Lagrange dual problems are given.

2 - The relations between the optimal objective values of the Fenchel, Fenchel Lagrange and Lagrange dual problems, constructed by weak conjugate maps, and optimality conditions

Yalcin Kucuk, Department of Mathematics, Anadolu University, anadolu Universitesi Fen Fakultesi Matematik Bolumu, 26470, Eskisehir, ykucuk@anadolu.edu.tr, *Ilknur Atasever, Mahide Kucuk*

Augmented Lagrangian dual problem, which is constructed by using weak conjugate maps, and optimality conditions were studied by Azimov and Gasimov for nonconvex optimization problems. In this work, the relations between the optimal objective values of Lagrange, Fenchel and Fenchel Lagrange dual problems, which are constructed by using weak conjugate maps, are given. Furthermore, optimality conditions for Fenchel and Fenchel Lagrange dual problems are presented.

3 - Dynamic games and symmetric duality in variational problems

Iqbal Husain, Mathematics, Jaypee College of Engineering and Technology, Dept. of Mathematics, Jaypee College of Engineering and Technology, A-B Road, Raghogarh, Guna.MP, 476-226, Bhopal, MadhyaPradesh, India, ihusain11@yahoo.com

Certain single and multiple dynamic games are modeled and shown to be equivalent to pairs of symmetric dual single objective variational problems and symmetric dual multiobjective variational problems which have more general formulations than the traditional ones. Further for these pairs, the usual duality results are established under certain generalized convexity conditions and it is also shown that our results can be considered as dynamic generalizations of those of the corresponding static cases through natural boundary valued problems.

4 - Mixed type symmetric and self duality for multiobjective variational problems with support functions

Iqbal Husain, Mathematics, Jaypee College of Engineering and Technology, Dept. of Mathematics, Jaypee College of Engineering and Technology, A-B Road, Raghogarh, Guna.MP, 476-226, Bhopal, MadhyaPradesh, India, ihusain11@yahoo.com, *Rumana Mattoo*

Mixed type symmetric dual pair for multiobjective variational problems containing support functions is formulated. This mixed formulation unifies two existing pairs Wolfe and Mond-Weir type symmetric dual multiobjective variational problems containing support functions. For this pair of mixed type nondifferentiable multiobjective variational problems, various duality theorems are established under convexity-concavity and pseudoconvexity-pseudoconcavity of certain combination of functionals appearing in the formulation. A self-duality theorem under additional assumptions on the kernel functions that occur in the problems is validated. A pair of mixed type nondifferentiable multiobjective variational problem with natural boundary values is also formulated to investigate various duality theorems.

■ WC-35

Wednesday, 12:20 - 13:40

6.2.46

Integer Nonlinear Programming

Stream: Mixed-Integer Non Linear Programming

Invited session

Chair: *Christoph Buchheim*, Fakultät für Mathematik, Technische Universität Dortmund, Germany, christoph.buchheim@tu-dortmund.de

1 - Integer Programming Subject to Monomial Constraints

Dennis Michaels, Institute for Operations Research, ETH Zuerich, Raemistrasse 101, 8092, Zuerich, Switzerland,

dennis.michaels@ifor.math.ethz.ch, *Christoph Buchheim, Robert Weismantel*

We investigate integer programs containing equality constraints where the left hand sides consist of one monomial. Due to the number-theoretic nature of these constraints, standard methods based on linear algebra cannot be applied directly. Instead, we present a reformulation resulting in integer programs with linear constraints and polynomial objective functions, using prime decompositions of the right hand sides. Moreover, we show that minimizing a linear objective function with nonnegative coefficients over bivariate constraints is possible in polynomial time.

2 - A Fast Algorithm for Convex Quadratic Integer Programming with Applications in Electronics

Christoph Buchheim, Fakultät für Mathematik, Technische Universität Dortmund, Germany, christoph.buchheim@tu-dortmund.de, *Alberto Caprara, Andrea Lodi*

We present a branch-and-bound algorithm for minimizing a convex quadratic objective function over integer variables subject to convex constraints. In a given node of the enumeration tree, corresponding to the fixing of a subset of the variables, a lower bound is given by the continuous minimum of the restricted objective function. We improve this bound by exploiting the integrality of the variables using suitably-defined lattice-free ellipsoids.

Experiments with instances of the closest vector problem as well as instances arising in an application in electronics show that our approach is very fast on both unconstrained problems and problems with box constraints. The main reason is that all expensive calculations can be done in a preprocessing phase, while a single node in the enumeration tree can be processed in linear time in the problem dimension.

3 - N-ary Relation Persistencies for Unconstrained Quadratic Binary Optimization : Generation, Implications, Linearization.

Sergine Gueye, Laboratoire de Mathématiques Appliquées du Havre (LMAH), Université du Havre, 25 rue Philippe Lebon, BP 540, 76058, Le Havre Cedex, France, serigne.gueye@univ-lehavre.fr, *Philippe Michelon*

We propose and exploit some persistencies on product of several variables for the Unconstrained Quadratic Boolean Problem (UQBO). These persistencies are generalization of known results on one or a product of two variables derived from the so-called first and second-order derivatives. From a set of persistencies some others may be deduced with various techniques using graph theory or Constraint Programming. Generation and deduction of persistencies gives an iterative procedure that may solve entirely low density instances. For harder cases, it is possible to derive valid inequalities added in any linearization scheme. Numerical results are presented.

4 - The Power of SDP Relaxations - Computing Strong Bounds for QAPs and Graph Problems

Hans Mittelmann, School of Math&Stats, Arizona State University, Box 871804, 85287-1804, Tempe, AZ, United States, mittelmann@asu.edu

As is well-known semidefinite relaxations of discrete optimization problems yield excellent bounds on their solutions. We present two examples from our recent research. The first addresses the quadratic assignment problem and a formulation is developed which yields the strongest lower bounds known for larger dimensions. Utilizing the latest iterative SDP solver and ideas from verified computing a realistic problem from communications is solved for dimensions up to 512. The second area is the computation of bounds in graph problems. A strategy based on the Lovasz theta function is generalized to compute lower bounds for the chromatic number of graphs and upper bounds on the spherical kissing number utilizing SDP relaxations. Multiple precision SDP solvers are needed and improvements on known results for kissing numbers in dimensions up to 23 are obtained. This is joint work with Jiming Peng and Frank Vallentin.

■ WC-36

Wednesday, 12:20 - 13:40

3.1.05

Container Terminal Applications

Stream: OR and Real Implementations

Invited session

Chair: *Ulrich Dorndorf*, INFORM GmbH, Pascalstr. 23, 52076, Aachen, Germany, udorndorf@acm.org

1 - Scheduling freight trains in rail-rail transshipment yards

Erwin Pesch, FB 5, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, erwin.pesch@uni-siegen.de, Nils Boysen, Florian Jaehn

Transshipment yards, where gantry cranes allow for an efficient transshipment of containers between different freight trains, accelerate container handling, so that multiple smaller trains with equal destination can be consolidated to a reduced number of trains. An important problem continuously arising during the daily operations of a transshipment yard is the train scheduling problem, which decides on the succession of trains at the parallel railway tracks. This problem with a special focus on resolving deadlocks and avoiding multiple crane picks per container move is investigated.

2 - Optimized load planning of trains in intermodal transportation

Florian Bruns, Institute of Mathematics, Technical University of Clausthal, Germany, fbruns@uos.de, Sigrid Knust

We study the problem of load planning for trains in intermodal container terminals. The objective is to assign load units to wagons of a train such that the utilization of the train is maximized, and setup and transportation costs in the terminal are minimized. Contrary to previous approaches additionally weight restrictions for the wagons are integrated into our model. We present two different integer linear programming formulations and test them on some real-world instances. It is shown that even non-commercial MIP-solvers can solve our models to optimality in reasonable time.

3 - Scheduling triple cross-over stacking cranes in a container yard

Frank Schneider, INFORM -GmbH, Pascalstrasse 23, 52076, Aachen, Germany, frank.schneider@inform-ac.com

We describe an approach for scheduling triple cross-over rail mounted stacking cranes at a real container yard with automated container storage blocks with asynchronous hand over at the transfer areas at both block front ends. The problem is characterized by frequent long crane moves that make job assignment and crane routing particularly challenging as a tight synchronization between the cranes is required. Simulation results show that our method performs significantly better than commonly used heuristics, leading to a productivity gain of more than twenty percent.

WC-37

Wednesday, 12:20 - 13:40

3.1.09

Territorial Decision Making

Stream: MCDA I: New Approaches and Applications

Invited session

Chair: Florent Joerin, ESAD, Université Laval, Pavillon Félix-Antoine-Savard, 2325, rue des bibliothèques, G1V 0A6, Quebec City, Quebec, Canada, Florent.Joerin@esad.ulaval.ca

1 - Cohesive groups for cohesive representations : how to structure the problem of urban sprawl ?

Florent Joerin, ESAD, Université Laval, Pavillon Félix-Antoine-Savard, 2325, rue des bibliothèques, G1V 0A6, Quebec City, Quebec, Canada, Florent.Joerin@esad.ulaval.ca, Pierre Rondier

This contribution illustrates the use of social representations towards the enrichment of problem structuring methods. Our goal is to propose a participatory approach throughout facilitating the emerging of a collective shared representation of complex problems. Organizing stakeholders in subgroups with varied levels of cohesiveness enables to identify with transparency the core problem representations. Using media interaction in the written press and collective cognitive mapping, we compare how cohesiveness structures the social representations of Urban Sprawl in the Quebec metropolitan Area

2 - Approaching Investments On Gas Transmission Networks With Robustness

Slawomir Pietrasz, CRIGEN-DETI-PSO, GDF SUEZ, 361 av du President Wilson, 93210, St-Denis-La-Plaine, France, slawomir.pietrasz@gdfsuez.com

Making investment decisions on regional transmission networks that no decision maker would regret is becoming a challenge for the French gas operator GRTgaz. Focusing on the evolving context of investment studies we identify uncertain technical, economic and strategic parameters who play a significant role in the out coming investment proposition. We analyse what is at stake when it comes to robustness and flexibility by introducing a risk measure. Eventually we offer a set of new R&D approaches, that we hope, will enable to shift present operational models into future robust decision rules.

WC-38

Wednesday, 12:20 - 13:40

6.2.44

Perishable item inventory management

Stream: Inventory Management

Invited session

Chair: Stefan Minner, Business Administration, University of Vienna, Brünner Strasse 72, 1210, Vienna, Austria, stefan.minner@univie.ac.at

1 - Computing replenishment cycle policy parameters for a perishable item with non-stationary stochastic demand under service level constraints

Karin Pauls-Worm, Operations Research and Logistics, Wageningen UR, Hollandseweg 1, 6706KN, Wageningen, Netherlands, karin.pauls@wur.nl, Roberto Rossi, René Haijema, Jack van der Vorst

Inventory management of perishable products is one of the key challenges in food industry. The decision maker has to determine the timing and production quantity of each replenishment, in order to minimise expected costs, guarantee a service level and avoid excessive waste. We formulate a mixed-integer linear programming model to compute optimal replenishment cycle policy parameters for an item with a fixed lifetime of any length and a stochastic erratic demand under service level constraints. The model keeps track of the ages of the items in stock and uses a FIFO policy.

2 - Modelling Two-Echelon Serial Inventory Systems with Perishable Items

Fredrik Olsson, Industrial Management and Logistics, Lund University, Ole römers väg 1, Box 118, SE-221 00, 22100, Lund, Sweden, Fredrik.Olsson@iml.lth.se

This paper deals with a continuous review, two-echelon serial inventory system with perishable items. Transportation times and the lifetime of items are fixed. When the age of an item has reached its lifetime, the item is useless and consequently discarded from the system. The downstream location faces Poisson demand, and demand that cannot be met immediately is backordered. We develop an efficient approximate technique for evaluation of (S-1,S) policies. In a simulation study we evaluate the quality of our approximation. The results show that our technique works well in most cases.

3 - A one warehouse, multiple retailer distribution inventory system for perishable products

Stefan Minner, Business Administration, University of Vienna, Brünner Strasse 72, 1210, Vienna, Austria, stefan.minner@univie.ac.at

There exist large research streams for durable product, multi-echelon systems and single echelon inventory systems for perishable products. The challenge especially in the latter case is that base-stock policies are no longer optimal. However, the combination of both problems most relevant in food distribution has not received much attention. We present a periodic review multi-echelon model and determine optimal order quantities and the allocation of incoming orders to the retailers under service level constraints. In a numerical study, we compare different rationing policies and analyze the impact of perishability on the optimal degree of inventory centralization.

4 - Computing an optimal ordering policy and deriving an day dependent (s, S) rule for perishables with fixed ordering costs.

René Haijema, Operations Research and Logistics, Wageningen University and Research center, Hollandseweg 1, 6706 KN,

Wageningen, Netherlands, rene.haijema@wur.nl, Jan Van Der Wal, Nico van Dijk

For a product with a fixed shelf life, we compute a cost optimal stock-age dependent ordering policy, assuming fixed ordering costs and unit outdated and shortage costs. An optimal policy is computed by solving a periodic Markov decision problem. By simulation of the optimal policy we easily derive simpler rules, e.g. an (s, S) rule with day dependent parameter values. For a case on blood products, the (s, S) rule appears to be close to optimal, whereas order-up-to S rules perform 10-20% worse. The optimal (MDP) policy is computed thus for deriving and benchmarking simpler rules.

■ WC-39

Wednesday, 12:20 - 13:40

6.2.45

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, jan.weglarz@cs.put.poznan.pl

1 - Discrete-continuous project scheduling — a review of recent results

Grzegorz Waligora, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Wielkopolska, Poland, grzegorz.waligora@cs.put.poznan.pl, Jan Weglarz

Discrete-continuous project scheduling problems are considered, in which non-preemptable, precedence-related activities simultaneously require for their processing units of some discrete resources and an amount of a single continuous, renewable, and limited resource. The processing rate of each activity is an increasing, continuous function of the amount of the continuous resource allotted to the activity at a time. A review of the results obtained for two scheduling criteria: makespan minimization and net present value maximization, under different processing rate functions, is presented.

2 - Metascheduling of workflow jobs in a computational grid

Marek Mika, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, Poland, Marek.Mika@cs.put.poznan.pl, Jan Weglarz

Workflow jobs belong to the most complex computational jobs, and are often performed in computational grids. We assume that grid resources are divided into computational and network ones. Two types of tasks are considered: computational tasks requiring computational resources and transmission tasks requiring network resources. Scheduling jobs on a grid are made at two levels: global for the entire grid and local for a given site. We propose an algorithm for the metascheduler which operate at the global scheduling level in order to find a feasible resource allocation that minimize the makespan.

3 - Optimal allocation of a non-renewable continuous resource for jobs performed sequentially

Rafal Rozycki, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, Poland, rafal.rozycki@cs.put.poznan.pl

In the paper a variant of discrete-continuous scheduling problem is considered. We assume that a given set of jobs of different characteristics has to be performed sequentially using a single non-renewable continuous resource with limited capacity. We propose a general method for finding an optimal continuous resource allocation for different scheduling criteria. Moreover, some cases where a solution can be found analytically, are showed as well.

4 - A longitudinal study of the production scheduling literature

Jose M Framinan, Industrial Management, University of Seville, School of Engineering, Ave. Descubrimientos s/n, E41092, Seville, Spain, framinan@us.es, Paz Perez Gonzalez, Jose M. Molina-Pariente

In this work we analyze the evolution of the production scheduling literature. A number of well-known OR-journals are identified and the published papers on production scheduling are analyzed in an automatic manner in order to present how this field has been reflected (in these journals) over the years and the topics that have received most attention. A number of conclusions can be obtained from this work, as the relative weight of the field has greatly varied over the years from one journal to another, and the topics treated show an extremely scattered trend.

■ WC-40

Wednesday, 12:20 - 13:40

6.2.52

Recent Advances in Engineering Optimization

Stream: Engineering Optimization

Invited session

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Predispatch of Interconnected Hydroelectric Power Systems with Network Topology Modification

Silvia Carvalho, University of Campinas, Brazil, silvia@densis.fee.unicamp.br, Aurelio Oliveira, Christiano Lyra

In this work the primal-dual interior point method is used to minimize the DC predispatch generation costs and transmission losses on hydroelectric power systems with previously scheduled maneuvering. A matrix structure study is performed, to consider the changes that occur in the system along the planning period. This alternative is compared with a straight optimization approach, which does not take advantage of the problem special structure. Numerical experiments with IEEE and Brazilian power systems show the speed and robustness of the problem approach.

2 - Improvements on Hyperbolic Smoothing Clustering Method for Application with Graphics Processing Unit

Ricardo Farias, PESC, COPPE - UFRJ, Centro de Tecnologia, Bloco H, Sala 319, Cidade Universitaria, Rio de Janeiro, RJ, Brazil, 21.941-972, Rio de Janeiro, Rio de Janeiro, Brazil, rfarias@gmail.com, Sergio B. Villas-Boas, Adilson Elias Xavier, Marcelo Signorelli

The minimum sum-of-squares clustering problem solved by Hyperbolic Smoothing Clustering Method adopts a smoothing strategy that solves a sequence of low dimension differentiable unconstrained optimization problems. We propose the GPU Hyperbolic Smoothing Clustering Method which contains parameters to control the balance of data-processing and data-transfer between CPU and GPU. The influence of the parameters of our method is investigated about its influence on performance.

3 - Modelling the conditional variance of wind farm output utilising realised volatility

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

In time series analysis, independence means the series and the squared series show no autocorrelation. If there is no autocorrelation of the series but there is of the squared series, then weak dependence. This occurs when one examines wind farm output with for forecasting the level of output. To construct error bounds on the forecast when one has high frequency data also available, realised volatility is used to estimate the variance. We model 10 second data as an AR(3) process to derive an expression for the variance at a 5 minute time scale in terms of the autoregressive coefficients.

4 - Investigating Optimal EOL Recall Policy for Environmentally Conscious Supply Chain Network

Vildan Ozkır, Barbaros Bulvarı Yıldız Teknik Üniversitesi Endüstri Mühendisliği Bölümü Bektap, 34349, Istanbul, Turkey, vildanozkir@gmail.com, Huseyin Basligil

Recent European legislations about sustainability and environment, SC problems become more complex due to the necessity of considering much more decision variables. As new technology generation life cycle become shorter, consumption rate of valuable resources increases. These huge valuable rubbish heaps yield considerable amount of economic loss and environmental damage. Shortly, this study investigates the most profitable way of environmentally conscious SC design. We propose a MILP model including the idea of collecting more end-of-life products by adjusting incentive prices.

■ WC-41

Wednesday, 12:20 - 13:40

3.1.06

Forestry Management and Long Term Financial Decisions

Stream: Long Term Financial Decisions

Invited session

Chair: *Klaus Seeland*, Institute for Environmental Decisions IED, ETH Zürich, Natural and Social Science Interface, Sonneggstr. 33, SOL E 6, CH-8092, Zurich, Switzerland, klaus.seeland@env.ethz.ch

1 - Applying Mean-Variance rules in the allocation of land use, to avoid deforestation processes in Southern Ecuador

Baltazar Calvas, Institute of Forest Management, Technische Universität München, Am Hochanger 13, 85354, Freising, Bayern, Germany, calvas@forst.wzw.tum.de, *Thomas Knoke*

We used Monte Carlo Simulations to generate frequency distribution for the NPV of four land use options, addressing prices and productivity risks. Land use options (pasture, reforestation, intercropping and silvopasture) were them combined to maximise the Reward-to- variability ratio. The optimum combination was 17 % pasture, 41 % reforestation, 18 % intercropping and 24 % silvopasture. The mixed land use improved NPV and risk compared to the conventional single pasture system.

2 - Urban forest carbon balance optimization - the case of Lahti, Finland

Antti Mäkinen, Department of Forest Sciences, University of Helsinki, Latokartanonkaari 7, Helsingin Yliopisto, 00014, Helsinki, antti.makinen@helsinki.fi

We present a case study of urban forest carbon balance optimization from Lahti in Southern Finland. A forest simulation and optimization model was coupled with a dynamic soil carbon model for predicting the effect of forest management on soil carbon. The optimized management scenarios were (i) maximized carbon stock and (ii) minimized carbon release into the atmosphere taking into account the wood-based product lifecycle and energy production potential.

3 - Real option valuation of forest plantation investments in Brazil

Markku Kallio, Department of Business Technology, Helsinki School of Economics, Runeberginkatu 14-16, FIN-00100, Helsinki, kallio@hse.fi, *Markku Kuula*

Decisions concerning investments in the real assets commonly involve uncertainties, flexibilities and market imperfections. In case of investments in emerging markets, risks relate to political, environmental and economic uncertainties, for instance. In this paper, we present how a firm, The Forest Company, may analyze eucalyptus pulpwood plantation investments in Brazil employing real option valuation. We propose a computational method for valuation of real options which allows incomplete and imperfect markets.

4 - Regional Forest Organizations and their Financial Impact on Forestry and Small Forest Owners in Central Switzerland

Klaus Seeland, Institute for Environmental Decisions IED, ETH Zürich, Natural and Social Science Interface, Sonneggstr. 33, SOL E 6, CH-8092, Zurich, Switzerland, klaus.seeland@env.ethz.ch

The capacity for innovation by the establishment of RO and their impact on regional economic development has been investigated by forest expert interviews and a questionnaire survey among small forest owners in the Canton of Lucerne. The net financial return from their forest holding and marketing effectiveness, proportion of certified forest and wood products the RO members are significantly better off after only a short period of time as compared to the non-organized.

■ WC-42

Wednesday, 12:20 - 13:40

3.1.07

Graph Cleaning

Stream: Graph Searching and Guarding

Invited session

Chair: *Pawel Pralat*, Department of Mathematics, West Virginia University, 26505, Morgantown, WV, United States, pralat@math.wvu.edu

1 - The Fast Searching Problem

Boting Yang, Dept. of Computer Science, University of Regina, 3737 Wascana Parkway, S4S 0A2, Regina, Saskatchewan, Canada, boting@cs.uregina.ca

Edge searching is a graph problem that corresponds to cleaning a contaminated graph using the minimum number of searchers. We define fast searching as a variant of this extensively studied problem. Fast searching corresponds to an internal monotone search in which every edge is traversed exactly once and searchers are not allowed to jump. We give an introduction to fast searching, describe the relationship between graph cleaning and fast searching, and present some recent progress in computing fast search numbers.

2 - Cleaning Graphs with Brushes

Margaret-Ellen Messinger, Mathematics Department, Mount Allison University, New Brunswick, Canada, wynn11@hotmail.com

Initially we assume all edges and vertices of a network are contaminated or "dirty". Brushes are placed on some vertices and at each step, one vertex is "cleaned" whereupon it sends a brush along each dirty incident edge (cleaning those edges). A brush may not traverse an already cleaned edge. One challenge is to determine the minimum number of brushes needed to clean a graph: the brush number of a graph. We'll explore that challenge and discuss some bounds on the brush number.

3 - Minors for digraphs

Paul Hunter, Computing Laboratory, Oxford University, Parks Road, OX1 3QD, Oxford, United Kingdom, paul.hunter@comlab.ox.ac.uk

What is an appropriate definition for a digraph minor? In this talk I answer this question in the most vague way possible, but highlight the difficulties of providing anything more definitive.

4 - Copwin Edge Critical Graphs

Shannon Fitzpatrick, Mathematics and Statistics, University of Prince Edward Island, 550 University Avenue, C1A4P3, Charlottetown, PE, Canada, sfitzpatrick@upe.ca

In the game of Cop and Robber, a single cop tries to apprehend a robber as they alternately move along edges of a reflexive graph. Graphs in which the cop always wins are called copwin graphs. A Copwin Edge Critical graph, with respect to edge addition (deletion), is graph that is not itself copwin, but the addition (deletion) of any edge results in a copwin graph. In this talk, I will discuss some of the properties of Copwin Edge Critical graphs and give a characterization of those that are also planar.

■ WC-43

Wednesday, 12:20 - 13:40

8.2.02

Sustainable Development in Civil Engineering and Multiattribute

Stream: OR for Sustainable Development

Invited session

Chair: *Tatjana Vilutiene*, Dept. of Construction Technology and Management, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT01001, Vilnius, Lithuania, tatjana.vilutiene@vgtu.lt

1 - Birstonas first eco-town in Lithuania: from the idea to the Eco-life Project

Tatjana Vilutiene, Dept. of Construction Technology and Management, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT01001, Vilnius, Lithuania, tatjana.vilutiene@vgtu.lt, *Vaidotas Šarka, Darius Biekša, Edita Šarkien*

The activities in ECO-life project intend to demonstrate the use of a practical and participatory approach, which can be used as an outlet for selected community planning and implementation of sustainable urban areas. The goals of communities within ECO-life project cover the integration of specific innovations like new decisions for building envelope, new metering and supply system, polygeneration technologies and "whole town approach". The paper also analyses the barriers which have to be overcome in Lithuania and possibilities to apply the multi-criteria decision aid.

2 - Multi-criteria assessment of design projects' managers by applying AHP and Additive Rational Assessment (ARAS) methods

Zenonas Turskis, Dept. of Construction Technology and Management, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT01001, Vilnius, Lithuania, zenonas.turskis@st.vgtu.lt, *Povilas Vainiunas, Edmundas Kazimieras Zavadskas, Jolanta Tamosaitiene*

Construction planning processes are extremely important. Project manager must be well experienced in all stages of project implementation. Projects' managers characteristics are considered to be less or more important for the effective project. Qualifying of design projects' managers is a vital part of construction process. For managers' assessment and decision supporting Additive Rational Assessment method (ARAS) was applied. The model presented in this study shows that the ARAS method aggregated together with the AHP method and expert questioning are effective tool.

3 - Multi-objective stochastic simulation-based optimisation applied to supply chain planning

Liana Napalkova, Department of Modelling and Simulation, Riga Technical University, 1, Kalku Street, LV-1658, Riga, Vidzeme, Latvia, Liana.Napalkova@rtu.lv, *Galina Merkurjeva*

The multi-objective stochastic simulation-based optimisation problem with constraints and mixed decision variables is investigated. To solve the problem, an approximate Pareto-optimal front is generated. The hybrid two-phase optimisation method integrates evolutionary computation and response surface-based methodology. A multi-objective genetic algorithm is used for a global search of Pareto-optimal solutions, whereas RSM-based linear search allows local improving the solutions. The hybrid method is applied to simulation optimisation of multi-echelon cyclic planning parameters.

4 - Water supply regional management by stochastic programming

Leonidas Sakalauskas, Statistical Modelling, Institute of Mathematics & Informatics, Akademijos 4, 2600, Vilnius, Lithuania, sakal@ktl.mii.lt, *Kestutis Zilinskas*

Effective planning of resources management is important factor for facilitating socio-economic development and eco-environmental sustainability. Such a planning effort is complicated with a variety of uncertain, dynamic and non-linear factors as well as their interactions. In this study, a stochastic quadratic programming method is developed for reflecting dynamics of uncertainties of water supply systems based on a continuously distributed set of scenarios as well as tackling nonlinearities in the objective function to reflect the effects of marginal utility on system benefits and costs. The method developed can support the analysis of various policy scenarios that are associated with different levels of economic consequences when the promised targets are violated. The developed method is applied to a case study of planning water resources in management and development of regional ecological sustainability. The results have been generated and are helpful for decision makers in not only identifying desired resources- allocation strategies but also gaining insight into the tradeoff between economic objective and eco-environment violation risk.

WC-44

Wednesday, 12:20 - 13:40

8.2.03

Dynamical Systems and Mathematical Modelling in OR I

Stream: Dynamical Systems and Mathematical Modelling in OR

Invited session

Chair: *Selma Belen*, Mathematics and Computer, CAG University, Adana-Mersin Karayolu Uzeri, Yenice-Tarsus, 33800, TARSUS / Mersin, Turkey, selmabelen@cag.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Electrical Energy Optimization in Spacecraft Attitude Control System Using Proper Configuration of Actuators

M. Navabi, Shahid Beheshti University, Iran, Islamic Republic Of, civil.space.edu@gmail.com, *N. Nassiri*

Today's microsatellites (less than 100 kg in mass) are increasingly considered for scientific and commercial purposes. In designing attitude control system and choosing actuators is a viable task to consider energy storage, because microsatellites do not have abundant energy storage and rely on solar panels and rechargeable batteries. Here, a study of an ACS based on optimal control theory, has been done to achieve high precision control performance and minimize the electrical energy consumption. A numerical example is presented in this paper to demonstrate the solution technique.

2 - Organization and Innovation: a System Dynamics Approach

Boada Alejandro, Facultad Administracion de Empresas, Universidad Externado de Colombia, Calle 12 No. 1-17 Este, Bogota, Colombia, alejandro.boada@uexternado.edu.co, *Nancy Mahecha, Maria Teresa Sequeda, Saldana Carolina*

This research seeks to identify inhibitors and motivator for innovation inside the companies; based on general systems theory and complex thought, the Organization is presented as a social system consisting of subsystems and inter-relations. We develop a model, based on the systems dynamics, to represent the interaction patterns and behaviours in order to introduce organizational innovation in companies. By analyzing and modelling subsystems and their interactions, researchers present a different approach to the conventional way of relation innovation and organization.

3 - Superneutrality on the transition path in a cash-in-advance model with recursive utility

Kenji Miyazaki, Faculty of Economics, Hosei University, 4342 Aihara, 194-0298, Machida, Tokyo, Japan, miya_ken@hosei.ac.jp

This paper investigates whether a change in rates of monetary supply enhances rates of capital accumulation in a cash-in-advance monetary model with recursive utility. The paper discovers that the sign of the effect of growth rate of money on capital accumulation depends not only on the curvature of felicity but also on the slope and the curvature of the discounting rate function. When the discounting rate decreases with consumption, and the discounting rate and felicity is sufficiently concave, then inflation deteriorates capital accumulation on the transition path.

4 - Modeling the Diffusion of Chain Emails

Alexandros Kainich, National Technical University of Athens, 15780, Athens, Greece, alexkainich@hotmail.com, *John Coletos*

We study the diffusion of chain emails using data from a single e-mail account. The social network formed has 15,058 nodes. We propose a way of organizing data and of modeling the spread of emails according to the cascade model. Still, we apply the algorithm of k-best for identifying 8 nodes that can provide the greatest expected distribution and propose a way to improve the speed of the program. Finally, we present the social network graph, explain the results of the algorithm and describe the usefulness. The search for k-best nodes can be very useful in marketing.

■ WC-45

Wednesday, 12:20 - 13:40

8.2.12

Category and Shelf Space Management

Stream: Demand and Supply 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

Chair: *Michael Sternbeck*, Logistics, Catholic University of Eichstaett Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, michael.sternbeck@ku-eichstaett.de

1 - Coordinating category management and store operations through extended planograms

Rob Broekmeulen, OPAC, TU Eindhoven, P.O. Box 516, Pav. E10, 5600 MB, Eindhoven, -, Netherlands, r.a.c.m.broekmeulen@tue.nl

Almost half of the shelf allocations in planograms of retail stores are insufficient from a logistic costs perspective. During the allocation process, category managers focus on increasing product variety and profitability, taking high shelf availability for granted. Too low allocations require unrealistic in-store replenishment frequencies, resulting in higher costs and/or lower service than expected. We propose a coordination mechanism between category management and store operations based on differentiated service levels to address this issue.

2 - Retail demand and supply planning with shelf space and price management

Alexander Hübner, Operations Management, Catholic University Eichstaett-Ingolstadt, Auf der Schanz 49, 85049, Ingolstadt, Germany, alexander.huebner@ku-eichstaett.de, *Heinrich Kuhn*

Integrating consumers into demand and supply chain planning is the key lever to increase value chain efficiency and performance in retail. Consumers' demand for better service-levels and prices, whereas retailers respond with increasing product variety, becoming more price competitive and striving towards higher service levels. These have greatly increased the complexity of managing the business. We develop a corresponding demand and supply chain planning framework. With price optimization we will exemplify the interrelated planning issues, to set price levels, and allocate shelf space.

3 - Shelf Space Driven Assortment Planning for Seasonal Consumer Goods

Joern Meissner, Management Science, Lancaster University Management School, Room A48, LA14YX, Lancaster, United Kingdom, j.meissner@lancaster.ac.uk, *Kevin Glazebrook*

We consider the operations of a "fast-fashion" retailers. Zara and others have developed and invested in merchandize procurement strategies that permit lead times as short as two weeks. Our research focuses on the use of the most valuable resource of such a retailer: shelf space. We investigate the use of multi-armed bandits to model the assortment decisions under demand learning. The learning aspect is captured by a Bayesian Gamma-Poisson model. We propose a knapsack based index heuristic that results in policies that are close to theoretically derived upper bounds.

4 - Simulating shoppers' behavior for managers' training.

Maximo Bosch, Industrial Engineering, University of Chile, Republica 701, Santiago, Chile, mbosch@dii.uchile.cl, *Alejandra Puente*

Modern stores are organized in Categories, each one treated as an independent business unit. The Category Manager is in charge of pricing, spacing, assortment, and promotional decisions. A simulation game based on shoppers' behavior under changes in these decisions was developed to support the training of Category managers. This is a noncompetitive web based simulator incorporating recent shoppers' behavior theory.

■ WC-46

Wednesday, 12:20 - 13:40

8.2.14

Numerical methods for derivatives pricing and hedging

Stream: Numerical Methods in Finance

Invited session

Chair: *Michèle Vanmaele*, Applied Mathematics and Computer Science, Ghent University, Krijgslaan 281, S9, 9000, Gent, Belgium, michele.vanmaele@ugent.be

1 - Pricing American Call Options under the Assumption of Stochastic Dividends

Susanne Kruse, S-University of Applied Sciences, Hochschule der Sparkassen-Finanzgruppe, Simrockstr 4, 53179, Bonn, Germany, susanne.kruse@dsgv.de, *Marlene Mueller*

In financial mathematics stock prices are usually modeled directly as a result of supply and demand and under the assumption that dividends are paid continuously. In contrast economic theory gives us the dividend discount model assuming that the stock price equals the present value of its future dividends. These two models need not to contradict each other - in their paper Korn and Rogers (2005) introduce a general dividend model preserving the stock price to follow a stochastic process and to be equal to the sum of all its discounted dividends. In our talk we specify the model of Korn and Rogers in a Black-Scholes framework in order to derive a closed-form solution for the pricing of American Call options under the assumption of a known next dividend followed by several stochastic dividend payments during the option's time to maturity.

2 - Hedging in the interest rate market and the commodity market

Nele Vandaele, Applied Mathematics and Computer Science, Ghent University, Krijgslaan 281 (S9), 9000, Gent, Belgium, nele.vandaele@ugent.be, *Kathrin Glau*, *Peter Leoni*

The theory concerning quadratic hedging (QH) strategies is rather elaborate, while there is almost no literature available on applications to concrete examples. In this talk we determine QH strategies for interest rate derivatives and for derivatives typical appearing in the commodity market. In the interest rate (resp. commodity) market, we determine the (adjusted) delta-hedge and the QH strategy for a swaption (resp. an option written on several assets, while we can only invest in a weighted combination of the underlyings). A crucial step in the numerical implementation is the application of the Fourier transform.

3 - Vanna-Volga methods applied to FX derivatives: from theory to market practice

Griselda Deelstra, Mathematics, Actuarial Sciences, Université Libre de Bruxelles (U.L.B.), Boulevard du Triomphe, CP 210, 1050, Brussels, Belgium, griselda.deelstra@ulb.ac.be, *Frédéric Bossens*, *Gregory Rayée*, *Nikos Skantzos*

We study Vanna-Volga methods which are used to price first generation exotic options in the Foreign Exchange market. They are based on a rescaling of the correction to the Black-Scholes price through the so-called 'probability of survival' and the 'expected first exit time'. We offer a justification of the core technique for the case of vanilla options and show how to adapt it to the pricing of exotic options. Our results are compared to a large collection of indicative market prices and to more sophisticated models. Finally we propose a simple calibration method based on one-touch prices.

4 - Local Volatility Pricing Models for Long-dated FX Derivatives

Gregory Rayée, Mathematics, Actuarial Sciences, Université Libre de Bruxelles (U.L.B.), 55 chemin de bas ransbeck, 1380, Lasne, Belgium, grayee@ulb.ac.be, *Griselda Deelstra*

We study the local volatility function associated to a 3-factor pricing model for FX derivatives. The spot FX rate is governed by a geometric Brownian motion with a local volatility, while domestic and foreign interest rates follow a Hull-White one-factor Gaussian model. The model is suitable to price and hedge long-dated FX derivatives. We derive the local volatility function and obtain different approaches to calibrate the local volatility on the FX option's market. Then, we derive a calibration method for one extension which allows the volatility of the spot FX to have stochastic behavior.

■ WC-47

Wednesday, 12:20 - 13:40

8.2.16

Data Mining in Early Warning Systems I

Stream: Data Mining in Early Warning Systems

Invited session

Chair: *Tobias Klatt*, Department of Economic Studies, Göttingen University, Platz der Göttinger Sieben 3, 37073, Göttingen, Germany, Tobias.Klatt@wiwi.uni-goettingen.de

1 - A trapezoidal Fuzzy DEMATEL-approach to assess dependencies among sub-indicators of a hierarchical disaster indicator model for indirect industrial disaster vulnerability

Michael Hiete, Institute for Industrial Production (IIP), Karlsruhe Institute of Technology (KIT), Hertzstrasse 16, 76187, Karlsruhe, Germany, michael.hiete@kit.edu, *Mirjam Merz*, *Frank Schultmann*

A hierarchical indicator framework to assess the vulnerability of industrial sectors against indirect disaster effects is developed for risk management. Fuzzy Decision-Making Trial and Evaluation Laboratory methodology (DEMATEL) — a method to analyze direct and indirect dependencies between variables — is enhanced for trapezoidal membership functions and used to analyze the dependencies between the sub-indicators. Correcting the elicited importance weights of the indicator model for the dependencies helps to avoid unwanted multiple counting of single dimensions within the indicator model.

2 - An empirical causality procedure for objective early indicator identification

Tobias Klatt, Department of Economic Studies, Göttingen University, Platz der Göttinger Sieben 3, 37073, Göttingen, Germany, Tobias.Klatt@wiwi.uni-goettingen.de, *Klaus Moeller*, *Judith Huelle*

Early indications of environmental changes are crucial to the companies' success under increasing complex and dynamic environments. To overcome subjective assessments used in early indicator selection, we propose an objective identification procedure to evaluate possible early warning indicators concerning their causal relationship with internal planning variables. An empirical application reveals that the procedures' employment reduces the risk of selecting insignificant indicators and improves planning accuracy.

Wednesday, 14:00 - 15:20

■ WD-02

Wednesday, 14:00 - 15:20

3.2.14

Keynote Talk 12

Stream: Keynote Speakers

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 - Computational Complexity of Stochastic Programming

Alexander Shapiro, Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, GA30332, 30332, Atlanta, Georgia, United States, ashapiro@isye.gatech.edu

Stochastic programming is a popular approach to optimization under uncertainty. Its origins are going back to pioneering papers of Dantzig(1955) and Beale (1955). The traditional approach to solving stochastic programming problems is to construct scenarios representing what may happen in the future. From a modelling point of view such scenarios can be considered as a discretization of the underline (true) stochastic data process. Consequently, computational complexity of the obtained optimization problem is determined by the number of generated scenarios. Unfortunately the number of scenarios needed to approximate the "true" distribution of the data process grows exponentially both with increase of the number of random parameters and number of stages. A way of dealing with this explosion of the number of scenarios is to use randomization approaches based on Monte Carlo sampling techniques. In this talk we discuss theoretical and computational aspects of the Monte Carlo sampling approach to solving two and multi-stage stochastic programming problems.

■ WD-04

Wednesday, 14:00 - 15:20

3.2.13

Constructive and local search methods

Stream: Metaheuristics

Invited session

Chair: *Philippe Lacomme*, Laboratoire LIMOS, Université Blaise Pascal, BP 10125, 63173, Aubière Cedex, France, lacomme@sp.isima.fr

Chair: *Fernanda Raupp*, DEI, PUC-Rio, Brazil, fraupp@puc-rio.br

1 - Intensive Local Search Procedure: a new point-to-point metaheuristic for constrained continuous global optimization

Fernanda Raupp, DEI, PUC-Rio, Brazil, fraupp@puc-rio.br, *Wendel Melo*, *Marcia Fampa*

We present a new derivative-free point-to-point metaheuristic for constrained continuous global optimization called Intensive Local Search Procedure (ILSP). It employs classical strategies of metaheuristics for combinatorial optimization as well as combined strategies for approaching continuous spaces, which are applied in an exploration process in increasingly refined neighborhoods of current points.

We show efficiency of ILSP on a standard set of 13 well-known test problems. Further, we compare its performance with some existing metaheuristics on the same set of test problems.

2 - Implementing 2-opt based tabu search on sparse asymmetric TSPs

Sumanta Basu, Operations Management, XLRI, Jamshedpur, Room No. 3, TMDC Building, XLRI Campus, C.H. Area (East), 831001, Jamshedpur, Jharkhand, India, sumanta@xlri.ac.in, *Diptesh Ghosh*

Traveling salesperson problem (TSP) instances encountered in real-world logistics operations are often sparse and asymmetric, and of large size. The literature on tabu search heuristics for the traveling salesman problem primarily deals with relatively small symmetric TSPs defined on complete graphs. In this paper, we provide data structures which speed up the performance of tabu search on large sparse asymmetric TSPs. We show that the speed up using our data structures is significant, and allows us to use tabu search on much larger instances than those reported in the literature.

3 - A new greedy approach to the Quadratic Assignment Problem (QAP)

Theodoros Gevezes, Mathematical and Physical Sciences, Aristotle University of Thessaloniki, 51124, Thessaloniki, Greece, theogev@gen.auth.gr

A new greedy approach is presented for the QAP, where instead of building a solution starting from an empty set, a feasible solution is reached gradually by deleting the worst elements. In order to implement this greedy approach, a set of necessary and sufficient conditions for a zero-one matrix to be a solution of the QAP is proved, while the verification of these conditions requires the solution of linear assignment problem with additional constraints. The new greedy approach has been incorporated in a Greedy Randomized Adaptive Search Procedure (GRASP) with favorable computational results.

4 - A new heuristic for the minimization of tool switches problem

Edson Senne, Mathematics, UNESP/FEG, Caixa Postal 205, 12516-410, Guaratingueta, SP, Brazil, elfsenne@feg.unesp.br, *Antonio Chaves*, *Horacio Yanasse*

The minimization of tool switches problem (MTSP) seeks a sequence to process a set of jobs so that the number of tool switches required is minimized. This work presents a new heuristic for the MTSP. This heuristic has a constructive phase, which is based on a graph where the vertices correspond the tools and exists an arc $k=(i,j)$ binding vertices i and j if tools i and j are necessary for the execution of task k , and an improved phase based on the Iterated Local Search. Computational results show that the proposed heuristic has better performance than other methods from the literature.

■ WD-05

Wednesday, 14:00 - 15:20

3.2.16

Electronics

Stream: Metaheuristics

Invited session

Chair: *Marc Sevaux*, EU/ME, Université de Bretagne Sud - UEB, Lab-STICC - CNRS UMR 3192, Centre de Recherche - BP 92116, 56321, Lorient, France, marc.sevaux@univ-ubs.fr

Chair: *André Rossi*, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr

1 - Implementation of the UMTS Technology in the GSM existing Network: capacity/interference optimization

Abdellah El Fallahi, logistics & computer sciences, ENSA Tetouan, ENSA Tetouan, ENSA, 93000, Tétouan tanger, Tétouan, Morocco, aelfallahi@gmail.com

UMTS is the Third Generation mobile telecoms networks which will bring video, music and internet services to the cell phone and a range of electronic products. This paper deals with the implementation of the UMTS services in the existing GSM900 bandwidth. It focuses on the issue of spectrum and capacity reduction in UMTS900 deployment area and buffer area, which can be seen as an optimization problem, where the decision variable is the number of transmitters that assure an acceptable QoS of the GSM service. An efficient tabu search method is proposed to solve this problem.

2 - Exact and metaheuristic approaches for memory cache management

Maria Soto, Lab-Sticc, Université de Bretagne Sud, Rue Saint Maude, 56100, Lorient, Brittany (Bretagne), France, maria.soto@univ-ubs.fr, *André Rossi*, *Marc Sevaux*

Designing embedded systems is more and more challenging as technology empowers to integrate an increasing number of functionalities in a microchip. Because of this complexity increase, designers rely on CAD software which produce chips that often lack optimization. Consequently, the designed microchips are too power-consuming. Memory cache management has been shown to have a deep impact on performances, thus this work focuses on data allocation to memory banks. This issue is shown to be close to the k-weighted graph coloring problem and is addressed with graph coloring inspired metaheuristics

3 - Point Coverage, Sink Location, and Data Routing Problems in Wireless Sensor Networks: MILP Formulations and Solutions

Kuban Altinel, Dept. of Ind. Eng., Bogazici Univ, Bebek, 34342, Istanbul, Turkey, altinel@boun.edu.tr, *Necati Aras*, *Evren Guney*, *Cem Ersoy*

The point coverage, sink location, and data routing problems are considered within a unified frame and two integrated mixed-integer linear programming formulations are developed. They are difficult to solve and a hybrid procedure is proposed. The best sensor locations are sought by tabu search in the upper level. For the fixed sensor locations, the remaining problem of determining sink locations and data routes are solved approximately in the lower level. According to the experimental results performed on a number of test instances, we can say that the new method is efficient and accurate.

4 - Multi-objective optimization of Memory Built-In-Self-Test sharing

Yann Kieffer, laboratoire G-SCOP, 38031 Cedex 1, Grenoble, France, yann.kieffer@g-scop.inpg.fr, *Zaourar Lilia*, *Nadia Brauner*

Because of the growing integration of systems-on-chips, testing semiconductor on-chip memories is becoming more and more challenging. To improve testability and reduce costs, the additional testing circuitry has to be shared among memories. This sharing impacts the surface cost of these special elements, and also both the test time and test power necessary to test the individual chips after production. We present a model and solution for this sharing problem, where both sequential and parallel sharing are allowed, as specified by compatibility rules given as parameters of the optimization.

■ WD-06

Wednesday, 14:00 - 15:20

8.2.30

DEA Application VII - Retailing and health

Stream: DEA and Performance Measurement

Invited session

Chair: *Stella Sofianopoulou*, Industrial Management & Technology, University of Piraeus, 80 Karaoli & Dimitriou street, 18534, Piraeus, Greece, sofianop@unipi.gr

1 - Assessment for Teaching and Medical Integrated Activities inside Brazilian University Hospitals

Angela Silva, Economia, Unoiversidade Estadualdo Rio de Janeiro, Rua Belisario Tavora 80 ap 506, 22245-070, Rio de Janeiro, Rio de Janeiro, angela@pep.ufrj.br, *Marcos Estellita Lins*, *Maria Stella Castro Lobo*, *Roberto Fiszman*

This paper measures the performance of Brazilian Federal University Hospitals and the integration between medical and teaching activities. We propose a Network DEA model that considers the medical care and the teaching dimensions simultaneously, with equivalent weights. We consider an output-oriented VRS model. The chosen external input variables were: physicians, teachers (for both dimensions), beds and operational expenses (for the medical care dimension); the output variables were: medical grad students (teaching dimension) and adjusted admissions (medical care dimension)

2 - The assessment of retailing efficiency using Network Data Envelopment Analysis

Clara Vaz, Escola Superior de Tecnologia e de Gestão, Instituto Politécnico de Bragança, Campus de Santa Apolónia, Apartado 134, 5301 - 857, Bragança, Portugal, clvaz@ipb.pt, *Ana Camanho*, *Rui Guimarães*

This paper describes a method for the assessment of retail store performance based on DEA. The assessment considers the stores aggregate several subunits, corresponding to sections with management autonomy. This motivated an analysis at the section level and the store level. The performance assessment of the sections involves a comparison among similar sections located in different stores, and evaluates efficiency spread. This is followed by an analysis at the store level to define targets for the sections by using a Network model that takes into account the sections share limited resources.

3 - Analyses of investment efficiency using network DEA

Hirofumi Amatatsu, Information Science of Graduate School of Engineering, Seikei University, 3-3-1 Kichijoji-Kitamachi, 180-8633, Musasino-shi, Tokyo, Japan, amatatsu@mint.ocn.ne.jp, *Tohru Ueda*

Enterprises have been investing to keep their positions in markets or to make new positions. Central and local governments have also been doing similar activities. In this paper we propose DEA algorithms to evaluate efficiency of these investments using financial reports and input-output tables for multiple periods. The algorithms include 1) Dynamic DEA algorithms for simple organizations 2) Dynamic DEA algorithms for matrix type network organizations and 3) Malmquist productivity indexes.

4 - Retail chain performance evaluation using Data Envelopment Analysis

Vassilis Dedoussis, Industrial Management & Technology, University of Piraeus, 80 Karaoli & Dimitriou str., 185 34, Piraeus, Greece, vdedo@unipi.gr, *Stella Sofianopoulou*

The efficiency of a retail chain is a major issue in the retailer's competitiveness, since its profitability depends on the profitability of its parts. Data Envelopment Analysis is employed for resolving this problem in a fast food retail chain and assessing managerially useful measures of store-level retail productivity. The mathematical model created is multidimensional and accepts multiple inputs and outputs, both quantitative and qualitative for every outlet, which are then used as tools for measuring the technical efficiency of the stores. Computational results from a real-world test case are presented.

■ WD-07

Wednesday, 14:00 - 15:20

8.2.47

Project Scheduling

Stream: Project Management and Scheduling [c]

Contributed session

Chair: *Premysl Sucha*, Department of Control Engineering, Czech Technical University, Faculty of Electrical Engineering, Karlovo namesti 13, Prague 2, 121 35, Prague, Czech Republic, suchap@fel.cvut.cz

1 - Time-cost tradeoffs under time and cost chance constraints

Zohar Laslo, Industrial Engineering and Management, SCE-Shamoon College of Engineering, Bialik/Bazel Strs, 84100, Beer Sheva, Israel, zohar@sce.ac.il, *Gregory Gurevich*

Seeking for the improvement of the project planning, we analyzed two current procedures and a new developed procedure for crashing the project completion by additional budget. We consider a project with various types of activities where the randomness of their duration derives from external uncertainty, internal uncertainty or both of them and where correlation between their actual cost and random duration is known. The objective is to 'optimize' the allocation of budget among project activities, seeking to minimize the budget, subject to any chance constrained contractual due date.

2 - Social Network Analysis of project partnership

Blazanka Divjak, Faculty of organization and informatics, University of Zagreb, Pavlinska 2, 42 000, Varazdin, blazanka.divjak@foi.hr, *Nina Begicevic*, *Petra Peharda*

In this paper we present a research on the social network of project partnership in the EUREKA network. The main method used is the Social Network Analysis. Two hypotheses were set: H1 Countries from the same region cooperate more among themselves than with the countries from any other region. H2 Central countries in the social network of partnership in EUREKA projects are developed countries. We tested the hypotheses on countries from Northern, Central, Mediterranean, Western and South-Eastern and Eastern Europe. The results indicate that countries from the same region cooperate more with the countries outside the region and that the central countries in the social network are developed countries.

3 - Flexible Human Resource Management through Decision Support Systems - A Case-Study in a Contact Center Outsourcer

João Justino, HR Department, Teleperformance Portugal, R Alexandre Braga 25-B, 1150-003, Lisboa, Portugal, jj1165@acuity.pt, *Joao Telhada*

Managing the relationship with employees, while keeping high levels of quality in customer satisfaction, has been a continuous challenge for business managers. Usually this relationship is strict, thus introducing flexibility is a breakthrough innovation that can only be achieved in a business intelligence framework. A case study is presented describing the design, adoption and implementation of an intelligence system in a contact center outsourcer for managing the usage of operators in a flexible way. Some indicators are given that illustrate the importance of such systems.

4 - Take-give Resources in Project Scheduling with Time Windows

Premysl Sucha, Department of Control Engineering, Czech Technical University, Faculty of Electrical Engineering, Karlovo namesti 13, Prague 2, 121 35, Prague, Czech Republic, suchap@fel.cvut.cz, *Zdenek Hanzalek*

The problem that we address in this work is motivated by a real scheduling problem from a lacquer production which is seen as the project scheduling problem with general temporal and resource constraints. In addition, there are special resources called take-give resources that are needed from the beginning of an activity to the completion of another activity. In addition, we consider sequence dependent changeover time on take-give resources. We suggest two heuristic solutions to solve the problem. Performance of both heuristics is evaluated on a set of lacquer production benchmarks.

■ WD-08

Wednesday, 14:00 - 15:20

6.1.36

Various Advances on Management and Scheduling II

Stream: Project Management and Scheduling

Invited session

Chair: *Erwin Pesch*, FB 5 - Institute of Information Systems, University of Siegen, Hoelderlinstr. 3, 57068, Siegen, Germany, pesch@fb5.uni-siegen.de

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Edmund Burke*, School of Computer Science & IT, University of Nottingham, Jubilee Campus, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, ekb@cs.nott.ac.uk

1 - Evaluation and comparison of project management software

Vassilis Kostoglou, Department of Informatics, Alexander TEI of Thessaloniki, P.O. Box 141, 57400, Thessaloniki, Greece, vkostogl@it.teithe.gr

Most projects are characterized by complexity due to their size, the requirement for scheduling of tasks and tracking of progress, and the dire need for using their resources efficiently. A large number of relevant software is available to project managers. This work examines thoroughly and evaluates 12 selected project management programmes on six introduced main criteria, each consisting of several components. All programmes are tested and ranked for every criterion and aggregately according to their scores on a five grade scale. Software performances are commented and conclusions are drawn.

2 - On Resource Complementarity in Activity Networks — Preliminary Results

Helder Silva, IFAM - Instituto Federal de Educação, Ciência e Tecnologia do Amazonas, Rua Governador Danilo Areosa S/N,

69075351, Manaus, Amazonas, Brazil, helder@ifam.edu.br,
Anabela Pereira Tereso, José Oliveira

The methodology of project management has been widespread in organizations of different functions and sizes. In this context, we address the issue of optimal resource allocation, and more specifically, the analysis of complementarity of resources (primary resource and supportive resource) in a project. We develop a conceptual system capable of determining the ideal mixture of resources allocated to the activities of a project, such that the project is completed on time with minimal cost. In this paper, we present the mathematical model, development details and the preliminary results obtained.

3 - Forming a balanced team

Stanislaw Walukiewicz, Systems Research Institute, Polish Academy of Sciences, ul. Newelska 6, 01-447, Warsaw, Poland, Stanislaw.Walukiewicz@ibspan.waw.pl

We formulate the problem of formation an effective team, using the terms following Belbin. Next, we reformulate the approach using the concept of social capital and proximity. By social capital we understand formal and informal relations between at least two people. As they are not disjoint, we study proximity - specific interrelations linking people solving a given problem. We show that there are four forms of proximity and that they are mutually disjoint. We compare our approach to the existing balancing methods.

4 - Modular Operational Support System (OSS) to Cutting Processes Parameters Optimization

Elesandro Baptista, Industrial Engineering Post Graduation Program, UNINOVE-Nove de Julho University, Av. Francisco Matarazzo, 612, 05001-100, São Paulo, São Paulo, Brazil, elesandro@uninove.br, Nivaldo Coppini, Êmili Haguilhara

Cutting processes management has great value to industrial companies. Normally, currently used operational conditions are based on tool maker's catalogs and on the operator experience. It is undisputed that each manufacturing scenario has its own characteristics and the optimized conditions can be achieved mainly with collected data from their own shop floor experience. The aim of this paper is to develop a project for a modular Operational Support System (OSS) that allows the user to optimize cutting process parameters in its own manufacturing scenario in real time with the process.

■ WD-09

Wednesday, 14:00 - 15:20
6.2.53

Convex Duality in Mathematical Programming

Stream: Mathematical Programming
Invited session

Chair: Sorin-Mihai Grad, Faculty of Mathematics, Chemnitz University of Technology, 09107, Chemnitz, Sachsen, Germany, grad@mathematik.tu-chemnitz.de

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - On a zero duality gap result in extended monotropic programming

Radu Ioan Bot, Faculty of Mathematics, Chemnitz University of Technology, Reichenhainer Str. 39 Zi. 612, 09107, Chemnitz, Germany, bot@mathematik.tu-chemnitz.de, Ernö Robert Csetnek

In this presentation we discuss and improve a zero duality gap statement given in [D.P. Bertsekas, Extended monotropic programming and duality, Journal of Optimization Theory and Applications 139 (2), pp. 209-225, 2008] for an extended monotropic programming problem. To this aim we use some convex analysis specific techniques based on subdifferential calculus, whereby a determinant role is played by a generalization of the Hiriart-Urruty - Phelps formula.

2 - Duality for vector optimization problems via a general scalarization

Sorin-Mihai Grad, Faculty of Mathematics, Chemnitz University of Technology, 09107, Chemnitz, Sachsen, Germany, grad@mathematik.tu-chemnitz.de, Radu Ioan Bot

Considering a vector optimization problem to which properly efficient solutions are defined by using convex cone-monotone scalarization functions, we attach to it, by means of perturbation theory, new vector duals. When the primal problem, the scalarization function and the perturbation function are particularized, different dual vector problems are obtained, some of them already known in the literature. Weak and strong duality statements are delivered in each case. Thus we extend to a more general framework the results presented in our contribution to the previous EURO Conference from Bonn.

3 - Conjugate Duality in Multiobjective Optimization

Gert Wanka, Faculty of Mathematics, Chemnitz University of Technology, Chemnitz University of Technology, Faculty of Mathematics, D-09107, Chemnitz, Germany, gert.wanka@mathematik.tu-chemnitz.de

This paper is devoted to some concepts and results regarding duality for convex vector optimization problems. We consider problems with and without geometric and cone constraints and deal with Lagrange, Fenchel and Fenchel-Lagrange duality. We establish weak, strong and converse duality results accompanied by necessary and sufficient optimality conditions.

References

R. I. Bot, S.-M. Grad, G. Wanka, Duality in vector optimization. Springer-Verlag Berlin Heidelberg 2009

4 - A new and condensed linearization algorithm for an important branch of Linear Fractional Programming Problem

Reena Kapoor, mathematics, delhi university, j-5/4a krishna nagar, Delhi, 110051, Delhi, Delhi, India, reena_3105@rediffmail.com

This paper deals with Linear Fractional Programming Problem with bounded variables under the restriction: absolute value of the denominator is greater than or equal to M0. An example is constructed to show importance of the problem in real world. One way to solve the problem is: divide it into two separate LFPP and apply Charnes-Cooper Method. The underlying contribution of this paper is: it provides a compact process that linearize the considered problem at one go. Comparative study of two techniques is also given. An example and the codes and data sets for the procedure are given in the end.

■ WD-11

Wednesday, 14:00 - 15:20
8.2.38

Advances in the Use of Information Technology IV

Stream: Emerging Applications of OR
Invited session

Chair: Sevgi Ozkan, Information Systems, Middle East Technical University, ODTU Enformatik Enstitüsü, İsmet İnönü Bulvarı, 06531, Ankara, Turkey, sozkan@ii.metu.edu.tr

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Verification of the validity on the pattern of Royal e-customer purchasing behavior

Masashi Nakagawa, web business technology, The kyoto college of graduate studies for informatics, 606-8225, kyoto, Japan, nakagawa.3719@gmail.com, Hong Seung Ko, Shasha Liu, Megumi Hiramoto, Takeshi Teramoto

The visualization of e-customer behavior is a very key issue in e-business. It is needed to understand the e-customer behavior process and the purchase pattern to visualize an e-customer behavior. In this paper, we will check up that the e-customer who must be retained and took the behavior pattern of following up the 7 steps of behavior process brings out the profitable sales to a company. Consequently, we verify that the profitable sales are increased by the most valuable e-customer taking the 7 steps through the correlation analysis and the causal analysis.

2 - Verification of the validity on the 7 steps of e-customer behavior

Haruki Takada, The kyoto college of graduate studies for informatics, 606-8225, kyoto, Japan, htakada@websui.com, *Hong Seung Ko*

In online way, the e-customer value to create a long term profits becomes a very important element. For this evaluation on the Internet / through e-customer behavior process, we propose the 7 steps of royal e-customer behavior process to be developed. We verify the effectiveness and the validity of the 7 steps by nomological validity and causality analysis. Furthermore, for measuring e-customers' value we consider motives which are appraisal criteria and factors concerning with following up the 7 steps.

3 - Quantile Analysis for Multidimensional Acceptance Intention of E-reader

Tzyy Jane Lai, Department of International Business., Yuan Ze University, 135 Yuan Tung Rd. ChungLi, 320, TaoYuan, Taiwan, Taiwan, fntjlay@saturn.yzu.edu.tw, *Hsien-Tung Tsai, Ya-Ling Chiu*

This study incorporates three different theories to build a multidimensional framework and use quantile regression to investigate the dynamic effects of determinants on users that have different level of acceptance intentions. Firstly, we extends the TAM and TPB model and then incorporate the social-identity expressiveness effects of technology adoption which includes cosmopolitanism and global identification. The study argues that the proposed framework can provide a more comprehensive picture in describing users' acceptance intention of e-reader.

■ WD-12

Wednesday, 14:00 - 15:20

8.2.39

AHP 08

Stream: Analytic Hierarchy Processes, Analytic Network Processes

Invited session

Chair: *Eizo Kinoshita*, urban science, Meijo University, 4-3-3,nijigaoka, 509-0261, kani, gifu, Japan, kinoshit@urban.meijo-u.ac.jp

1 - Evaluation of Information Security and Efficient System Using Dominant AHP

Norikumo Shunei, Management, General Management department, 12-5 Harayama, Okamachi, 444-0005, Okazaki, Aichi, Japan, norikumo@asu.ac.jp, *Eizo Kinoshita*

In this study, I introduce a concept of the SA (the security architecture) that developed from a concept of EA(enterprise architecture) into the evaluation of information security service. Using the framework and the characteristic of the hierarchy model, it combines dominant AHP and suggests the technique of the new system optimization and promotion of efficiency.

2 - Determining MDF & particleboard's marketing effective criteria

Majid Azizi, wood and paper sciences and technology, Faculty of natural resources, University of Tehran, karaj, tehran, Iran, Islamic Republic Of, mazizi@ut.ac.ir, *Fatemeh Sarfi, Mehdi Faezipour, Amin Arian*

Goal of the research is determining MDF and particleboard effective criteria with respect to customer preferences. AHP has been applied to determine weighing values of the criteria. First step a decision tree is categorized in three major groups: qualitative, technical & technological and marketing criteria. In second step questionnaire prepared, distributed and gathered responses from the customers. Final results showed the highest priority of criteria for particleboard and MDF are nail and screw holding ability and machine ability of the panel, respectively.

3 - A Super Pairwise Comparison Matrix in Dominant AHP

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*

In this study, we propose the super pairwise comparison matrix (SPCM) which is a pairwise comparison matrix whose element is the relative ratio from a pairwise comparison of weights of the combination of alternatives and criteria. Furthermore, in the case of dominant AHP, we prove that the weights calculated by the logarithmic least square method to the SPCM equal the weights calculated by geometric mean method to the ordinary pairwise comparison matrices.

4 - A Comparison of Dominant AHP/CCM and AHP/ANP

Eizo Kinoshita, urban science, Meijo University, 4-3-3,nijigaoka, 509-0261, kani, gifu, Japan, kinoshit@urban.meijo-u.ac.jp

The Theory of Games is a conflict descriptive type model designed to minimize one's loss. AHP, on the other hand, is a conflict solving type model and offers a method to describe which element in the conflict is more critical. This paper analyze the comparison of Dominant AHP/CCM (Concurrent Convergence Method), proposed by Kinoshita and Nakanishi, with AHP/ANP, proposed by Saaty and present the calculation methods and the mathematical structure of the former in the process.kkk

■ WD-13

Wednesday, 14:00 - 15:20

2.2.21

Decision support for practical logistics problems

Stream: Location Analysis

Invited session

Chair: *Hokey Min*, Management, Bowling Green State University, Dept of Management, 3008C, Bowling Green State University, 43403, Bowling Green, Ohio, United States, hmin@bgsu.edu

1 - An Intelligence Decision Support System for Paratransit Service Vehicle Routing and Scheduling

Hokey Min, Management, Bowling Green State University, Dept of Management, 3008C, Bowling Green State University, 43403, Bowling Green, Ohio, United States, hmin@bgsu.edu, *Emanuel Melachrinoudis*

In this paper, we propose an intelligent decision support system for solving multi-depot, multi-vehicle, and capacitated call-a-ride paratransit service problems with sliding time windows. The proposed system has been applied to real problems encountering the Toledo Area Regional Paratransit Services (TARPS) in the United States.

2 - Truck Routing and Driver Scheduling under Hours of Service Regulations

Emanuel Melachrinoudis, Mechanical and Industrial Engineering, Northeastern University, 360 Huntington Avenue, 2115, Boston, MA, United States, emelas@coe.neu.edu, *Hokey Min*

Hours-of-service (HOS) regulations are intended to ensure truck drivers get adequate rest and perform safe operations. However, restricting the driver's consecutive driving hours and expanding off-duty hours, combined with road traffic and other delays may lead to substantial transportation cost increases. A model that determines the route of a single truck and its driver's schedule under HOS and time-dependent vehicle speed is developed that minimizes total trip time. The model is solved by a heuristic procedure and is tested

3 - Locating a Semi-Obnoxious Facility with Mixed Distance Metrics

Emre Yavuz, Mechanical and Industrial Engineering, Northeastern University, 235 Park Dr. Apt 20, 02215, Boston, MA, United States, emreyavuz999@gmail.com, *Emanuel Melachrinoudis*

Semi-obnoxious facilities are those facilities that both provide a service to the community and have adverse effects on the people and the environment, such as power plants, chemical plants, airports, incinerators and waste dumps. These facilities should be located far away from population centers, but not too far away in order to contain transportation costs. A mixed distance metric bicriteria model is developed to locate a semi-obnoxious facility on a network by using network distances for transportation and Euclidean distances for undesirable effects and it is illustrated in an example involving the location of a semi-obnoxious facility in the Bursa Province of Turkey.

4 - Theory of constraints for closed-loop supply chain management

Hokey Min, Management, Bowling Green State University, Dept of Management, 3008C, Bowling Green State University, 43403, Bowling Green, Ohio, United States, hmin@bgsu.edu

Close-loop supply chain operations often require dramatic changes in business paradigms that include the coordination of both forward and reverse supply chain flows, the substitution of disposal for salvage, and the tracing of products throughout their entire life cycles. These changes are often preceded by cultural changes across the supply chain. To embark on the successful change in closed-loop supply chain operations, this paper proposes a theory of constraints that can map necessary changes in the close-loop supply chain and guide those changes within various system constraints.

■ WD-14

Wednesday, 14:00 - 15:20

2.2.15

Stochastic methods in actuarial sciences

Stream: Actuarial Sciences and Stochastic Calculus

Invited session

Chair: *Griselda Deelstra*, Mathematics, Actuarial Sciences, Université Libre de Bruxelles (U.L.B.), Boulevard du Triomphe, CP 210, 1050, Brussels, Belgium, griselda.deelstra@ulb.ac.be

1 - On a discrete time risk model with interest

Maude Gathy, département de mathématique, service de Probabilité, Université Libre de Bruxelles, Boulevard du Triomphe, CP 210, 1050, Bruxelles, Belgium, mgathy@ulb.ac.be, *Claude Lefèvre*

This work is concerned with a discrete time model where an insurer receives fixed premiums and pays the claims amounts respectively at the beginning and at the end of the time periods. Non-null rates of interest are also incorporated. An exponential bound for the ruin probability over any finite time horizon is first provided. It depends on the length of the time horizon via an adjustment coefficient. The possibility for the insurer to use proportional reinsurance is then investigated.

2 - Local risk minimization in case of stochastic volatility and jumps

Michèle Vanmaele, Applied Mathematics and Computer Science, Ghent University, Krijgslaan 281, S9, 9000, Gent, Belgium, michele.vanmaele@ugent.be, *Nele Vandaele*

The locally risk-minimizing hedging strategy for a risky asset whose price process is a continuous semimartingale is obtained from the risk-minimizing hedging strategy under the minimal martingale measure. However in the discontinuous case, this is no longer true. We will explain how one can determine the locally risk-minimizing hedging strategy in this latter case. As applications we will derive LRM hedging strategies for stochastic volatility models and for unit-linked life insurance contracts where the underlying asset is driven by a Lévy process.

3 - Absolute ruin in the insurance risk model of Ornstein-Uhlenbeck type

Ronnie Loeffen, Weierstrass Institute (WIAS), Mohrenstrasse 39, 10117, Berlin, Germany, loeffen@wias-berlin.de, *Pierre Patie*

We consider the classical risk process where the company earns interest on positive surplus and pays interest (at the same rate) when the surplus is negative. In this model, the company can get absolutely ruined, which is the event where the premium income can no longer compensate the interest payments. We derive simple expressions for the Laplace transform in space of both the finite and infinite time absolute ruin probability as well as the two-sided exit problem (related to the absolute ruin level). These Laplace transforms can be inverted for specific cases of the claim size distribution.

4 - Backward stochastic differential equations and stochastic control: A direct approach and an application to portfolio optimization

Xavier De Scheemaekere, Solvay Brussels School of Economics and Management, Université Libre de Bruxelles (U.L.B.), Av.

F.D. Roosevelt, 50, CP 145/1, 1050, Brussels, Belgium, xdeschee@ulb.ac.be

This paper investigates the connection between backward stochastic differential equations (BSDEs) and Hamilton-Jacobi-Bellman partial differential equations (HJB PDEs) in stochastic control. Like HJB PDEs, BSDEs can be used to express the optimal solution of a stochastic control problem directly. Moreover, this stochastic approach naturally extends to the nonlinear case, i.e. when the payoff function is expressed in terms of a nonlinear conditional expectation. These results are applied in finance to solve linear and nonlinear dynamic portfolio optimization problems.

■ WD-15

Wednesday, 14:00 - 15:20

2.2.12

Traveling salesman problems

Stream: Vehicle Routing [c]

Contributed session

Chair: *Ana Paias*, DEIO/CIO, University of Lisbon, Portugal, ampaia@fc.ul.pt

1 - Towards A Learning-based Heuristic Searching Reform Scheme

Fan Xue, Department of Industrial and Systems Engineering, Hong Kong Polytechnic University, Honghom, N/A, Kowloon, Hong Kong, dewolf.xue@polyu.edu.hk, *C.y. Chan*, *W.h. Ip*, *C.f. Cheung*

We investigate the issue of improving heuristic searching with supervised learning in large scale optimization. We noticed the "self-similarity" in many problems and present an efficient model that can learn "patterns" from a small sub-problem and amend the heuristics in the given problem. Experiments were conducted on large-scale benchmark problems, including the Euclidean Traveling Salesman and the Staff Rostering. We find the results encouraging as we hope it unveils a promising direction of taking advantage of the power of machine learning in large-scale optimization.

2 - Sampling-based Heuristics for the Probabilistic Traveling Salesman Problem with Deadlines

Dennis Weyland, IDSIA, Galleria 2, 6928, Manno - Lugano, Switzerland, dennis@idsia.ch

The Probabilistic Traveling Salesman Problem with Deadlines is a Stochastic Vehicle Routing Problem with a computationally demanding objective function. We present an approximation for the objective function using Monte Carlo Sampling and use this approximation in some heuristics. Those heuristics are comparable with state-of-the-art approaches in terms of solution quality, while requiring significantly less computational time.

3 - Solving the Multicolor TSP

Emanuele Tresoldi, Università Statale di Milano, 20100, Milano, emanuele.tresoldi@unimi.it, *Roberto Wolfler-Calvo*, *Sylvie Borne*

The problem addressed in this paper is a new interesting variant of the classical asymmetric traveling salesman problem. The set of nodes to visit is obtained by joining clusters of nodes, each one characterized by a color. Two nodes of the same color must be separated in the optimal sequence by at least H and at most K nodes of the other colors. The problem consists in finding the optimal hamiltonian cycle, respecting all the different separation constraints. We present formulations, exacts and heuristics approaches. The computational results prove the efficacy of the proposed algorithms.

4 - Integer Linear Programming and Dynamic Programming approaches for a Traveling Purchaser Problem with Additional Side-Constraints

Ana Paias, DEIO/CIO, University of Lisbon, Portugal, ampaia@fc.ul.pt, *Luis Gouveia*, *Stefan Voss*

We study the traveling purchaser problem with a limit on the maximum number of markets to be visited, a limit on the number of items bought per market and where only one copy per item needs to be bought. We present an ILP model and several variations of a Lagrangian relaxation combined with a subgradient optimization procedure. The relaxed problem is solved by dynamic programming (DP) as it can result from applying a state space relaxation technique to a DP formulation for the problem. Computational results show the effectiveness of the methods.

■ WD-17

Wednesday, 14:00 - 15:20

1.3.14

Data Mining Tools and Improvements

Stream: Computational Statistics

Invited session

Chair: *Fatma Yerlikaya Ozkurt*, Scientific Computing, Institute of Applied Mathematics, Industrial Engineering Department, Middle East Technical University, 06531, Ankara, Turkey, fatmayerlikaya@gmail.com

Chair: *Elcin Kartal Koc*, Statistics, Middle East Technical University, Department of Statistics, No:234, 06531, Ankara, Turkey, kartalelcin@gmail.com

1 - Parameter Estimation for Semiparametric Models with CMARS and Its Applications

Fatma Yerlikaya Ozkurt, Scientific Computing, Institute of Applied Mathematics, Industrial Engineering Department, Middle East Technical University, 06531, Ankara, Turkey, fatmayerlikaya@gmail.com, *Pakize Taylan*, *Gerhard-Wilhelm Weber*

The particular form of Generalized Linear Models are the semiparametric models in that the usual parametric terms are augmented by a single nonparametric component. The advantage of semiparametric models consists in some grouping (linear and nonlinear or parametric and nonparametric) that could be done for the features to assign appropriate submodels. We apply CMARS, constructed by conic quadratic programming, for the nonparametric part. For the parametric part, least square estimation with Tikhonov regularization is used. The applications of this study will be analyzed.

2 - An ACO-based Clustering Algorithm

Tulin Inkaya, Industrial Engineering, Middle East Technical University, METU Industrial Engineering Department, 06531, Ankara, Turkey, tulin@ie.metu.edu.tr, *Sinan Kayaligil*, *Nur Evin Ozdemirel*

Aim of the proposed ACO-based clustering algorithm is to generate a set of non-dominated solutions which includes the target clusters. Ants form a network by placing edges between points that are in the same cluster. In the pre-processing step, neighborhoods of points and subclusters are formed in a graph theoretic context. In ACO, only the points on the subcluster boundaries are used in clustering to ensure computational efficiency and ACO focuses on outlier detection and merging operations. Performance of the proposed algorithm is tested on various data sets.

3 - Designing control limits of average control chart using subgroups for non-normal processes

Shih-Chou Kao, Graduate School of Operation and Management, Kao Yuan University, No.1821, Jhongshan Rd., Lujhu Township, 821, Kaohsiung County, Taiwan, kaosc@cc.kyu.edu.tw

Most articles determined the related constant values of an average control chart based on simple sizes, not subgroups for the skewed distributions. Rare researches discussed the influence of subgroups on monitoring for the skewed distributions and determined the suitable constant values of an average control chart. The study determined the constants of the average control chart by using a simulation method and fixing the probability of type I that is 0.0027 with log-normal distribution to construct the average control chart. Furthermore, compared the probabilities of type I and type II errors among the control charts, including the weighted variance (WV), skewed correction (SC) and traditional Shewhart control charts, the proposed control chart is superior to them, in terms of the two probabilities for a skewed process.

■ WD-18

Wednesday, 14:00 - 15:20

1.3.15

Data Mining for Credit Scoring

Stream: Applications in Business Intelligence and Knowledge discovery

Invited session

Chair: *Hsin-Vonn Seow*, Business School, University of Nottingham-Malaysia Campus, Jalan Broga, Selangor Darul Ehsan, 43500, Semenyih, Selangor, Malaysia, Hsin-Vonn.Seow@nottingham.edu.my

1 - Recovery Rate Modelling for Unsecured Consumer Credit: Watching early repayment behaviour pays

Jie Zhang, School of Management, University of Southampton, Quantitative financial risk management centre, Building 2, Highfield Campus, Southampton, SO17 1BJ, Southampton, England, United Kingdom, jz3g08@soton.ac.uk, *Lyn Thomas*

Estimating Recovery Rate (RR) has become more important in consumer credit because of the new Basel Accord regulation and the increase in number of defaulters due to the recession. We examine whether short-term RR is helpful in modelling final RR. It is found that 12-month RR and 24-month RR are very significant variables in final RR prediction models. Thus, we look at two-stage models, where in stage one, short-term RR is predicted, and then the predicted short-term RR is used in the overall RR prediction models.

2 - Transactors and Pricing

Hsin-Vonn Seow, Business School, University of Nottingham-Malaysia Campus, Jalan Broga, Selangor Darul Ehsan, 43500, Semenyih, Selangor, Malaysia, Hsin-Vonn.Seow@nottingham.edu.my, *Lyn Thomas*

The saturated condition of the market for personal financial products requires financial institution to look at ways of increasing the acceptance rate of their products. We take the example of credit cards and varying the interest rates on them to make it more attractive to potential consumers. To achieve that, we advocate including a Transactor Score in the model to find a variant of interest rate on the card to offer that would have a high acceptance take from the potential consumer

3 - Improving a Bank's Quality of Products & Services and its Attractiveness by using systems & tools from manufacturing operations

Maria Mavri, Business Administration, University of the Aegean, 8 Michalon Street, 82100, Chios, Greece, m.mavri@ba.aegean.gr, *Vassilis Angelis*, *Katerina Dimaki*, *George Konstantas*

The ability of a bank to attract customers depends on its Image which has already been defined as a function of a multitude of factors. The present work assumes that a bank can effectively be represented as a manufacturing operation and uses tools and systems from this area to map out, assess and redesign the bank's processes so as to improve its effectiveness and efficiency. Furthermore it uses the improvements achieved at process level, as inputs to the bank image model, thus, quantifying the effect of those improvements, on the quality of bank services and on its overall attractiveness.

■ WD-19

Wednesday, 14:00 - 15:20

1.3.20

Nonsmooth and Nonconvex Optimization Methods

Stream: Nonsmooth Optimization

Invited session

Chair: *Marko M. Mäkelä*, Department of Mathematics, University of Turku, FI-20014, Turku, Finland, makela@utu.fi

Chair: *Napsu Karmitsa*, Department of Mathematics, University of Turku, FI-20014, Turku, Finland, napsu@karmitsa.fi

1 - Truncated codifferential method for nonsmooth non-convex optimization

Adil Bagirov, School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.bagirov@ballarat.edu.au

We propose a new algorithm to locally minimize nonsmooth functions represented as a difference of two convex functions (DC functions). The algorithm is based on the concept of codifferential. It is assumed that DC decomposition of the objective function is known a priori. We develop an algorithm to compute descent directions using a few elements from codifferential. The convergence of the minimization algorithm is studied and its comparison with different versions of the bundle methods using results of numerical experiments is given.

2 - A New Trust Region Algorithm Using Radial Basis Function Models

Seppo Pulkkinen, Department of Mathematics, University of Turku, Vesilinnantie 5, Turun yliopisto, 20014, Turku, Finland, seppo.pulkkinen@utu.fi

We present a new derivative-free algorithm using interpolation models and trust regions for black box optimization problems. The model function is constructed as a linear combination of radial basis functions augmented with a linear polynomial tail. A novel feature of the algorithm is that it solves the trust region subproblem by using a d.c. decomposition of the model function. The new algorithm is also tailored for exploiting possible structure of the problem. Numerical results illustrating the efficiency of the new algorithm compared to the present algorithms will also be presented.

3 - Sparse regression via a trust-region proximal method

Dongmin Kim, University of Texas at Austin, The University of Texas at Austin Department of Computer Sciences 1 University Station C0500 Taylor Hall 2.124, 78712-0233, Austin, TX, dmkim@cs.utexas.edu, *Suvrit Sra*, *Inderjit Dhillon*

We present a method for sparse regression problems. Our method is based on the nonsmooth trust-region framework that minimizes a sum of smooth convex functions and a nonsmooth convex regularizer. By employing a separable quadratic approximation to the smooth part, the method enables the use of proximity operators, which in turn allow tackling the nonsmooth part efficiently. We illustrate our method by implementing it for three important sparse regression problems. In experiments with synthetic and real-world large-scale data, our method is seen to be competitive, robust, and scalable.

4 - Comparing Nonsmooth Optimization Methods and Software

Napsu Karmitsa, Department of Mathematics, University of Turku, FI-20014, Turku, Finland, napsu@karmitsa.fi, *Adil Bagirov*, *Marko M. Mäkelä*

Nonsmooth optimization (NSO) methods may be divided in two main groups: subgradient and bundle methods. When developing new methods, testing is usually made between similar methods. We compare both bundle and subgradient methods as well as some methods that lie between them. The test set includes large amount of different NSO problems: e.g. convex and nonconvex problems, piecewise linear and quadratic problems and problems with different sizes. The aim of this paper is not to foreground some method over the others but to get an insight of which method to select for certain types of problems.

■ WD-21

Wednesday, 14:00 - 15:20

6.2.47

Social Policy and Education

Stream: Education, and Social 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 - Performance management and school achievement in Portuguese secondary schools

Cláudia S. Sarrico, Social, Juridical and Political Sciences, University of Aveiro, 3810-193, AVEIRO, Portugal, c.s.sarrico@ua.pt, *Maria J. Rosa*, *Margarida F. Cardoso*

The purpose of this study is to better understand the relationship between performance management practices of Portuguese secondary schools and their achievement. Quantitative methods are used to measure school performance, taking a value-added approach. Schools are then positioned in a matrix of measured performance vs perceived performance (ranking by exam results). A set of schools with different levels of performance was selected for qualitative in-depth case study analysis. The study provides a better understanding of which performance management practices are behind school success.

2 - Efficacy beliefs of teachers to optimize learning opportunities: Incentives for teacher education policy-making

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, *Feyza Erden*

Data based on a nationwide survey supported by TUBITAK show that overcrowding of class size has a number of dramatic disadvantages such as unequal participation of students, less active learning opportunities, and increased number of misbehaviors which may hinder optimum learning. This study helps understand the teacher efficacy levels in classroom management, especially in overcrowded public schools, which may in return provide an incentive for policy-makers to undertake teacher education policies, and equal school quality opportunities.

■ WD-22

Wednesday, 14:00 - 15:20

3.1.10

Maritime Vessel Routing and Deployment

Stream: Maritime Logistics

Invited session

Chair: *Jose Fernando Alvarez*, Research & Innovation – Maritime Transport, Det Norske Veritas, Veritasveien 1, BRINO911, 1322, Høvik, Baerum, Norway, jose.fernando.alvarez@dnv.com

1 - The linearized simultaneous string-design and cargo-routing problem

Christian Edinger Munk Plum, Operations Research - DTU Management, Network Advanced Solutions - Maersk Line, Esplanaden 50, 1098, Copenhagen K, Denmark, Christian.Edinger.Munk.Plum@maersk.com

A global liner shipping company's network consists of a billion-dollar investment in assets and similarly sized operational costs. The problem of designing this network, to minimize costs while considering many operational constraints is thus of great relevance. Empirical studies of the cost structure of a network's strings (ship rotations), show a linear relation to the capacity and length of the string. This is used in the formulation of the problem, which will be solved with decomposition techniques such as column generation.

2 - Improving the logistics of moving empty containers - Can new concepts avoid a collapse in container transportation?

Stefan Voss, Wirtschaftsinformatik/Information Systems, University of Hamburg, Von-Melle-Park 5, 20146, Hamburg, Germany, stefan.voss@uni-hamburg.de, *Robert Stahlbock*

Despite any crisis total seaborne trade has quadrupled over the past decades. However, billions of Euros are spent to deal with inefficiencies caused by repositioning of empty containers. Increased container population and global trade imbalance led to accumulation of empty containers in some major port areas and container shortage in others. We provide an analysis of data emphasizing the imbalances of container transportation. We discuss approaches for reducing empty container movements. Moreover, we discuss solution concepts to overcome parts of this situation.

3 - Ship Scheduling

Fotini Malliappi, School of Mathematics, UNIVERSITY OF SOUTHAMPTON, Highfield Road, SO17 1BJ,

SOUTHAMPTON, United Kingdom,
fmaliappi@googlemail.com, *Chris Potts*

The presentation will focus on a classic ship scheduling problem, in which the routing and scheduling of a heterogeneous fleet of ships with time windows for pick-ups and deliveries at multiple ports is required in order to maximise profits. We will present an integer programming formulation of the problem. However, its complexity is such that heuristics methods are needed. A computational evaluation of a multi-start local search heuristic versus a variable neighbourhood search implementation will be presented as it indicates which method offers the most potential.

4 - Simultaneous Deployment and Network Design in Liner Shipping: Formulation and solution method

Shahin Gelareh, Production Planning - Operations Research, Technical University of Denmark, Lyngby 2800, Building 426, 67663, Copenhagen, Copenhagen, Germany,
shahin.gelareh@gmail.com, *David Pisinger*

We propose a linear mixed integer programming formulation for simultaneous design of network and deployment of containerships. We aim at overcoming the gap between the strategic planning problem of network design and tactical level problem of fleet deployment. By separating the string generation problem from the model, we propose a novel enumerative hierarchical decomposition approach based on an underlying primal decomposition method for solving instances of the problem either optimally or heuristically. Our computational results indicate superiority of our method to CPLEX on all instances.

■ WD-23

Wednesday, 14:00 - 15:20

6.2.49

Data Mining in Portfolio Analysis 2

Stream: Data Mining in the Financial Sector

Invited session

Chair: *Vadim Mottl*, Intelligent Systems, Computing Center of the Russian Academy of Sciences, Vavilov St. 40, 119333, Moscow, Russian Federation, vmottl@yandex.ru

Chair: *Michael Markov*, Markov Processes International, 25 Maple Str, Suite 200, 07901, Summit, NJ, United States,
michael.markov@markovprocesses.com

1 - Portfolio Calibration Approach for Asset Allocation and Financial Optimizations

Michael Markov, Markov Processes International, 25 Maple Str, Suite 200, 07901, Summit, NJ, United States,
michael.markov@markovprocesses.com, *Evgeny Bauman*

We introduce the Portfolio Calibration method in Financial Optimizations that results in optimal portfolios preserving their efficiency in different market scenarios. For each scenario the portfolio is projected onto the efficient portfolio set and then aggregated. Different types of projections are introduced. A robust efficient set Calibrated Efficient Frontier is defined. A measure of stability of portfolio efficiency is suggested. Using Markowitz MVO as an example, we show that the Calibration method produces more stable results than both the original MVO and other approaches.

2 - Statistical analysis for style drift concept

Ilya Muchnik, Comp. Science, Rutgers University, 96 Frelinghuysen Road, 08854, Piscataway, NJ, United States,
muchnikilya@yahoo.com, *Megan Woods*, *Evgeny Bauman*,
Michael Markov

Practitioners have a strong interest to get a relevant score associated with the concept to estimate "a quality degree of a manager style". They take their attention on a variability of the manager's style based on traditional econometric methods for regression analysis. Usually they use as the score a variance for a constant-based regression model. In this paper we follow the same approach. Our novelty includes two advantages: as a base linear regression model with a dependency portfolio from a time scale, and, we characterize a manager style by two criteria, passive and active.

3 - Edge-preserving Kalman-Bucy filtration and smoothing of return time series: Detection of hidden events in the investment strategy

Olga Krasotkina, Tula State University, 300600, Tula, Russian Federation, ko180177@yandex.ru, *Vadim Mottl*, *Michael Markov*

The Bayesian approach to Dynamic Investment Style Analysis results in estimating a time-varying regression model of the publicly available time series of periodic returns on the portfolio being monitored with respect to the returns on asset classes the portfolio might be composed from. We consider an a priori Markov model of capital sharing which allows for sharp changes in the investment strategy. Having been applied to the return data of the Quantum hedge fund in 1992, the technique recovered the mechanism of the "Black Wednesday" (September 16) when George Soros broke the Bank of England.

4 - Variable selection in model-based clustering using penalized mixtures of t-distributions and an application to financial market segmentation

Alberto Cozzini, Statistics, Imperial College, 12 Kingswater Place, 1 Battersea Church Road, SW11 3BQ, London, England, United Kingdom, a.m.cozzini@ic.ac.uk, *Giovanni Montana*

We propose a model-based clustering algorithm for segmenting financial markets into homogeneous groups. Several indicators describing the price dynamics of the markets have been extracted from historical time series of returns and are used as variables for clustering. The suggested model is a penalised finite mixture of multivariate t-distributions. By taking a penalised likelihood approach, we are able to discern variables that are informative for clustering from unimportant variables. Various penalty functions and experimental results will be presented.

■ WD-24

Wednesday, 14:00 - 15:20

6.2.50

Practical Issues in Timetabling

Stream: Timetabling and Rostering

Invited session

Chair: *Geoffrey Forster*, Director, Scientia Ltd., CPC1, Capital Park, Fulbourn, CB21 5XE, Cambridge, United Kingdom,
geoffrey_forster@scientia.com

1 - Determining Most Convenient and Optimal Timetable by Assigning Difficulty Index

Harshita Agarwal, Computer Science and Engineering, PES Institute of Technology, Flat No:M-5, 1st floor, Sapthagiri Residency VII, #2/62, Kathriguppe Government School Road, off Kathriguppe main road,, 560085, Bangalore, Karnataka, India, h.agarwal2811@gmail.com, *Nitish Shangari*, *Saurabh Shekhar*

This paper proposes a scheme to generate alternative timetables for a dynamic constraint satisfaction problem and to select the most optimal solution. A novel algorithm to compute scores for each solution's popularity among students and faculty was innovated. Thus, the qualitative problem of obtaining timetables was successfully quantified. Real world constraints regarding faculty schedules, course requirements, laboratories and infrastructure were met using OR scheduling techniques. A generic tool ready for use in universities was developed. For case study, PESIT timetable was considered.

2 - Individual Student Timetables: What Has Been Implemented in Syllabus Plus and Lessons Learnt.

Geoffrey Forster, Director, Scientia Ltd., CPC1, Capital Park, Fulbourn, CB21 5XE, Cambridge, United Kingdom,
geoffrey_forster@scientia.com

We describe our experiences in incorporating individual student timetables into Syllabus Plus, a leading planning and timetabling system that is widely used throughout the World. Syllabus Plus uses constraint satisfaction techniques to construct optimised timetables that take into account the requirements of all resources including staff, students, rooms and equipment. The paper will explain how the needs of individual students can be considered at different stages in the timetabling lifecycle. The relevance of individual student timetables for those institutions that want to support the Bologna Process and its requirement for 3-year Bachelor degrees will be described.

3 - An integer programming approach for classroom infrastructure planning

Pablo A. Rey, Industrial Engineering, Universidad Diego Portales, Vergara 432, Santiago, Chile, pablo.rey@udp.cl, Jaime Miranda

The Faculty of Economics and Business at the Universidad de Chile is currently facing a rising increase in the number of enrollment causing serious infrastructure problems. For this reason it has embarked on a project that envisages the construction of a new building. This work presents an Integer Programming model that aims to determine the optimal number of classrooms in this building, additionally considering the schedules of the courses offered. It presents the current situation and a series of future scenarios that will guide the construction of this new building.

4 - A procedure to determine work-team cross-training goals to cope with production mix variation and employee absence

Jordi Olivella, Institute of Industrial and Control Engineering and Department of Management, Technical University of Catalonia, Avda Canal Olímpic, s/n, 08860, Castelldefels, Barcelona, Spain, jorge.olivella@upc.edu, David Nembhard

Often organizations introduce cross-training in their work teams to obtain benefits as flexibility and redundancy having neither a complete analysis of future production requirements nor operations schedule established in detail. Flexibility and redundancy effectiveness are difficult to measure in such a case and the procedures offered by the literature to define cross-training goals are not applicable. This situation is found in autonomous production teams and nurse services, between others. An intuitive system to establish the capacity to cope with production mix variation is proposed. A procedure is presented to determine the cross-training goals to cope with a certain production mix variation—defined with the aforementioned system—and with a certain level of employee absence, by minimizing the difficulty of the cross-training to be acquired.

■ WD-25

Wednesday, 14:00 - 15:20

6.2.48

ROADEF/EURO challenge senior session 3

Stream: ROADEF/EURO challenge

Invited session

Chair: Eric Bourreau, COCONUT, LIRMM, 161 Rue Ada, 34000, Montpellier, France, eric.bourreau@lirmm.fr

1 - A column generation approach for scheduling nuclear power plants refueling

Roberto Wolfler-Calvo, LIPN, Université Paris Nord, 93430, Villetaneuse, France, roberto.wolfler@lipn.univ-paris13.fr, Lucas Létocart, Laurent Alfandari, Antoine Rozenkop, Daniel Chemla, Guillaume Turri

A column generation approach is proposed for the problem of scheduling nuclear power plants production, outages and refueling. The columns represent feasible sequences of production and outages over the time horizon, for each of the nuclear power plants. This column generation scheme is started on a simplified and smaller version of the original problem. The columns are generated solving a shortest path subproblem for each nuclear power plant. Once chosen the optimal set of columns, an MIP model is solved including non-nuclear power plants and all demand scenarios.

2 - CSP and greedy algorithm for a large-scale energy management problem with varied constraints

Mirsad Buljubasic, Department of Mathematics, Faculty of Natural Sciences, Univ. Sarajevo, ul. Zmaja od Bosne 33, 71000, Sarajevo, Bosnia And Herzegovina, mirsad_bulj@yahoo.com, Haris Gavranovic, Faik Catibusic, Ibrahim Numanagic

The proposed method is divided in two interdependent procedures, each dealing with one subset of constraints. The set of constraints is divided in two subsets: one is dealing exclusively with outages of plants of type 2 and the other subset consists of constraints imposed on the level of production and the fuel consumption in all power plants. Several solutions for the first set of constraints is found using a CSP solver. Then, the greedy procedure determines the feasible plan of production respecting given schedule of outages. The method finds feasible solutions for all given 6 instances.

3 - Hybrid constraint programming/local search for a large-scale energy management problem with varied constraints

Hadrien Cambazard, Cork Constraint Computation Centre, -, Cork, Ireland, h.cambazard@4c.ucc.ie, Emmanuel Hebrard, Barry O'Sullivan

We describe our hybrid constraint programming/local search entry to the Roade/Euro Challenge. Our approach involves three steps: First, we schedule the outages of the Type 2 plants with a constraint program. Second, we determine the level of refueling performed at each outage and return a constraint, or cut, to the master problem, if infeasibility is detected. Third, we compute the daily production for each plant. The process is iterated, and at each iteration, the search is stochastically guided by the current best solution and through a relaxation of the objective function.

4 - A functional programming approach for an energy planning problem

Valentin Weber, G-SCOP, 46 avenue Félix Viallet, 38000, GRENOBLE, France, valentin.weber@g-scop.grenoble-inp.fr, Julien Darlay, Yann Kieffer, Louis Esperet, Guylain Naves

The ROADEF/EURO challenge 2010 is to give an actual program that solves a real-world energy management problem given by EDF, including discrete constraints, and uncertainty in the form of different, fixed, known scenarios. We tried what we think is an original angle of attack from the software engineering point of view: we use the functional programming language CAML to implement all of the input/output routines and ad-hoc combinatorial algorithms to solve the problem. We will report on the strengths and weaknesses of such an approach for a medium- or large-scale optimization problem.

■ WD-26

Wednesday, 14:00 - 15:20

3.1.11

New Achievements in Game Theory II (cooperative and noncooperative)

Stream: Cooperative Game Theory

Invited session

Chair: Mariana Rodica Branzei, Faculty of Computer Science, "Alexandru Ioan Cuza" University, 16, Berthelot St., 700483, Iasi, Romania, branzeir@info.uaic.ro

Chair: Sirma Zeynep Alparslan Gok, Mathematics, Faculty of Arts and Sciences, Suleyman Demirel University, Faculty of Arts and Sciences, Suleyman Demirel University, 322260, Isparta, Turkey, zeynepalparslan@yahoo.com

Chair: Gerhard-Wilhelm Weber, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Parametric Direct Mechanisms for Joint Replenishment

Evren Korpeoglu, Department of Industrial Engineering, Bilkent University, Bilkent University Engineering Faculty, Industrial Engineering Dept., 06800, Ankara, Turkey, evrenko@bilkent.edu.tr, Alper Sen, Kemal Guler

We consider the joint replenishment problem in a non-cooperative setting where players' characteristics are not verifiable. Joint replenishment frequency and allocation of joint costs are governed by parametric direct mechanisms based on players' reported characteristics. We obtain necessary and sufficient conditions for the existence and uniqueness of a Nash equilibrium in which all players participate in joint replenishment. We characterize the equilibrium behavior and analyze the equilibrium outcomes with respect to efficiency and the distribution of joint costs.

2 - On Taxes for Atomic Network Games with Heterogeneous Users

George Karakostas, Computing & Software, McMaster University, 1280 Main St. W., L8S4K1, Hamilton, Ontario,

Canada, karakos@mcmaster.ca, *Dimitris Fotakis, Stavros Kolliopoulos*

In atomic network games with a finite number of non-cooperative users selecting paths, the users experience congestion-dependent latency on the network edges. Our aim is to mitigate the inefficiency caused by the selfish users by introducing taxes on the edges. These taxes are strongly (weakly)-optimal if all of (at least one of) the induced equilibria minimize(s) the total latency. We show the existence of weakly-optimal taxes for single-source network games with heterogeneous users, each with a different tax sensitivity (heterogeneous), and discuss the existence of strongly-optimal taxes.

3 - Fair and Efficient Equilibrium in Collective Actions

Dongbin Huang, Department of Environmental Sciences, ETH Zurich, Institute of Terrestrial Systems, Universitaesstrasse 16, 8092, Zurich, Switzerland, dongbin.huang@env.ethz.ch, *Hans Rudolf Heinemann*

In collective actions, two or more persons strive for a solution that best satisfies multi-dimensional preferences of each. A good solution for all can be an equilibrium that is both fair and efficient. An adequately specified mechanism to achieve such an equilibrium will help to solve collective action problems. Here we define a fair and efficient solution as a contracting point on the trajectory of Nash solution where the potentials of increasing positions are maximally exploited, the common efficiency loss is within tolerance, and the exaggeration of positions is controlled.

4 - Downsian competition with an arbitrary number of parties

Tom Blockmans, MOSI, Vrije Universiteit Brussel, Pleinlaan 2, 1050, Brussel, Belgium, tblockma@vub.ac.be, *Mark Van Lokeren*

We consider a unidimensional model of spatial electoral competition with an arbitrary number of political parties. Voters are continuously distributed along $[0,1]$ such that the density is strictly positive on $(0,1)$. Downsian competition between the parties is modelled as a non-cooperative game with $[0,1]$ as the common strategy set. Extending the result of Sofronidis (Math. Social Sci. 50 (2005), no. 3, 331-335) with four parties, we determine the existence and value of the Nash equilibrium strategies as well as the necessary and sufficient conditions regarding voter distribution.

■ WD-27

Wednesday, 14:00 - 15:20

8.2.06

TRAFFIC MANAGEMENT

Stream: Transportation and Logistics

Invited session

Chair: *Riccardo Rossi*, Department of Structural and Transportation Engineering, University of Padova, Via Marzolo, 9, I35131, Padova, -, Italy, riccardo.rossi@unipd.it

1 - Analysis of gap-acceptance behavior at road junctions: experiments with a driving simulator

Massimiliano Gastaldi, Department of Structural and Transportation Engineering, University of Padova, Via Marzolo, 9, I35131, Padova, Padova, Italy, massimiliano.gastaldi@unipd.it, *Riccardo Rossi, Claudio Meneguzzer*

In this paper the preliminary results of experiments on gap-acceptance behavior using a fixed-base driving simulator are described. The analysis focuses on the right turn maneuver from a minor street at a priority road junction between two-lane two-way rural roads. The primary objectives of the research are: to test the driving simulator ability to represent a real gap-acceptance situation, by comparing the results with those obtained from the analysis of the real junction, and to analyze the effect on gap-acceptance behavior of conditions that are not easily recorded in the real situation.

2 - Roundabouts performance estimation: an experimental comparative analysis for different methodologies

Roberto Camus, Civil and Environmental Engineering, University of Trieste, P.le Europa, 1, 34127, Trieste, Italy,

camus@dica.units.it, *Massimiliano Gastaldi, Giovanni Longo, Riccardo Rossi*

This paper presents the results carried out from a comparative analysis of roundabout capacity estimation models. Using data collected during experimental observations performed on an existing roundabout, different types of models (macro, micro and mesoscopic) have been compared with reference to their capability to estimate real capacity. A detailed analysis has interested in particular an mesoscopic approach which refers to the facility as a succession of merging areas and allows estimating capacity, traffic flows and delays.

3 - The effect of information quality on travelers' behavior in ATIS context of choice

Roberta Di Pace, Department of Transpo.Engineering "L.Tocchetti", University of Naples Federico II, via Claudio, 21, 80125, napoli, italy, Italy, roberta.dipace@unina.it, *Gennaro Nicola Bifulco*

In order to model travelers' compliance under ATIS (Advance Traveler Information Systems), the effect of information accuracy has been studied. The research has been carried out by considering data from two experiments (based on a Stated Preference approach), carried out by means of two different travel simulators. In the experiments respondents are asked to made repeatedly their route choices All observed choices have been analyzed by applying appropriate statistical test and the effect of information accuracy on compliance has been tested under different reliability scenarios.

4 - An empirical analysis of vehicle time headways on rural two-lane two-way roads

Riccardo Rossi, Department of Structural and Transportation Engineering, University of Padova, Via Marzolo, 9, I35131, Padova, -, Italy, riccardo.rossi@unipd.it, *Massimiliano Gastaldi, Riccardo Maratini*

This paper presents the results carried out from an experimental analysis focused on vehicle time headways distributions with reference to two-lane two-way roads. Our attention has been focused on roads localized in Northern Italy and characterized by different levels of traffic; using data collected by inductive loops and radar sensors, a wide set of observations has been made available. The statistical analysis of these data has allowed to test a set of headway distribution models highlighting their goodness-of-fit with reference to the empirical distributions.

■ WD-28

Wednesday, 14:00 - 15:20

8.2.10

Scheduling in Production and Communication

Stream: Scheduling

Invited session

Chair: *Celia Glass*, Cass Business School, City University, 106 Bunhill Row, EC1Y 8TZ, London, United Kingdom, c.a.glass@city.ac.uk

1 - Experimental evaluation of the work function algorithm for solving the on-line k-server problem

Robert Manger, Department of Mathematics, University of Zagreb, Bijenicka cesta 30, 10000, Zagreb, Croatia, manger@math.hr, *Tomislav Rudec, Alfonzo Baumgartner*

We are concerned with practical applicability of the work function algorithm (WFA) for solving the on-line k-server problem. Our aim is to measure experimentally the actual performance of the WFA in terms of its serving costs. First, we describe a relatively efficient implementation of the WFA. Next we present some experiments based on our implementation, where the WFA has been tested on considerably large problem instances. By using the obtained experimental results, we finally compare the performance of the WFA with the corresponding theoretical estimates and with some other algorithms.

2 - Scheduling with identical machines and servers

Wafaa Labbi, Faculty of Mathematics, USTHB University, BP 32, El-Alia, Bab-ezzouar, 16111, Algiers, fawalab@yahoo.fr, *Mourad Boudhar*

In this talk, we address the problem of scheduling tasks on identical machines in the presence of servers. Before being processed on a machine, each task must undergo a special processing by servers. Machines as well as the servers can process only one task at the one and same time. We show that the problem is NP-hard and we give new polynomial subproblems. A new exact method based on mathematical modeling and heuristics are also presented with experimentation results. Based on randomly generated instances, these experimentations enable us to assess the efficiency of the suggested methods.

3 - Optimization of Schedules for a Multi-Task Production Cell

Karin Thornblad, Mathematical Sciences, Chalmers University of Technology, 412 96, Göteborg, Sweden, karint@chalmers.se, *Ann-Brith Strömberg*, *Michael Patriksson*, *Torgny Almgren*

To produce optimal schedules for a real production cell in the aircraft engine industry working as a job-shop, three different optimization models are developed and tested on real production data at various levels of work load. The current production planning prerequisites are studied in order to construct relevant and functional objective functions. The evaluation of the results is performed using real instance data in a simulation model and compared with production schedules formed by the existing built-in scheduling algorithm together with a number of priority functions.

4 - Periodic Scheduling for Wireless Mesh Networks

Celia Glass, Cass Business School, City University, 106 Bunhill Row, EC1Y 8TZ, London, United Kingdom, c.a.glass@city.ac.uk, *Eun-Seok Kim*

Wireless mesh networks (WMNs) provide flexible and low-cost Internet and Broadband access. Local access points (e.g., for WiFi access) connect to each other to facilitate a wide-area wireless mesh network. The star nature of access nodes disposes them to perfectly-periodic scheduling in which time is divided into time-slots, and each client gets a time slot at a predefined frequency. However, the problem of finding a feasible perfect-periodic schedule is NP-hard. We develop feasibility conditions for perfect periodic scheduling, using number-theoretic techniques, and devise a polynomial time algorithm for 3 co-prime frequencies. The results form a foundation for realistic scheduling of WMNs.

■ WD-29

Wednesday, 14:00 - 15:20

8.2.11

Information and Ambiguity in Financial Modeling

Stream: Financial Modeling

Invited session

Chair: *Georg Pflug*, Department of Statistics and Decision Support Systems, University of Vienna, Universitaetsstrasse 5, A-1010, Vienna, Austria, georg.pflug@univie.ac.at

1 - Multi-period acceptability functionals: The role of information monotonicity

Raimund Kovacevic, Statistics and Decision Support Systems, University Vienna, Universitaetsstr. 5, 1010, Wien, Wien, Austria, raimund.kovacevic@univie.ac.at

Multi-period acceptability functionals value discrete-time stochastic processes (e.g. representing income streams). Typically such functionals can be used as objective functions in (multistage) stochastic optimization. Multi-period functionals are defined in a generic way, such that the information available (expressed as filtration) enters explicitly the definition of the functional. Information monotonicity then demands that the value of a process increases, if information arises faster over time, which is expressed by a finer filtration. We analyze several functionals from literature with respect to information monotonicity and give a characterization of this property for certain class of functionals, related to the composition of conditional acceptability functionals.

2 - Ambiguity and minimaxity in portfolio selection and

Georg Pflug, Department of Statistics and Decision Support Systems, University of Vienna, Universitaetsstrasse 5, A-1010, Vienna, Austria, georg.pflug@univie.ac.at, *David Wozabal*, *Alois Pichler*

The typical procedure in portfolio optimization is to fix a probability model and to find an optimal portfolio for exactly this probability model. However, there is often much uncertainty about the correct model. We call the model uncertainty "ambiguity". Under ambiguity, the portfolio problem has the form of a maximin problem. We discuss saddlepoint solutions and demonstrate, that large ambiguity finally leads to optimal portfolios, which are equal-weight portfolios.

3 - Minimum VaR and Minimum CVaR Optimal Portfolios: Estimation and Inference Procedure

Taras Bodnar, Department of Statistics, European University Viadrina, Grosse Scharnstrasse 59, 15230, Frankfurt (Oder), Germany, bodnar@euv-frankfurt-o.de, *Wolfgang Schmid*, *Taras Zabolotsky*

We derive the finite-sample distributions of the estimated characteristics of the minimum VaR and of the minimum CVaR portfolios. Very useful stochastic representations of these estimators are obtained and used for deriving their conditional and unconditional moments. The joint distribution of the estimated expected return and the estimated variance. This result is used for deriving exact tests for the corresponding portfolio characteristics and for constructing joint confidence regions for the minimum VaR and the minimum CVaR portfolios in the mean-variance space.

4 - p-Order Conic Programming in Stochastic Optimization

Pavlo Krokhmal, Mechanical and Industrial Engineering, University of Iowa, 3131 Seamans Center, 52242, Iowa city, IA, United States, krokhmal@engineering.uiowa.edu

We discuss modeling of risk preferences in stochastic programs via p-order conic constraints. As an illustration, a portfolio optimization problem is considered. Several solution approaches are presented, including reduction to second-order conic programming and polyhedral approximations of p-order cones, as well as a branch-and-bound scheme for mixed-integer problems with p-conic constraints. Computational results of portfolio optimization case studies are discussed.

■ WD-30

Wednesday, 14:00 - 15:20

8.2.13

OR methods in portfolio management and asset allocation

Stream: Operational Research and Quantitative Models in Banking

Invited session

Chair: *David Pla-Santamaria*, Alcoy School, Technical University of Valencia, 03801, Alcoy, Spain, dplasan@esp.upv.es

1 - Downside risk: How to select efficient portfolios from Dow Jones blue chips by the mean-semivariance efficient frontier model (E-SV)

Mila Bravo, ALCOY SCHOOL, TECHNICAL UNIVERSITY OF VALENCIA, 03801, ALCOY, Spain, mibrasel@epsa.upv.es, *David Pla-Santamaria*

This paper is characterized as follows. Scope and purpose: to apply E-SV (Ballester, 2005) to an actual example of portfolio choice in which downside risk is measured by the semivariance. Opportunity set and observation period: Dow Jones stocks with daily prices observed over the period 2005-09. Returns: they are capital gains weekly computed. Validity of results is affected by these limitations. Diversification constraints: portfolio weight cannot exceed 5%. Results: significant differences between E-SV and E-V portfolios of equal expected returns are found. Comparisons between them are made.

2 - Portfolio selection with multiple time horizons: a stochastic goal programming approach

Antonio Benito, Economics and Social Sciences, Technical University of Valencia, Plaza Ferrández y Carbonell s/n, EPSA, 03801, Alcoy, Alicante, Spain, anbebe@esp.upv.es, *Ana Garcia-bernabeu*, *Ignacio Gonzalez*

Traditional approaches to portfolio selection require establishing a time horizon of historical returns over a period that the investor defines in a conventional way. To avoid arbitrary choice of this horizon we propose to use stochastic goal programming (SGP) with multiple criteria C_j ($j = 1, 2, \dots, n$) such as C_1 (observed returns over the last two years), C_2 (last three years) and C_3 (last four years). As information provided by these horizons is of different quality/reliability, the criteria are weighted from the investor's opinions on this reliability.

3 - Asset allocation for standard and non-standard ethical investors

Verónica Cañal, Applied Economics, University of Oviedo, Avda. del Cristo s/n, 33006, Oviedo, Spain, Spain, vcanal@uniovi.es, Celia Bilbao, Mar Arenas-Parra, Maria Victoria Rodriguez Uribe

In an asset allocation problem the ethical investor seeks the combination of securities that best suit his ethical profile. In this work we present models to asset allocation when the investor's objectives include ethical features. We detect the standard ethical investors applying revealed preference techniques for estimating the implicit prices of each ethical attribute. A non-standard ethical investor disagrees with the assessment obtained by the revealed preference techniques. We have modeled both types of ethical investors.

■ WD-33

Wednesday, 14:00 - 15:20

8.2.19

Decision making under model uncertainty

Stream: Energy, Environment and Climate

Invited session

Chair: *Pauline Barrieu*, Statistics, London School of Economics, Houghton street, WC2A 2AE, London, United Kingdom, p.m.barrieu@lse.ac.uk

Chair: *Max Fehr*, Statistics department, LSE, WC2A2AE, London, United Kingdom, m.w.fehr@lse.ac.uk

1 - Assessing Cleanup Costs

Bernard Sinclair-Desgagné, International Business, HEC Montréal, 3000 Chemin de la Côte Sainte-Catherine, H3T2A7, Montréal, Québec, bsd@hec.ca, Pauline Barrieu

The remediation of contaminated sites is often subject to substantial cost overruns. This systematic discrepancy between estimated and realized costs is chiefly responsible for misguided land use and wasteful delays in the re-conversion of former industrial sites. This paper derives relatively tractable and simple formulas for better assessing cleanup costs. These formulas are based on generic remediation methods, deal explicitly with incomplete information and uncertainty, and are robust to misspecification in key parameters such as the effectiveness of a prescribed treatment.

2 - A Monte Carlo method for problems of optimal stochastic control with convex value functions

Juri Hinz, Logistics, Zurich University of Applied Sciences, IDP, Rosenstrasse 3, CH-8401, Winterthur, Switzerland, hizr@zhaw.ch

We present a method for the calculation of the optimal policy for infinite horizon optimal control problems whose value function is convex. Control problems of this type appear in many applications and encompass important examples arising in the area of partially observed Markov decision processes. We show that the calculation performance can be improved by a modification of the classical least-square approach. Our adaptation is based on the convexity property of conditional expectation, valid in our framework.

■ WD-35

Wednesday, 14:00 - 15:20

6.2.46

MINLP - Problem-specific Approaches

Stream: Mixed-Integer Non Linear Programming

Invited session

Chair: *Sarah Drewes*, Department of Mathematics, Technische Universität Darmstadt, Dolivostr. 15, 64293, Darmstadt, Germany, drewes@mathematik.tu-darmstadt.de

1 - An MIP Approach to Gas Network Optimization

Bjoern Geissler, Discrete Optimization, Technische Universität Darmstadt, Dolivostr. 15, 64293, Darmstadt, Germany, geissler@mathematik.tu-darmstadt.de, Alexander Martin, Antonio Morsi, Lars Schewe

Many optimization problems over networks can be modeled most naturally as mixed-integer nonlinear (nonconvex) programs. Real-life problems often result in large-scale MINLPs, which are currently far away from being solvable by state-of-the-art solvers. Therefore, we present techniques to construct arbitrary tight mixed-integer linear programming relaxations of an underlying MINLP which satisfy an a priori error bound. We demonstrate the suitability of our approach by means of gas network optimization problems.

2 - Decomposition Techniques for MINLPs on Loosely Coupled Networks

Antonio Morsi, Mathematics, TU Darmstadt, Dolivostr. 15, 64293, Darmstadt, Germany, morsi@mathematik.tu-darmstadt.de, Bjoern Geissler, Alexander Martin, Lars Schewe

Decomposition techniques are an effective way of partitioning a large problem into smaller ones. We reduce the complexity of nonlinear loosely coupled network flow problems by decomposing the underlying network topologically. A relaxation of the constraints coupling adjacent blocks yields a partitioning. Based on this decomposition we present primal and dual solution methods in the context of our motivating applications from gas and water transport optimization. These methods are applied to produce a solution to the overall problem by calculating lower and upper bounds from the subproblems.

3 - Mixed 0/1-Kelly Criterion: Geometric mean maximization revisited

Sebastian Pokutta, Department of Mathematics, Technische Universität Darmstadt, Alois-Eckert-Str. 4, 60528, Frankfurt, Germany, sebastian.pokutta@mac.com, Sarah Drewes

Second order cone programs occur in a natural way in financial risk management and portfolio optimization. While in the case of continuous variables these problems can be solved efficiently, in the presence of integral variables, representing e.g., indivisible assets, the situation becomes significantly more complicated. We present an approach for maximizing the geometric mean (which is equivalent to the Kelly Criterion) of affine functions with binary variables. Exploiting the structure of this class of programs (weakly-coupled second order cone programs) these programs can be solved fast.

4 - On Bound Computations for MINLP

David M. Gay, AMPL Optimization LLC, 87108-3379, Albuquerque, NM, United States, dmg@ampl.com

Various techniques, such as branching, bounding, cut-generation, and generation of outer approximations can all be useful in algorithms for solving mixed-integer nonlinear programming problems. When the nonlinear parts of a MINLP problem can be specified algebraically, slope computations (to which various European authors have contributed) can be useful in computing bounds, outer approximations, and domain reductions. This talk provides a review of these computations.

■ WD-36

Wednesday, 14:00 - 15:20

3.1.05

Linear and Conic Programming I

Stream: Linear and Conic Programming

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Sergei Chubanov*, University of Siegen, Hoelderlinstr. 3, Siegen, Deutschland, 57076, Siegen, Germany, sergei.chubanov@uni-siegen.de

1 - An approach based on conic formulation and MC technique for the time-cost trade-off problem

Mohammad Reza Peyghami, Mathematics, K.N. Toosi University of Technology, Math. Department, K.N. Toosi University of Technology,, P.O.Box 16315-1618, Tehran, Iran, 16315-1618, Tehran, Iran, Islamic Republic Of, peyghami@kntu.ac.ir

A new approach based on conic formulation and Monte Carlo (MC) simulation technique is provided for the Time-Cost Trade-off Problem (TCTP) in PERT networks in which all activities are subjected to linear cost function and assumed to be exponentially distributed. The aim is to maximize the project completion probability in a predefined due date. To do so, TCTP is constructed as a nonlinear optimization problem in a single path with decision variables of activity mean durations. We then develop an algorithm based on MC simulation technique and conic formulation to solve general TCTP.

2 - Finding the Extrema of Continuous Piecewise Linear Functions

Özge Arslan, Industrial Engineering, Koc University, Koc Universitesi Rumelifeneri Yolu, 34450 Sariyer, Istanbul, Turkey, odemiryapan@ku.edu.tr, Metin Turkey

Development of accurate models and efficient solution algorithms for piecewise linear functions attracted a lot of attention because of its wide range of application areas. In this paper a novel linear programming formulation is presented to find the extrema of continuous piecewise linear functions in all shapes (convex, concave, non-convex). The simplex method moves among the extreme points of the feasible region while searching the optimal solution and our formulation constructs a feasible region which utilizes this property of the simplex method.

3 - Divide and conquer: A polynomial algorithm for linear programming

Sergei Chubanov, University of Siegen, Hoelderlinstr. 3, Siegen, Deutschland, 57076, Siegen, Germany, sergei.chubanov@uni-siegen.de

We present an algorithm for solving systems of linear inequalities. The algorithm uses a divide-and-conquer algorithm as an oracle. The algorithm is polynomial. Moreover, the algorithm can either find a solution of the system or decide that there is no 0,1-solution in strongly polynomial time.

■ WD-37

Wednesday, 14:00 - 15:20
3.1.09

Application of outranking approach for sustainable development

Stream: MCDA I: New Approaches and Applications

Invited session

Chair: Pascal Oberti, University of Corsica, UFR Droit Economie,, Av. Jean-NICOLI, BP 52, 20250 CORTE, 20250, Corte, France, pascal.oberti@univ-corse.fr

Chair: Jean-François Noël, Université d'Angers, 78047, Angers, France, Jean-Francois.Noel@uvsq.fr

1 - Sustainable development, economics and multicriteria evaluation: which links with the outranking approach?

Jean-François Noël, CEMOTEV, University of Versailles - Saint Quentin en Yvelines, UVSQ - UFR SSH, 47 Boulevard Vauban, 78047, Guyancourt cedex, France, Jean-Francois.Noel@uvsq.fr, Pascal Oberti

In the ecological economics framework, evaluation of projects and policies for sustainable development is generally performed using multicriteria methods. However, the outranking approach is still little used. The purpose of this communication is to explore possible links. More particularly, will be considered: the hypothesis of weak comparability of the values, the substitutability or complementarity of natural capital to other forms of capital, the identification of sectoral situations and finding the best compromise, the rationality of actors, the distribution of winners and losers.

2 - Application of ELECTRE IS method to photovoltaic plant projects selection in Corsica

Pierrick Haurant, Univeristé de Corse, 20250, Corte, France, haurant@univ-corse.fr, Pascal Oberti, Marc Muselli

High solar potential and advantageous purchase tariffs of photovoltaic (PV) electricity make Corsica's island very attractive for industrials of this sector. Confronted with an unprecedented offer of PV plant projects, regional public actors having to deliver an opinion resorted to multicriteria evaluations for aiding a file based selection. This communication presents the main results of a study which was ordered to us. Will be underlined project constraints, evaluation criteria and other associated parameters, as well as final recommendation resulting from outranking ELECTRE IS method.

3 - Management effectiveness assessment in marine protected areas: practices and feasibility of an outranking approach

Ange-Michel Poli, Université de Corse, 20250, Corte, France, poli.ange-michel@wanadoo.fr, Jean-François Noël, Pascal Oberti

The multiple uses and objectives of marine protected areas (MPAs) involve a planned, adaptive and effective management. What practices, methodologies and operational tools to assess the effectiveness of this management? This paper analyzes in the literature the protocols for monitoring and evaluation, and study the feasibility of these methodologies within French, Mediterranean and African MPAs. We particularly highlight what can bring the outranking approach, restricted to a pseudo-criterion or ELECTRE-type in a multicriteria context.

■ WD-38

Wednesday, 14:00 - 15:20
6.2.44

Recent Advances in Spare Parts Inventory Management

Stream: Inventory Management

Invited session

Chair: Joern Meissner, Management Science, Lancaster University Management School, Room A48, LA14YX, Lancaster, United Kingdom, j.meissner@lancaster.ac.uk

1 - On cross-correlation of demand for spare parts

Nezih Altay, Management, DePaul University, 1 E. Jackson Blvd., Suite 7000, 60604, Chicago, Illinois, United States, naltay@depaul.edu

Although the literature on the effects of correlation on stock control is plentiful, research mainly focuses on the correlation of demand of a single item (auto-correlation) or demand of multiple items (cross-correlation). A considerable portion of spare parts, on the other hand, display time-based cross-correlation, i.e. demand size is correlated with the time interval between demand occurrences. We explore the effects of time-based cross-correlation on stock control of spare parts.

2 - Traditional and Non-Traditional Methods of Forecasting Lumpy Demand: Inventory Control Implications

Adriano Solis, Management Science Area, School of Administrative Studies, York University, 4700 Keele St, M3J 1P3, Toronto, Ontario, Canada, asolis@yorku.ca, Somnath Mukhopadhyay, Rafael S. Gutierrez

Simple exponential smoothing, weighted moving average, Croston's method, Syntetos-Boylan approximation (SBA), and neural network (NN) modeling are applied on a time series dataset of very lumpy demand. A simple NN model is found superior overall with respect to several scale-free forecast accuracy measures. However, demand forecasting performance may not translate into inventory systems efficiency. A periodic review inventory control system with forecast-based order-up-to levels is simulated. Holding and shortage costs and service levels are considered. Findings/insights will be presented.

3 - Service Parts Inventory Control with Lateral Transshipment that Takes Time

Guangyuan Yang, Erasmus University Rotterdam, Econometric Institute, Burg. Oudlaan 50, H09-21, 3062 PA, Rotterdam, Rotterdam, Netherlands, gyang@ese.eur.nl, Rommert Dekker

In equipment-intensive industries, the transshipment time for some slow moving service parts is not negligible. We assess the effect of non-negligible lateral transshipment time on various aspects of spare parts inventory control. Furthermore, we introduce customer-oriented service levels by taking the uncommitted pipeline stocks into account. A case study in the dredging industry shows that lateral transshipment may lead to lower system performance. Furthermore, we find that considerable savings can be obtained when we include the uncommitted pipeline stocks in inventory control decisions.

4 - Demand Categorization for Safety Stock Planning of Spare Parts

David Bucher, Management Science, Lancaster University, Lancaster University Management School, Department of Management Science, LA1 4YX, Lancaster, Lancashire, United Kingdom, d.bucher@lancaster.ac.uk, *Joern Meissner*

We develop a demand categorization system for an automated selection of statistical (compound) distributions for safety stock planning for items with intermittent demand. We test our new technique on the data of the spare parts inventory of a major German car component manufacturer with 20,000 SKUs. The simulation shows significant cost reduction and an increased service level. Our results promote the application of categorization tools directly linked to the configuration of inventory systems.

■ WD-39

Wednesday, 14:00 - 15:20

6.2.45

Scheduling and lotsizing under uncertainties I

Stream: Scheduling under Resource Constraints

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 Kovalyov*, Faculty of Economics, Belarusian State University, Nezavisimosti 4, 220030, Minsk, Belarus, kovalyov_my@yahoo.co.uk

1 - A lot-sizing and scheduling problem under uncertainties

Alexandre Dolgui, IE & Computer Science, Ecole des Mines de Saint Etienne, 158, cours Fauriel, 42023, Saint Etienne, France, dolgui@emse.fr, *Kseniya Schemeleva*, *Frédéric Grimaud*

We consider the lot-sizing and scheduling problem under uncertainties. It is assumed that all machines at the production line are imperfect, notably we concede that a deal of processed parts can be defective and each machine can breakdown. Thus we deal with random yields and random lead time uncertainties. The planning horizon and demand for parts of all products are given. We assume that a set-up time is necessary to change the type of manufacturing product. The goal is to optimize the order of lots and number of items of each product for a given planning horizon.

2 - Batching Work and Rework Processes to Minimize the Makespan

Frank Werner, Faculty of Mathematics, Otto-von-Guericke University, FMA,I, Institute of Mathematical Optimization, PSF 4120, 39016, Magdeburg, Germany, frank.werner@mathematik.uni-magdeburg.de, *Irina Gribkovskaia*, *Sergey Kovalev*

A planning problem of an imperfect production is considered with a main facility and a facility dedicated to remanufacturing defective units. Units after processing in main facility are inspected for quality in batches. The quality inspection requires some time. Defective units are transported to the remanufacturing facility. The transportation also requires some time. The problem is to find a sequence of batch sizes such that the makespan is minimized. A linear programming formulation is suggested and an $O(\log K)$ time solution algorithm is developed.

3 - Heuristics for an integrated production and maintenance planning problem

Marouane Alaoui Selsouli, Ecole des Mines de Nantes, IRCCyN, La Chantrerie 4, rue Alfred Kastler, B.P. 20722, - F-44307,

NANTES Cedex 3, France, malaou07@emn.fr, *Najib. M. Najid*, *Abdelmoula Mohafid*

We consider a problem of integrating production and maintenance. Maintenance problem is the problem of determining the dates of preventive maintenance actions in time windows. Production problem treats the production planning problem known as multi items capacitated lot sizing problem. The resulting problem is modelled as a linear mixed-integer program. It takes into account demand shortage and the reliability of the production line. We will solve the problem with a Lagrangean heuristic and heuristic based on columns generation. The aim of those heuristics is to provide a lower bound and to construct a feasible solution for the integrated problem. Computation results show a comparison between the Lagrangean heuristic and heuristic based on columns generation.

4 - Push and pull heuristics for remanufacturing with yield uncertainty

Erwin van der Laan, RSM Erasmus University, P.O.Box 1738, 3000DR, Rotterdam, Netherlands, elaan@rsm.nl

In this paper we focus on the uncertainty in the quality of a recoverable product and its implications for managing a hybrid manufacturing/remanufacturing inventory system. We propose simple heuristics for controlling the inventories of both recoverable products and serviceable products (which is a mix of remanufactured and manufactured products) that are easily implemented in practice. An extensive numerical study quantifies the performance of the heuristics under various scenarios.

■ WD-40

Wednesday, 14:00 - 15:20

6.2.52

Recent Advances in Industrial and Engineering Optimization I

Stream: Engineering Optimization

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Stream Mapping Value (MVS) Applied to Improve Productivity and Minimize Waste in a Tool for Stamping Maker

Milton Vieira Junior, Industrial Engineering Post Graduation Program, Nove de Julho University - UNINOVE, Av. Francisco Matarazzo, 612, 05001-100, São Paulo, São Paulo, Brazil, mvieirajr@uninove.br, *Nivaldo Coppini*, *Marcelo Bonandi*

Many companies agree on improvement of manufacturing process using lean techniques. Value Stream Map can show where extra materials are piling up and it is often used to introduce lean manufacturing procedure. The aim of this work was to create a current state diagram that showed how the process currently works in tools for stamping maker. The second step was to identify the problems areas and create future state diagram that allows improving the process, reducing the waste and increase efficiency and quality

2 - Cellular Manufacturing Application in Bosch Diesel Systems Injector Plant

Zerin Turgut, Industrial Engineering, Bosch Diesel Systems/Bursa Unit, Bosch Sanayi ve Ticaret A.Ş., Organize Snayi Bölgesi Yeşil cad. no:27, 16159, Bursa, Turkey, zerin.turgut@tr.bosch.com, *Ihsan Ozer*, *Burak Erismis*, *Halil Özbek*, *Cem Tangil*

Cellular manufacturing was implemented in body production with 377 employees, 150 machines and 21 consequent sub-processes. Formerly, production had a complex structure with no scalability, lower productivity and higher WIP levels. Heuristic methods and lean principles were used to create scalable cells, discrete event simulation in EM-Plant software developed and a non-dominated solution found. Real life results are promising by higher productivity, less WIP and lead time. The most important consequence is a flexible, easy-to-manage, transparent, traceable and improvable system.

3 - An efficient model for multiobjective cell formation in group technology

Dmitry Krushinsky, Department of Operations, University of Groningen, Nettelbosje 2, 9747 AE, Groningen, Netherlands, d.krushinsky@rug.nl, *Boris Goldengorin*

Cell formation is a key concept in group technology that provides a useful way to increasing the productivity and improving flexibility of a manufacturing system. Given approaches use sequential procedures and construct cells by heuristics, or formulate the problem as a mixed-integer linear program known to be computationally hard and use heuristics. We show that p-Median problem based cell formation model can be solved to optimality by general purpose solvers CPLEX, Xpress etc. on a standard PC within seconds.

4 - Reliability and Sensitivity Analysis of a Repairable System with Imperfect Coverage and Service Pressure

Kuo-Hsiung Wang, Department of Applied Mathematics, National Chung-Hsing University, Department of Applied Mathematics, National Chung-Hsing University, 402, Taichung, Taiwan, khwang@amath.nchu.edu.tw

We study an M/M/R machine repair problem with variable servers in which failed machines balk. We derive analytic steady-state solutions through which several system performance measures can be obtained. A cost model is developed to determine the optimal values of the number of busy servers and balking rate. We use the direct search method and the Newton's method to find the global minimum value until the balking rate constraint is satisfied. Numerical results are provided in which various system performance measures are evaluated under optimal operating conditions.

■ WD-41

Wednesday, 14:00 - 15:20

3.1.06

Monte Carlo and Malliavin Calculus

Stream: Simulation Methods in Finance

Invited session

Chair: *Henry Schellhorn*, mathematics, Claremont Graduate University, 710 N. College Ave, 91711, Claremont, CA, United States, Henry.Schellhorn@cgu.edu

1 - An Algorithm for the Pricing of Path-Dependent American Options Using Malliavin Calculus

Henry Schellhorn, mathematics, Claremont Graduate University, 710 N. College Ave, 91711, Claremont, CA, United States, Henry.Schellhorn@cgu.edu

We propose a recursive scheme to calculate backward the values of conditional expectations of functions of path values of Brownian motion. This scheme is based on the Clark-Ocone formula in discrete time. We construct an algorithm based on our scheme to efficiently calculate the price of American options on securities with path-dependent payoffs. Our algorithm can be combined with regression-based Monte Carlo methods, like the Tsitsiklis-Van Roy algorithm. In this case, our algorithm remedies the decrease of performance experienced by regression-based methods when the number of basis functions, or regressands, needs to be quite large, because of path-dependence.

2 - A Table Method For Random Variate Generation

İsmail Başoğlu, Industrial Engineering, Bogazici University, Bogazici University Industrial Engineering Department, 34342 Bebek, Istanbul, 34342, İstanbul, Turkey, ismail.basoglu@boun.edu.tr, *Wolfgang Hörmann*

For generating random variates from non-standard distributions, we need universal algorithms. In this research, we come up with a universal algorithm "Polynomial Density Inversion (PDI)". We try to see if it is competitive with existing methods with respect to simplicity, speed and other performance criteria. Mainly, the method approximates the density with piecewise polynomials. The algorithm is complicated, yet we can obtain outstanding approximations with small tables. Marginal execution time is also small which makes the PDI a preferable method for a large number of random variates.

■ WD-42

Wednesday, 14:00 - 15:20

3.1.07

Cops and Robber Games

Stream: Graph Searching and Guarding

Invited session

Chair: *Nancy Clarke*, Mathematics and Statistics, Acadia University, 12 University Avenue, B4P2R6, Wolfville, Nova Scotia, Canada, nancy.clarke@acadiau.ca

1 - Characterizations of k-copwin graphs

Nancy Clarke, Mathematics and Statistics, Acadia University, 12 University Avenue, B4P2R6, Wolfville, Nova Scotia, Canada, nancy.clarke@acadiau.ca, *Gary MacGillivray*

We give two characterizations of the graphs on which k cops have a winning strategy in the game of Cops and Robber. These generalize the corresponding characterizations that are known in the one cop case. In particular, we give a relational characterization of k-copwin graphs, for all finite k, and then use this characterization to obtain a vertex elimination order characterization of such graphs. Instead of the elimination order being of the vertices of the given graph G as in the one cop case, it is an ordering of the vertices of the (k+1)-fold categorical product of G with itself. Most of our results hold for variations of the game and some of them extend to infinite graphs.

2 - The Watchman Problem

Bert Hartnell, Mathematics & Computing Science, Saint Mary's University, 923 Robie St., B3H 3C3, Halifax, Nova Scotia, Canada, Hartnell@smu.ca

Although a security firm may want to have all nodes in a network monitored at all times (by a person or sensor either at the node itself or adjacent) this may be too expensive. This gives rise to the watchman problem where a person traverses the graph (returning to the starting point) in such a way that every node is either in this closed tour or adjacent to it. In general, given a network G and an integer t, we would like to determine the minimum number of watchmen needed, and their rounds, so that the maximum time that any node is not monitored is t. Limited progress will be described.

3 - Graph searching games for the WDM reconfiguration problem

David Coudert, Mascotte, CNRS/INRIA/UNSA, 2004 route des Lucioles, B.P. 93, 06902, Sophia Antipolis, France, David.Coudert@sophia.inria.fr

The routing reconfiguration problem in WDM networks is to schedule the switching's of a set of lightpaths from one routing to a new predetermined one. This problem is modeled as a digraph processing game, closely related to graph searching games, in which a team of agents is aiming at clearing, or processing, the vertices of a digraph. In this talk, we will survey the main results on digraph processing games, and in particular the complexity and hardness of optimizing tradeoffs between the total number of agents used and the total number of vertices occupied by an agent during the strategy.

4 - Graph Searching and Graph Decompositions

Nicolas Nisse, MASCOTTE, INRIA, I3S(CNRS/UNS), INRIA, 2004 routes des Lucioles, 06902, Sophia Antipolis, France, nicolas.nisse@sophia.inria.fr

In graph searching, a team of mobile agents must catch a fugitive hidden in a graph. Many versions of search problems have been considered that all look for a strategy allowing to catch the fugitive using the fewest number of agents. We briefly survey the numerous research directions in this field. Then, we focus on the relationship between search games and graph decompositions. Namely, we explain how search games provide an algorithmic interpretation of path- and tree-decompositions. This point of view allowed us to obtain new duality results generalizing those in the literature.

■ WD-43

Wednesday, 14:00 - 15:20

8.2.02

Life Insurance, Risk Management & OR

Stream: Life Insurance, Risk Management & OR

Invited session

Chair: *Angelika May*, Institut für Mathematik, Carl von Ossietzky Universität Oldenburg, 26111, Oldenburg, Germany, angelika.may@uni-oldenburg.de

1 - Credit Risk approach to value R&D projects in the pharmaceutical industry

Nora Lisse, Institut für Mathematik, Universität Oldenburg, Carl-v.-Ossietzky-Str. 9-11, 26111, Oldenburg (Oldb), Germany, nora.lisse@uni-oldenburg.de, *Angelika May*

R&D projects in the pharmaceutical industry are exposed to a high risk of default either due to the failure of a research phase or to a poorly performing commercialization of the produced drug. Instead of using a standard real option approach we derive the value of these risks with two different approaches from credit risk theory. In this presentation we focus on the valuation of the market risk with a first-passage time model and illustrate our adaptation of this method through real data examples.

2 - Intersections of ruin probabilities with respect to the initial surplus

Tatjana Slijepcevic-Manger, Faculty of Civil Engineering, University of Zagreb, Fra Andrije Kacica-Miosica 26, 10000, Zagreb, Croatia, tmanger@grad.hr

In this paper we study intersections of ruin probability functions with respect to the initial surplus for two risk models. The insurance company could use one model with smaller probability of ruin up to the intersection and then change to the other model in order to minimize the probability of ruin.

3 - On Devising an Alarm System for Insurance Companies

Shubhabrata Das, QMIS, Indian Institute of Management Bangalore, Faculty Block C 2nd Floor, Bannerghatta Road, 560076, Bangalore, India, shubho@iimb.ernet.in, *Marie Kratz*

One way of risk management for an insurance company is to develop an early and appropriate alarm system before the possible ruin, defined through the status of the aggregate risk process which in turn is determined by premium accumulation as well as claim settlement out-go for the insurance company. This paper designs an effective alarm system with a fair measure of effectiveness. We present comparisons of performances when the loss severity has Exponential, Pareto or discrete Logarithmic distribution.

■ WD-44

Wednesday, 14:00 - 15:20

8.2.03

Dynamical Systems and Mathematical Modelling in OR II

Stream: Dynamical Systems and Mathematical Modelling in OR

Invited session

Chair: *Selma Belen*, Mathematics and Computer, CAG University, Adana-Mersin Karayolu Uzeri, Yenice-Tarsus, 33800, TARSUS / Mersin, Turkey, selmabelen@cag.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Automated Traders in Commodities Electronic Markets

Fodil Laib, Dépt. of Operational Research, University of Bejaia, Targa Ouzemour, Bejaia, 16000, Bejaia, fodil.laib@cevital.com

Our purpose is to automatize trading of commodities by using automated agents instead of human traders. In this setup, each producer and consumer has a trading agent in the market arena trading on his behalf. The agent is fed with a stream of supply and demand forecasts, then it uses a parameterized trading strategy to build sell or buy orders. The performance of this trading system is measured by computing the distance between the generated price pattern compared to a benchmark pattern. We suggested a simulation approach to find the optimal parameters of the trading strategy.

2 - A discussion on the Hamiltonian dynamical systems, integrable systems and dynamical system of diffusion of information

Selma Belen, Mathematics and Computer, CAG University, Adana-Mersin Karayolu Uzeri, Yenice-Tarsus, 33800, TARSUS / Mersin, Turkey, selmabelen@cag.edu.tr, *Gerhard-Wilhelm Weber*, *Erik Kropat*

In this paper, we discuss on the mechanism of diffusion which is not identical to the mechanism of diffusion observed in Hamiltonian systems. As the reversibility is certainly an important symmetry property in the context of Hamiltonian systems, it is discussed that if the reversibility is equivalent to a spatial symmetry.

3 - A Dynamic Model for Evaluating the Effects of Piracy in Film Industries

Sercan Oruc, Industrial Engineering, Middle East Technical University, Turgut Ozal Mah. 15. Cad., Utku Sit. 7/13 Batikent, 06370, Ankara, -, Turkey, sercanoruc@gmail.com

Film industry, as a type of creative industries, constitutes a dynamic environment where uncertainty is at high levels. This complexity renders the more traditional OR models somewhat ineffective, and thus, requires a dynamic analysis. In this study, a model showing the dynamics of film exhibition is given. The model shows the interactions within and between the theatrical and the DVD sales channels. The possible effects of piracy to the model are discussed, using the inferences obtained by the created model. The model is examined with scenario and sensitivity analysis. The model also can be extended for the whole film industry, or for some other creative industries like the publishing industry.

4 - A System Dynamic Approach in Managing the Levels of Neurotransmitter for Patients with Chronic Depression

Armagan Bayram, Industrial Engineering, Istanbul Kultur University, IKU Atakoy Campus Room 216 Bakirkoy, 34156, Istanbul, armagannbayram@yahoo.com, *Dicle Cevizci*, *Canan Herdem*

A dynamic model is developed to analyze depression, caused by low levels of neurotransmitters between synapses. Neurotransmitter levels should be kept at a certain level. Antidepressants are used to increase the serotonin levels by closing these pumps. However, overdose of these antidepressants increases serotonin levels so much and triggers other diseases. Many unexpected cases can be prevented by seeing the behavior. In this model, behavior of disease and difference between healthy people are observed.

■ WD-45

Wednesday, 14:00 - 15:20

8.2.12

Logistics and Promotions Management

Stream: Demand and Supply 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 - Modelling a logistics problem in retailing industry under uncertainty in an operational level

Yousef Ghiami, Management, University of Southampton, Building 2, University Road., Highfield, Southampton, SO17

1BJ, Southampton, United Kingdom, yg5g09@soton.ac.uk, Yue Wu

Uncertainties are the main sources of risk, making the planning for the future, challenging. In supply chain management field, researchers have been investigating uncertain factors (e.g. demand and raw material cost) and put effort to tackle these uncertainties and the consequent risks. In this research a three-echelon supply chain of a perishable product (e.g. dairy products) is considered, with stochastic demand at the stores. In this model the total logistics cost is considered, including transportation costs, production costs in plants and inventory costs in plants and stores. In order to deal with the demand uncertainty, the problem has been modelled with Robust Optimization approach.

2 - Hedging Retail Promotions - Bidding Coordinating Contracts into a Pull Supply Chain with Retailer Power

Arnd Huchzermeier, Production Management, WHU - Otto Beisheim School of Management, Burgplatz 2, 56179, Vallendar, Germany, ah@whu.edu, Andreas Breiter

Demand risk from price promotions creates waste in the supply chain. We show that offering option contracts in addition to spot contracts can achieve coordination even in the presence of a dominant retailer. Employing a model of stockpiling consumers, we formulate a stochastic process of promotional demand. Based on point-of-sales data from a major German supermarket chain, we fit our model and quantify the additional profits achieved. A portfolio of supply contracts can simultaneously reduce i) out-of-stock situations and ii) end-of-period coverage, clearing the channel for future promotions.

3 - Markdown Optimization in a Retail Chain under Demand Substitution

Ozlem Cosgun, Industrial Engineering, Istanbul Kultur University, Istanbul Kultur Universitesi endustri muhendisligi bolumu atakoy kampus, 34156, Bakirkoy, Istanbul, Turkey, ozlem_ince@hotmail.com, Ufuk Kula

We consider the markdown optimization problem faced by a leading apparel retail chain in Turkey. Markdown policies for product groups having a significant crossprice elasticity among each other should be jointly determined, which makes finding optimal policies for products computationally intractable as the number of products increases. We first decompose sales into three components: marked-down price, substitution and time effects by using MNL model. Then we formulate the problem as an MDP and use approximate dynamic programming approach to solve it and provide insights on the markdown policy.

4 - The Use of Generalized Additive Models for Demand Forecasting

Amirhossein Sadoghi, Department of Management and Engineering, Linköping University, Rydsvägen 242 A LGH 17, 584 34, Linköping, Sweden, amisa242@student.liu.se

Forecasting using time series is often based on linear regression. In this paper, we use the Generalized Additive Models (sum of smooth functions) instead of the linear regression to analyze the behavior of the system in the demand forecasting of make-to-stock problem. Main focus is on the existence of the nonparametric analogue of multicollinearity, concavity in sales data. This provides insight in to managing interdependent demands. We also investigate whether the specific temporal patterns are likely to affect the statistical forecasts of the sales history

■ WD-46

Wednesday, 14:00 - 15:20
8.2.14

Approximation of Probabilities for Exotic and Compound Options

Stream: Numerical Methods in Finance

Invited session

Chair: *Ömür Ugur*, Institute of Applied Mathematics, Middle East Technical University, 06531, Ankara, Çankaya, Turkey, ougur@metu.edu.tr

Chair: *Susanne Griebisch*, School of Finance and Economics, University of Technology Sydney, PO Box 123 Broadway, 2007, Sydney, NSW, Australia, susanne.griebisch@uts.edu.au

1 - The Evaluation of European Compound Option Prices under Stochastic Volatility using Fourier Transform Techniques

Susanne Griebisch, School of Finance and Economics, University of Technology Sydney, PO Box 123 Broadway, 2007, Sydney, NSW, Australia, susanne.griebisch@uts.edu.au

This study focuses on compound option pricing under Heston's stochastic volatility dynamics. The compound option value is not only sensitive to changes of the underlying asset, but also to future changes of volatility. We develop a numerical pricing algorithm to solve this problem. It exploits that the representation of the compound option value can be divided into a difference of probabilities under two different probability measures. Approximations of the probabilities are obtained through a FFT-technique. The results are compared with other numerical methods, showing promising results.

2 - The Evaluation of Swing Contracts with Regime Switching

Boda Kang, School of Finance and Economics, University of Technology Sydney, PO Box 123, Broadway, 2007, Sydney, New South Wales, Australia, Boda.Kang@uts.edu.au, *Carl Chiarella*, *Les Clewlow*

A typical gas swing contract is an agreement between a supplier and a purchaser for the delivery of variable daily quantities of gas, between daily limits, over a number of years at a set of contract prices. The main constraint of swing contracts are that in each gas year, there is a minimum volume of gas for which the buyer will be charged at the end of the year. We price such swing contracts for a regime-switching gas forward price curve. With the help of the recombining pentanomial tree, we are able to evaluate the prices, the optimal strategies and the hedge ratios of the swing contracts.

3 - A new unscented Kalman filter with higher order moment-matching

Ksenia Ponomareva, Brunel University, United Kingdom, ksenia.ponomareva@brunel.ac.uk, *Paresh Date*, *Zidong Wang*

A new approximate Bayesian algorithm is proposed which generates sample points and probability weights that match the predicted values of marginal skewness and kurtosis of the unobserved state variables, in addition to their mean and covariance matrix. Its performance is illustrated by an empirical example of yield curve modeling with financial market data. This algorithm is a useful alternative to the extended Kalman filter (due to improved accuracy) and particle filter (due to significantly reduced computation). Possible practical applications include forecasting of macroeconomic variables.

■ WD-47

Wednesday, 14:00 - 15:20
8.2.16

Data Mining in Early Warning Systems II

Stream: Data Mining in Early Warning Systems

Invited session

Chair: *Ozlem Ilk*, Statistics, Middle East Technical University, Middle East Technical University, Dept. of Statistics, Office No: 134,, Ankara, Turkey, oilk@metu.edu.tr

1 - Risk analysis study of maritime traffic in the strait of istanbul

Birnur Ozbas, Industrial Engineering Department, Bogazici University, Guney Kampus Muhendislik Binasi, Bebek, 34342, Istanbul, Turkey, birnur@ozbas.com.tr, *Ilhan Or*, *Tayfur Altioek*, *Ozgecan S. Uluscu*

In this paper, results of a simulation-based risk analysis study for the Strait of Istanbul is presented. A simulation model for the transit traffic in the Strait (which considers traffic rules, vessel profiles, pilotage services, meteorological/geographical conditions) has been developed. Regarding risk assessment, two sets of factors are sought for during each transit: the probability of an accident and the potential consequences of this accident, both conditioned on various triggering events. Then, as a simulation run proceeds, the risks generated by each transit vessel are assessed.

2 - Trouble Condition Sign Mining for Hydroelectric Power Plants

Takashi Onoda, System Engineering Lab., CRIEPI, 2-11-1, Iwado Kita, Komae-shi, 201-8511, Tokyo, Japan, onoda@criepi.denken.or.jp

Kyushu Electric Power Co., Inc. collects different sensor data (hereafter, operation data) to maintain the safety of hydroelectric power plants while the plants are running. It is very rare that trouble conditions occur in the power equipment. In this situation, we have to find trouble condition sign. In this paper, we consider that the rise inclination of special unusual condition data gives trouble condition sign. We propose an interactive trouble condition sign mining method for hydroelectric power plants by using one class and normal support vector machine. This paper also shows that the proposed method can find a trouble condition sign of bearing vibration from the real operation data.

3 - Mahalanobis-Taguchi System for the Prediction of Pressure Ulcers Development in Surgical Patients

Chao-Ton Su, Dept. of Industrial Engineering & Engineering Management, National Tsing Hua University, 101, Sec. 2, Kuang-Fu Rd., 30013, Hsinchu, Taiwan, ctsu@mx.nthu.edu.tw, *Li-Fei Chen*, *Yan-Cheng Chen*

The Mahalanobis-Taguchi system (MTS) is a diagnostic/forecasting tool integrating Mahalanobis distance, orthogonal arrays and signal-to-noise ratio. This study aims to employ MTS to predict the pressure ulcers development in surgical patients and identify risk factors from data from patients during surgical procedures. Here, MTS obtained better values in index of sensitivity and g-means than other analytical methods (Logistical regression, decision trees). We conclude that MTS is an effective approach for the diagnosis investigated.

4 - Statistical early warning systems for company failure

Ozlem Ilk, Statistics, Middle East Technical University, Middle East Technical University, Dept. of Statistics, Office No: 134,, Ankara, Turkey, oilk@metu.edu.tr, *Deniz Akinc*, *Murat Cinko*, *Didem Pekkurnaz*

Foreseeing the early signs of financial failure is important for both the economical development of the country and for the self - evaluation of individual firms. In this study, publicly available panel data are collected from Istanbul Stock Exchange and they are investigated with the goal of detecting likely to fail companies. Annual data on 146 industry firms are considered between the years of 1999 and 2002. Both logistic regression and Marginalized Transition Random Effects Models (MTREM) are used as early warning systems. By these models, financial success probabilities for each company are calculated at time t by using the financial statements at time $t-1$; and the factors related to financial failure are determined. Depending on the year and response type, the correct classification rates in logistic regression models range between 62% and 72%. On the other hand, MTREM resulted in higher correct classification rates, which are between 79% and 100%.

Wednesday, 15:40-17:00

■ WE-02

Wednesday, 15:40-17:00

3.2.14

EURO Management Science Strategic Innovation Prize (MSSIP 2010) on the topic of Optimization in Telecommunications

Stream: EURO Management Science Strategic Innovation Prize (MSSIP 2010) on the topic of Optimization in Telecommunications

Invited session

Chair: *Eric Gourdin*, CORE/TPN/TRM, Orange Labs, 38 rue du General Leclerc, 92794, Issy-les-Moulineaux, France, eric.gourdin@orange-ftgroup.com

1 - MSSIP 2010

MSSIP 2010 Winner, EURO, 0000, Brussels, MSSIP2010winner@gmail.com

The MSSIP Prize is awarded for an outstanding innovative contribution to Management Science/OR each year when a EURO Conference takes place. This time the subject is Optimization in Telecommunications and the prize is awarded at the EURO 2010 Conference taking place in Lisbon (Portugal). The prize is intended to recognize the role of Operational Research/Management Science in the context of modern telecommunications. The winner is announced at this session. The prize is sponsored by SAP AG (12000 Euro).

■ WE-05

Wednesday, 15:40-17:00

3.2.16

Tools for metaheuristics

Stream: Metaheuristics

Invited session

Chair: *Lars Magnus Hvattum*, Industrial Economics and Technology Management, Norwegian University of Science and Technology, Alfred Getz veg 3, Sentralbygg 1, N-7491 Trondheim, Norway, 7491, Trondheim, Norway, lars.m.hvattum@iot.ntnu.no

Chair: *Frédéric Gardi*, e-lab, Bouygues SA, 40 rue Washington, 75008, PARIS, France, fgardi@bouygues.com

1 - Toward Local Search Programming: LocalSolver 1.0

Frédéric Gardi, e-lab, Bouygues SA, 40 rue Washington, 75008, PARIS, France, fgardi@bouygues.com, *Thierry Benoist*, *Bertrand Estellon*, *Karim Nouioua*

This paper introduces Local Search Programming (LSP), as a paradigm allowing the practitioner to focus on the modeling of the problem using a simple formalism, and then to let its actual resolution to a solver based on efficient and reliable local-search algorithms. In other words, our goal is to offer a model-and-run approach to combinatorial optimization problems which are out of reach of existing Integer/Constraint Programming autonomous solvers. In this paper, LocalSolver 1.0 is presented, first software realization of our works on this subject.

2 - A Theoretical and Empirical Study of Evolutionary Squeaky Wheel Optimisation (ESWO)

Jingpeng Li, Computer Science, The University of Nottingham, Wollaton Road, NG8 1BB, Nottingham, United Kingdom, jpl@cs.nott.ac.uk, *Andrew J. Parkes*, *Edmund Burke*

The SWO approach is a new metaheuristic based on the evolution of single solution. It undertakes search via iterative disruption, improvement and construction. Our experiments on various domains have demonstrated its efficiency and effectiveness. By building its Markov chain model and undertaking a matrix analysis, we prove its global optimality and derive its convergence rate. By studying the stationary distribution with an example, we gain insight into how to embed domain knowledge into the search, and reveal some interesting properties (e.g. a non-monotonic increase with the fitness).

3 - Graphic Processor Unit Accelerated Simulated Annealing Framework

Fatih Nar, Mathematics and Computer, Çankaya University, Ögretmenler Caddesi, No:14 Balgat, 06530, Ankara, Turkey, fatihnar@cankaya.edu.tr, Erdal Yilmaz

In this study a generic framework for the parallel implementation of Simulated Annealing (SA) method is proposed. In proposed method search space is spanned by local SA search agents (SASAs) where optimum distribution of agents in search space is obtained using k-means clustering algorithm. Clusters are formed dynamically based on spatial position of SASAs and their fit values. Cost functions are categorized by GPU implementation issues and recommendations are given as a guideline.

4 - Robust Optimization via Robust Local Search

Kwong Meng Teo, National University of Singapore, Singapore, kwongmeng@alum.mit.edu, Dimitris Bertsimas

A robust optimization method admissible to convex/nonconvex problems and problems not explicitly described with convex mathematical functions will be presented. The Robust Local Search algorithm operates directly on response surfaces of the cost/constraint functions and assumes only a black-box problem description; thus, it can be used in most real-world applications. We shall introduce the concept of robust local minima, discuss the convergence properties of the algorithm towards these minima, and report the results in engineering design and healthcare applications.

■ WE-06

Wednesday, 15:40-17:00

8.2.30

DEA Application VIII — Software

Stream: DEA and Performance Measurement

Invited session

Chair: Ali Emrouznejad, Aston Business School, Aston University, B4 7ET, Birmingham, United Kingdom, a.emrouznejad@aston.ac.uk

1 - An algorithm for DEA

José Dulá, School of Business, Virginia Commonwealth University, Richmond, United States, jdula@vcu.edu

This short tutorial will present a faster output-sensitive frame-based algorithm for DEA, which is based on a two-phase procedure. The first phase identifies the extreme efficient entities, the frame, of the production possibility set. The frame is then used in a second phase to score the rest of the entities. The new procedure applies to any of the four standard DEA returns to scale. It also imparts flexibility to a DEA study since it postpones the decision about orientation, benchmarking measurements, etc., to after the frame has been identified.

2 - FURNAS RCM program's validation and quantitative corrections using Data Envelopment Analysis

Marcio Mariano Junior, Production Engineering, UFMG, Brazil, mj.marcio@gmail.com, Magno Silverio Campos, Joao Flavio F. Almeida

This paper validate a Reliability Centered Maintenance program of a Brazilian state owned electrical utility using an operations research model of Data Envelopment Analysis to analyze and rank their 500kV circuit breaker failure's mode, at that time using a simple FMEA and empirical engineering analysis. This model evaluates the relative performance and generate a pure quantitative priorities rank, without empirical inputs and corrections. Today a high number of engineers are retired and the model presented a correlation higher than 90% over the samples, been approved by the users.

3 - New Model Designer of DEAOS

Mohammad Reza Alirezaee, School of Mathematics, Iran University of Science and Technology, Hengam St., Resalat Sq., 16846, Tehran, Iran, Islamic Republic Of, mralirez@yahoo.com, Ali Niknejad, Nassrin Alirezaee

Wide variety of DEA models, which is growing day by day, creates a challenge to those who want to implement them. Complexities of the mathematical models make development of the models extremely hard. This problem is of great importance in DEAOS.Com which has a goal of delivering all the DEA models. To address this issue in DEAOS, a new model designer has been introduced. This engine allows the researchers to define models in an easy-to-use web interface. Doing so, will not just allow the researchers define their own models in the system but it will also simplify the verification process.

4 - Data Envelopment Analysis software for the advanced users

Ali Emrouznejad, Aston Business School, Aston University, B4 7ET, Birmingham, United Kingdom, a.emrouznejad@aston.ac.uk, Emmanuel Thanassoulis

This paper presents software that takes its features closer to the latest developments in the DEA literature. The new software addresses a variety of issues such as: Assessments under a variety of possible assumptions of returns to scale including NIRS and NDRS; truly unlimited number of assessment units (DMUs); Analysis of groups of data by estimating automatically separate boundaries by group; Malmquist Index and its decompositions; Super efficiency; Automated removal of super-efficient outliers under user-specified criteria; Cross efficiency; allocative efficiency and Bootstrapping.

■ WE-08

Wednesday, 15:40-17:00

6.1.36

Various Advances on Management and Scheduling III

Stream: Project Management and Scheduling

Invited session

Chair: Ayse Elvan Bayraktaroglu, Industrial Engineering, Istanbul Technical University, Isletme Fakultesi, Macka, 34367, Istanbul, bayraktaroglu@itu.edu.tr

1 - Assembly Line Balancing with Outsourcing

Rifat Gürçan Özdemir, Industrial Engineering Department, Istanbul Kültür University, Atakoy Campus, Atakoy-Bakirkoy, 34156, Istanbul, Turkey, rg.ozdemir@iku.edu.tr, Ufuk Kula

Outsourcing has become a popular company strategy in recent years. In this paper, we consider a single product assembly line design and balancing problem, in which the manufacturer has an option of outsourcing a pre-determined set of product's components. We develop a mathematical model that determines the optimal number of stations, solves the line-balancing problem. In addition, the model determines which components are to be outsourced. We apply the model in a home appliance product, and perform a numerical study to show the benefit of outsourcing.

■ WE-13

Wednesday, 15:40-17:00

2.2.21

Hub Location

Stream: Location Analysis

Invited session

Chair: 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

1 - Models for a single-assignment hub location problem with capacity levels

Isabel Correia, Departamento de Matemática- CMA, FCT-Universidade Nova de Lisboa, Monte da Caparica, 2829-516, Caparica, Portugal, isc@fct.unl.pt, Stefan Nickel, Francisco Saldanha-da-Gama

This paper considers an extension of the classical single-assignment hub location problem in which the capacity level of each potential hub must be chosen from a set of available capacities. For this problem different mixed integer linear programming models are presented. Some additional inequalities and pre-processing tests are proposed with the goal to enhance the models. We report the computational experience performed with a commercial solver in a battery of test problems in order to evaluate the performance of the different models discussed.

2 - Multimodal hub location and hub network design

Sibel A. Alumur, Industrial Engineering Department, TOBB University of Economics and Technology, Sogutozu cad. No:43, Sogutozu, 06560, Ankara, Turkey, salumur@etu.edu.tr, *Bahar Yetis Kara*, *Oya Ekin-Karasan*

In this new hub location problem, we include the possibility of using different hub links and allow for different transportation modes between hubs, and for different types of service time promises between origin-destination pairs while designing the hub network. In addition, we jointly consider transportation costs and travel times in this multimodal problem. We propose a linear mixed integer programming model together with some sets of effective valid inequalities and an efficient heuristic. Computational analysis is presented on the Turkish network data set.

3 - The Dynamic Uncapacitated Hub Location Problem

Ivan Contreras, Canada Chair in Distribution Management, HEC Montreal, 3000 chemin de la Cote-Sainte-Catherine, H3T 2A7, Montreal, Quebec, Canada, ivan.contreras@cirreil.ca, *Jean-François Cordeau*, *Gilbert Laporte*

This paper presents the Dynamic Uncapacitated Hub Location Problem which consists in selecting a set of hubs to be established and the routing of flow through the network, while minimizing the total cost over a finite time planning horizon. The costs include those for the location, operation and closing of hubs over time, and the costs of routing the flow. We propose a branch-and-bound algorithm that uses a Lagrangean relaxation to obtain good bounds at the nodes of the tree. Numerical results on a battery of instances with up to 100 nodes and 10 time periods are reported.

4 - Hub location problems with role dependent objectives

Justo Puerto, Estadística e I.O., Universidad de Sevilla, Facultad de Matemáticas, 41012, Sevilla, Spain, puerto@us.es, *Antonio Manuel Rodríguez-Chía*, *Ana Bel Ramos-Gallego*

Although hub location models have been analyzed from the sum, maximum and coverage point of views, as far as we know, they have never been considered under an alternative unifying point of view. In this paper we consider new formulations, based on the ordered median objective function, for hub location problems with new distribution patterns induced by the different users' roles within the Supply Chain network.

■ WE-14

Wednesday, 15:40-17:00

2.2.15

Industrial Applications in Risk Management

Stream: IBM Research Applications

Invited session

Chair: *Eleni Pratsini*, IBM Zurich Research Lab, Säumerstrasse 4, 8803, Zurich, Switzerland, pra@zurich.ibm.com

Chair: *Marco Laumanns*, IBM Research Zurich, 8803, Rueschlikon, Switzerland, mmlm@zurich.ibm.com

1 - From Optimal Solutions to Smart Decisions

Alain Chabrier, IBM España S. A., Santa Hortensia 26-28, 28002, Madrid, Spain, achabrier@es.ibm.com

In this talk we describe the challenges faced when developing custom optimization based solutions. We will also summarize some keys to success that we have learnt from developing such applications for many years. Finally, we present how a platform like IBM ILOG ODM Enterprise may help answering these challenges.

2 - Closing the gap between tactical ERP / MRP planning and operational execution in production industries — a simulation-based approach

Ulrich Schimpel, Business Optimization, IBM Research, Säumerstrasse 4, 8803, Rueschlikon, Switzerland, uschimpel@gmx.net, *Satyadeep Vajjala*, *Manuel Parente*

Our case study looks at a multi-stage microchip production process and addresses possibilities to close the gap between commonly deterministic MRP schedules and the multi-constrained stochastic LEAN execution. Thereby, we give a deeper understanding of effects like variability in the demand, yield, and in the lead times. We highlight strategies to mitigate those risks and effectively narrow the aforementioned gap. Our approach includes operational aspects like running production sites at different TAKTs, co-product relationships, and various capacity constraints.

3 - A Markov decision model for strategic resource management of power grid operators

Michael Guarisco, Institute for Operations Research, ETH Zurich, Raemistrasse 101, 8092, Zurich, Switzerland, guarisco@ifor.math.ethz.ch, *Marco Laumanns*, *Rico Zenklusen*

Based on regulatory requirements in electricity markets, power grid operators try to balance costs and quality of supply. The restoration time after incidents influences the quality of supply and depends on the availability of resources. We present a Markov decision model of a power supply system with endogenous restoration times. For each state of the power grid, the available resources are assigned to the failed components such that the expected average energy not supplied is minimized. The results may support strategic decisions of power grid operators in resource management.

4 - Web-based Expert Elicitation in Bayesian Networks

Lea Deleris, IBM, Dublin 15, Mulhuddart, Ireland, lea.deleris@ie.ibm.com, *Debarun Bhattacharjya*, *Bonnie Ray*

Bayesian networks are increasingly popular for representing causal relationships in risk analysis applications. One of the challenges they present is the elicitation of the parameters of the underlying conditional probability distributions. We present a web-based tool that facilitates this elicitation process, in particular for distributed teams. We also discuss analytical methods for determining the order in which parameters are to be elicited, in order to maximize the information salvaged in case of early drop-off from experts, a problem particularly relevant to web-based elicitation.

■ WE-15

Wednesday, 15:40-17:00

2.2.12

Vehicle Routing and Set Covering Models

Stream: Vehicle Routing [c]

Contributed session

Chair: *Rita Macedo*, Departamento de Produção e Sistemas, Universidade do Minho, Universidade do Minho, Escola de Engenharia, Departamento de Produção e Sistemas, Campus de Gualtar, 4710-057, Braga, Portugal, rita@dps.uminho.pt

1 - Consumer Dispersion and Logistics Costs in Various Distribution Systems

Marcel Turkensteen, Business Studies, ASB, Fuglesangs Alle 4, 8210, Aarhus V, Denmark, matu@asb.dk

We address the relationship between the geographical dispersion of a set of demand points and the expected logistics costs. This is relevant in the strategic marketing decision which groups of consumers to target. We devise quickly computable measures for the logistics costs. In our experiments, dispersed sets of demand points are created. For various types of distribution systems, expected logistics costs are computed using continuous approximation, location and routing methodologies. We find that the average distance between locations is an effective estimate of the logistics costs.

2 - On Generation of Routes for Set-Covering-Based Approach for Solving Capacitated VRP

Milan Stanojevic, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Serbia, milans@fon.rs, *Gordana Savic*

Real-world routing problems are very hard to be solved. One possible approach is to solve corresponding set-covering problem with limited number of predefined routes. With a controllable route generation algorithm one can influence the execution time and the quality of solution. We propose a route generation algorithm based on a savings heuristic similar to Clarke-Wright algorithm. Some computational results will be presented.

3 - Column generation based heuristic with heuristic pricing for capacitated vehicle routing problem

Cristián Cortés, Civil Engineering Department, Universidad de Chile, Blanco Encalada 2002, 5th floor, Santiago, Chile, ccortes@ing.uchile.cl, *Pablo A. Rey*

We show a heuristic algorithm for a distribution problem faced by a beer producer. The problem comprises trucks' fixed costs, delivery benefits, time windows and routes with more than 40 clients. The relaxed MP is solved to optimality by CG and a set-covering problem is built with selected columns. The IP is solved for routing. A GRASP is used to price out new columns; when it fails, an Elementary SP is used to either checking optimality or finding new routes. Computational experiments are shown

4 - Relaxation induced methods based on column generation for vehicle routing problems

Rita Macedo, Departamento de Produção e Sistemas, Universidade do Minho, Portugal, rita@dps.uminho.pt, *Cláudio Alves*, *J. M. Valério de Carvalho*, *Saïd Hanafi*

We address the resolution of vehicle routing problems through hybrid procedures that combine column generation, branch-and-bound and relaxation based heuristics. In particular, we combine the hybrid linear programming based algorithm proposed by Hanafi and Wilbaut (2009) for mixed integer programming problems with branch-and-price. These heuristics are convergent. They consist in solving iteratively the linear relaxation of the problem, and in deriving upper bounds. The linear relaxation corresponds to the well-known column generation model. Computational results are reported.

■ WE-17

Wednesday, 15:40-17:00

1.3.14

Recent OR Advances by Statistics, Probability and Performance Measures

Stream: Computational Statistics

Invited session

Chair: *Pakize Taylan*, Mathematics, Dicle University, 21280, Diyarbakir, Diyarbakir, Turkey, ptaylan@dicle.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - New empirical likelihood methods with applications

Gregory Gurevich, Industrial Engineering and Management, SCE - Shamoon College of Engineering, Balik Bazel, 84100, Beer Sheva, Israel, gregoryg@sce.ac.il, *Yossi Hadad*

The objective of this research is to propose and examine various nonparametric statistical procedures based on empirical likelihood ratio methodologies. If certain key assumptions are met, one can show parametric likelihood methods are very powerful and efficient statistical tools. However, when these key assumptions are not met the parametric approach may be not optimal. We develop various 'artificial' or 'approximate' likelihoods' techniques, which are both robust and efficient. These methods have a wide variety of applications in engineering and social science experiments.

2 - Methods based on mathematical optimization for semi-supervised data classification

Burak Ordın, Mathematics, Ege University, Ege University Science Faculty, Department of Mathematics, 232, izmir, bornova, Turkey, burak.ordin@ege.edu.tr, *Nur Uylas*

There has been an increase of interest for semi-supervised learning recently, because of the many datasets with large amounts of unlabeled examples and only a few labeled ones. In this paper we have compared two semi-supervised algorithms based on codifferential method and quasi-secant method for solving data classification problems. The algorithms compute hyperplane(s) to separate two sets with respect to some tolerance. An error function is formulated and an algorithm for its minimization is expressed. We present results of numerical experiments using several UCI test data sets.

3 - Lottery Data Analysis Using Hierarchical Decision-Making Model

Ulas Beldek, Eletronic and Communication Engineering Department, Çankaya University, Cankaya Universitesi, Ogretmenler caddesi no:14, Yuzuncuyi, Balgat, Cankaya, Ankara, 06530, Ankara, Turkey, u.beldek@cankaya.edu.tr, *Kemal Leblebicioğlu*

Lottery Sales forecasting has been addressed by using a single agent, previously. However, we propose a hierarchical decision-making model for the development of more than one agent where a lower level agent helps the development of higher level agent: The prediction of lower level agent is transferred to higher level by a performance measure. An intuitively suitable fusion equation combines the lower level decision with the decisions of a new developing structure to form the second level agent. Finally, the strength of the agents developed using the hierarchical model is demonstrated.

4 - The influence of self-attribution bias on managerial incentives and the choice of performance measures

Bjoern Anton, Chair of Accounting and Control, Technical University Munich - Germany, Arcisstraße 21, 80333, München, BY, Germany, bjoern.anton@wi.tum.de

We examine the effects of self-attribution bias on a multiperiod moral hazard model in which an agent does not know his own ability but infers it from the output of his work. We compare the behavior of an agent who takes too much credit from high outputs to a purely rational one. Our results are: 1. The biased agent's expected effort level is higher than that of a rational agent. 2. Low outputs may induce underconfidence / lower effort levels. 3. The level of overconfidence declines over time. 4. Aggregate performance measures may be better for biased agents.

■ WE-18

Wednesday, 15:40-17:00

1.3.15

Data Mining Applications in Business Intelligence

Stream: Applications in Business Intelligence and Knowledge discovery

Invited session

Chair: *Richard Weber*, Department of Industrial Engineering, University of Chile, Republica 701, 2777, Santiago, Chile, rweber@dii.uchile.cl

1 - Business Intelligence in Electronic Commerce — Case Study

Dragana Becejski-Vujaklija, Faculty of Organizational Sciences, University of Belgrade, Jove Ilica 154, 11000, Belgrade, Serbia, draganab@fon.rs

In this work possibilities that come from the application of business intelligence in electronic commerce and network environment will be presented. Processing a large number of data required specific data structures because daily operations do not allow analytical processes to operate unimpeded. Relational data could not be used in the analytical processes, therefore this work displays a structure of a Data Warehouse model used in small domestic electronic commerce firm to record all needed data for analysis.

2 - Forecasting and Management of Hospital Service Demand

Richard Weber, Department of Industrial Engineering, University of Chile, Republica 701, 2777, Santiago, Chile, rweber@dii.uchile.cl, *Oscar Barros*, *Eduardo Ferro*, *Carlos Reveco*

An efficient planning of hospital resources requires a reliable demand forecast. We are developing integrated management tools for several Chilean hospitals where based on predicted demand for several pathology types capacity planning for different resources is performed automatically. We compare traditional techniques such as linear regression and moving averages with more sophisticated tool such as neural networks. An out-of-sample error of about 7% (MAPE) convinced the decision makers at the hospitals and allows us to install the developed systems for daily operation.

3 - Improving Execution Time and Accuracy for IP Classification Problems in Large Data Sets

Jaime Miranda, Department of Management Control and Information Systems, Universidad de Chile, Diagonal Paraguay 257, Chile, jmirandap@fen.uchile.cl, *Richard Weber*, *Daniel Espinoza*

Many data mining applications require the analysis and classification of large data sets. Several methods exist for this task, being of particular interest Integer Programming (IP) models. However, these models' weakness is the required computational time limiting their applicability to small data sets. We present a heuristic that uses cluster analysis as preprocessing for a reduced IP model achieving both, significantly lower computational time and less classification errors.

4 - A 3PL providers classification model considering categorical variables on the use of information and communication technologies

Mônica M. M. Luna, Department of Production and Systems Engineering, Federal University of Santa Catarina, Campus Universitário, Trindade, 88040-900, Florianópolis, SC, Brazil, monica@deps.ufsc.br, *Carlos Ernani Fries*

ICT have greatly benefited the logistics industry, allowing high levels of connectivity between partners, promoting its differentiation and specialization. To characterize the service offer, a statistics and data mining based third-party logistics providers classification model which exclusively considers the presence of technological solutions through Yes/No statements is suggested. The results identified 3PL homogeneous clusters in the Brazilian market, equivalent to those models that make use of quantitative variables, usually associated with unreliability and difficult acquisition.

■ WE-19

Wednesday, 15:40-17:00

1.3.20

Nonsmooth Global Optimization

Stream: Nonsmooth Optimization

Invited session

Chair: *Alexander Kruger*, Graduate School of Information Technology & Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

1 - Asymptotic stability in optimal control problems with time delay

Musa Mammadov, Graduate School of Information Technology and Mathematical Sciences, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, m.mammadov@ballarat.edu.au

The problem of qualitative analysis of optimal trajectories for a special class of optimal control problems described by differential delay equations is considered. This kind of equations has attracted a significant interest in recent years due to their frequent appearance in a wide range of applications. They serve as mathematical models describing various real life phenomena in mathematical biology, population dynamics and physiology, electrical circuits and laser optics, economics, life sciences and others.

2 - Using extended cutting angle and penalty methods for solving semi-infinite programming problems

Albert Ferrer, Dpt. of Applied Mathematics I, Technological University of Catalonia, Av. Doctor Marañón, 44-50, 08028, Barcelona, Catalunya, Spain, alberto.ferrer@upc.edu

Recently a unified framework concerning to Remez-type algorithms and integral methods coupled with penalty and smoothing methods has been introduced for solving convex semi-infinite programming. The framework is theoretical and no computational results are reported. Nevertheless, it suggests new methods with interesting computational properties. We propose a specific implementation that use the Extended Cutting Angle Method as an auxiliary method of the main procedure. Computational results are reported.

3 - Direct Search Filter Methods

Aldina Correia, Mathematics, ESTGF-IPP, Edifício do Salto, n°4., blc 6, 5° esq, 4600-281, Amarante, Portugal, aic@estgf.ipp.pt, *João Matias*, *Pedro Mestre*, *Carlos Seródio*

Filter methods have been widely used in several areas of Constrained Nonlinear Optimization. These methods treat optimization problems as bi-objective attempts to minimize the objective function and a continuous function that aggregates the constraint violation functions. But, when the involved functions are non smooth, Unconstrained Derivative-free Methods must be used. This work presents results obtained by combining Filter method with other direct search methods and are proposed some alternatives to aggregate the constraint violation functions.

■ WE-20

Wednesday, 15:40-17:00

1.3.33A

Social Networks

Stream: Knowledge Discovery and Data Mining

Invited session

Chair: *Armando Mendes*, Mathematics, Azores University, Rua da Mãe de Deus, 9501-801, Ponta Delgada, Azores, Portugal, amendes@uac.pt

Chair: *Matthias Funk*, Mathematic, University of the Azores, Rua Gonçalves, 9500, Ponta Delgada, mfunk@uac.pt

1 - Large Social Networks Visualization Using the Algorithm of the Spanning Tree with Maximum Number of Leaves

Luís Cavique, DCeT, Universidade Aberta, Rua da Escola Politécnica 147, 1269-01, Lisboa, Portugal, lcavique@univ-ab.pt, *Armando Mendes*

In the web 2.0, social networks easily reach of thousands or millions of actors. A clear view of a small number of vertexes is easy to obtain. However, when the number of vertexes and edges increases, the view becomes incomprehensible. In this work, we intend to find the skeleton of the social network, by transforming the graph into a tree with the largest possible number of leaves, using the spanning tree algorithm with additional constraints.

2 - Combining Data Mining Algorithms for Web Recommendation

A. Jorge Morais, Department of Science and Technology, Universidade Aberta, Universidade Aberta - Delegação do Porto, Rua do Amial, 752, 4200-055, Porto, Portugal, ajorgemorais@gmail.com

Data mining algorithms are used for recommendation of pages that might be useful for the user according to past behavior (of a given user or a group of users). Combining several algorithms to optimize user satisfaction within a multi-agent environment can be done in two ways: a competitive approach, where each agent fights for grabbing user's attention, or a cooperative approach, where all agents play for the same side. In this work, both approaches were tested and a comparison of both against a single algorithm approach is presented.

3 - Integration of different Cliques of Proverbial Knowledge

Matthias Funk, Mathematic, University of the Azores, Rua Gonçalves, 9500, Ponta Delgada, mfunk@uac.pt, *Luís Cavique*

By using 14 distinct inquiries we were able to analyze the knowledge of a huge number of proverbs inside the cultural space of Azores. At Euro 2009, we developed a pattern matching algorithm by using a incidence matrix resulting from the pair wise common knowledge on the best-known proverbs. By randomly picked an inquiry and it was possible to identify an intrinsic correlation between the paremiological competence and the person's provenance. But these results must be validated with more data. Therefore, we now analyze all 14 inquiries with the same method in order to compare results.

4 - Hierarchical Clique Analysis in Social Networks Due to Common Knowledge of Proverbs

Armando Mendes, Mathematics, Azores University, Rua da Mãe de Deus, 9501-801, Ponta Delgada, Azores, Portugal, amendes@uac.pt, *Matthias Funk*

We present the Hierarchical Clique Analysis, a new algorithm for social networks analysis. The algorithm is exemplified with data about the recognition of proverbs collected in interviews in all Azorean islands and also in three Azorean emigration locations in the USA. Interpreting the set of this data as an incidence matrix of a graph, we obtain 8 oriented and isolated sub-graphs which distinguish the society in a kind of different families of proverbial users. The Hierarchical Clique Analysis finds distinct clusters with a high inner homogeneity.

■ WE-21

Wednesday, 15:40-17:00

6.2.47

Education and Sustainable Development

Stream: Education, and Social 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 - Mind the gap: modelling learning in a professional curriculum

Jo Smedley, Newport Business School, University of Wales, Newport, Allt-yr-yn Avenue, NP20 5DA, Newport, United Kingdom, jo.smedley@newport.ac.uk

In an increasingly litigious society, a legal understanding is often required to support learning in non-related areas. Accessibility can be assured through a range of technological and non-technological learning approaches with information appropriately 'packaged' to engage with a widened range of learners. This presentation will reflect on lessons learned during project development and implementation and present a model for action learning involving a professional curriculum. Outcomes reflect the differences in user expectations between academic and professional subjects.

2 - Unemployment Similarities among Portuguese Regions — a Cluster Analysis Approach

Elisa Barros, Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Bragança, Campus de Sta Apolónia, Apartado 1134, 5301-857, Bragança, Bragança, Portugal, ebarros@ipb.pt, *Alcina Nunes*

The regional distribution of the unemployed individual characteristics is of core importance for the development of public policies that can fight the unemployment phenomenon, especially in times of crises. The data mining cluster methodology allows finding groups of regional areas that share the same characteristics for the register unemployed and, therefore, helps in a better understanding of the problem and possible solutions. Preliminary results for the Portuguese regions show a clear division of the territory among four regions — north and south and urban and rural areas of the country — concerning individual characteristics such as the gender, age, education or unemployment duration. These results have policy consequences.

3 - Need for educational policy-making for the sustainable development of children living in poverty

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, *Aysegul Ozsoy*

Improving educational opportunities for children of poverty may have a positive impact on their lives, especially, it may lead them to an upward social mobility to enhance a sustainable future. This talk is based on data drawn from a nationwide study whose participants are parents and children from squatter neighborhoods. Findings rate financial issues at the top of needs, and urge schools to provide children with poor households better school quality facilities to receive equality of opportunity in education. Also, social adaptation to urban live emerges as a need for social policy-making.

■ WE-22

Wednesday, 15:40-17:00

3.1.10

Maritime Logistics: Theory and Practice

Stream: Maritime Logistics

Invited session

Chair: *Heng-Soon Gan*, Mathematics and Statistics, University of Melbourne, Australia, Department of Mathematics and Statistics, University of Melbourne, 3010, Parkville, VIC, Australia, hsg@unimelb.edu.au

1 - Robust short-sea ship routing and scheduling

Cristina Requejo, DMat-CIDMA, University of Aveiro, 3810-193, Aveiro, Portugal, crequejo@ua.pt, *Agostinho Agra*, *Marielle Christiansen*, *Rosa Maria Figueiredo*, *Lars Magnus Hvattum*

A fleet of ships must service a given set of cargoes. Several ports are closed for service during nights and weekends, the loading or discharging may take several days, and it is important to avoid ships waiting in ports during the weekend before finishing the service. Maritime transportation is associated with a high degree of uncertainty, mainly due to bad weather and unpredictable service times. We discuss how to design robust ship routes and schedules and present mathematical models.

2 - Optimizing Schedules for Cooperative Engagements from a United States Navy Sea Base

Javier Salmeron, Operations Research, Naval Postgraduate School, 1411 Cunningham Rd, 93943, Monterey, CA, United States, jsalmeron@nps.edu, *Jeffrey Kline*, *Greta S. Densham*

This work presents Global Fleet Station Mission Planner (GFSMP), an optimization tool to aid in planning and scheduling of humanitarian-assistance and other theater-security cooperation missions for the U.S. Navy. GFSMP helps fleet staffs to examine how one naval ship deployed for six months with embarked teams can best meet its mission and logistical requirements. We illustrate the application of GFSMP in the U.S. Second Fleet's Trident Warrior 2009 exercise. Solutions significantly improve total mission value achieved and reduce costs compared to manual planning.

3 - Discrete time models for an Inventory Ship Routing Problem

Agostinho Agra, Matemática, Universidade de Aveiro, campus universitário de santiago, 3810-193, Aveiro, Portugal, aagra@ua.pt, *Marielle Christiansen*, *Henrik Andersson*

We consider an Inventory Ship Routing Problem that combines routing and inventory management at all ports of a single product. The product is produced and stored at production ports and transported by a heterogeneous fleet of ships to the consumption ports. Inventory capacities are considered on the production and consumption ports. We present a mathematical formulation of the problem where the time is discretized to easily take the varying production and consumption rates into account. Then we discuss different approaches to strengthen that formulation and report computational results.

4 - A Multi-Product Inventory Routing Problem with Varying Consumption Rates

Heng-Soon Gan, Mathematics and Statistics, University of Melbourne, Australia, Department of Mathematics and Statistics, University of Melbourne, 3010, Parkville, VIC, Australia, hsg@unimelb.edu.au, *Henrik Andersson*, *Marielle Christiansen*

We consider here a maritime inventory routing problem with varying consumption rates minimising total shipment, inventory and purchasing costs. There are draft limitations on ships entering production and consumption ports. More than one product can be loaded onto a ship. We will present an arc-based formulation for this problem and report on some preliminary results, including a decomposition attempt.

■ WE-24

Wednesday, 15:40-17:00

6.2.50

Educational Timetabling

Stream: Timetabling and Rostering

Invited session

Chair: *Tiago Pais*, School of Computer Science, University of Nottingham, School of Computer Science, Jubilee Campus, NG8 2BB, Nottingham, Nottinghamshire, United Kingdom, txp@cs.nott.ac.uk

1 - University Course Timetabling using Graph Colouring Heuristics

Khodakaram Salimifard, Industrial Management Department, Persian Gulf University, Mahini Road, 7516913798, Bushehr, Iran, Islamic Republic Of, salimifard@pgu.ac.ir, *Salman Babaei*

Timetabling problems have been widely investigated in the operational research and artificial intelligence research communities for more than four decades. Graph colouring and generalizations are useful tools in modelling a wide variety of scheduling and assignment problems. This paper concentrates on university course timetabling. The primary purpose of our work is to solve a real timetabling problem at the Persian Gulf University of Iran. The paper is focused on weekly scheduling for the faculty of humanities. The problem includes 40 courses, 264 course groups, and 66 teachers that have to be assigned to 24 classrooms within some 25 predefined time slots. To find a solution for such a problem, we have applied a heuristic approach based on graph colouring. We have used three graph colouring constructive heuristics including (1) Largest Degree, (2) Largest Weighted Degree, and (3) Saturation Degree. Four types of hard constraint and four types of soft constraints are considered. Hard constraints have to be satisfied under any circumstances. Timetables with no violations of hard constraints are called feasible solutions. Soft constraints need to be satisfied as much as possible. Soft constraints are used to evaluate the goodness of the solutions. The results show that the timetable generated by the algorithm is much better than the one manually created by department staff.

2 - University course scheduling with expanding campus

Loo Hay Lee, Industrial and Systems Engineering, National University of Singapore, Singapore, iseel@nus.edu.sg, *Hung Hui-Chih*, *Kien-Ming Ng*, *Ek Peng Chew*

We consider a course scheduling problem for a university that is expanding its campus with a new location. The two parts of campus will be connected by shuttle service. Our problem is to reallocate courses to new part of campus and to minimize traffic impact. We first analyze student enrollment data and cluster courses according to their correlations. Based on existing course schedule, we predict the student movement and build a mixed integer programming model for course scheduling. We solve the model and then evaluate its traffic impact. Both analytic and numerical results will be presented.

3 - Using Choquet Integral to combine different heuristic values for the exam timetabling problem

Tiago Pais, School of Computer Science, University of Nottingham, School of Computer Science, Jubilee Campus, NG8 2BB, Nottingham, Nottinghamshire, United Kingdom, txp@cs.nott.ac.uk, *Edmund Burke*

In this work we present a constructive heuristic approach based on the Choquet integral. We use this method to combine the information given by different basic heuristics. A fuzzy measure is used to model the importance of each heuristic in addition to the interaction between them. We test our approach on 2 different testbeds and compare its performance against the individual heuristics. Moreover, we also compare the results against the best results reported in the literature.

■ WE-25

Wednesday, 15:40-17:00

6.2.48

ROADEF/EURO challenge senior session 4

Stream: ROADEF/EURO challenge

Invited session

Chair: *Christian Artigues*, LAAS, CNRS, 7 avenue du Colonel Roche, 31077, Toulouse Cedex 4, artigues@laas.fr

1 - ROADEF/EURO Challenge 2010: Final result announcement

Christian Artigues, LAAS-CNRS, 7 avenue du Colonel ROCHE, 31077, Toulouse Cedex 4, challenge@roadef.org, *Eric Bourreau*, *H. Murat Afsar*, *Ender Ozcan*, *Guillaume Dereu*

We present the results of the ROADEF/EURO Challenge 2010, an international optimization contest proposed jointly by EURO, the French OR society (ROADEF) and an industrial partner (EDF). Many prizes are offered. EDF proposes a 4000 euros for the junior category, 4000 euros for the senior category and 2000 euros for the multi-thread category. Intermediate qualification results (available since February 2010 on <http://challenge.roadef.org/>) have already shown that the competition is very tight, but after this presentation, the suspense will be over as the winners will be revealed.

■ WE-26

Wednesday, 15:40-17:00

3.1.11

Game Theory and Social Choice

Stream: Cooperative Game Theory [c]

Contributed session

Chair: *Dorota Marciniak*, Polish Academy of Sciences, Warsaw, Poland, Dorofia@gmail.com

1 - Cooperation in a group pursuit game

Yaroslavna Pankratova, Mathematics of economic research., International Banking Institute, Nevsky pr. 60, Saint-Petersburg, Russian Federation, yasyap@gmail.com

A nonzero-sum group pursuit game with one pursuer and m evaders is considered. Choosing control variables at current time moment each player knows the moment t and his own and all other players' positions. The evaders are discriminated what means that the pursuer knows their velocity vectors at the same moment t . With every nonzero-sum pursuit game we associate a corresponding cooperative game. We prove that in this game there exists the nonempty core. There is an interconnection between existence conditions of the Nash equilibrium of the pursuit game and nonemptiness of the core.

2 - Probabilistic power indices for games with abstention

Josep Freixas, Applied Mathematics 3, Technical University of Catalonia, Av. Bases de Manresa, 61-73, E-08242 MANRESA, Spain, 08242, Manresa, Spain, josep.freixas@upc.edu, *Daniel Palacios*

In this paper we introduce several power indices that admit a probabilistic interpretation for games with abstention or with three levels of approval in the input level. We analyze the analogies and discrepancies between standard known indices for simple games and these extensions for this more general context. We conclude by proposing procedures to easily compute them.

3 - A power analysis for voting games with consensus

Dorota Marciniak, Polish Academy of Sciences, Warsaw, Poland, Dorofia@gmail.com, *Josep Freixas*

In this presentation we introduce and examine the egalitarian property for the most established power indices on the class of simple games. We prove that Shapley—Shubik index, Banzhaf and Johnston scores also satisfy this property. We also give counterexamples for Holler, Deegan—Packel, normalised Banzhaf and normalised Johnston indices. We show that egalitarian property is a stronger condition for efficient power indices than the Lorentz domination.

■ WE-28

Wednesday, 15:40-17:00

8.2.10

Scheduling under Resource Constraints

Stream: Scheduling

Invited session

Chair: *Can Akkan*, Faculty of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, canakkan@sabanciuniv.edu

1 - New models for the Multi-Skill Project Scheduling Problem

Carlos Montoya, Département Automatique-Productique, Ecole des Mines de Nantes, La chantrerie, 4 rue Alfred Kastler, 44307, Nantes, Pays de la Loire, France, cmonto10@emn.fr, Odile Bellenguez-Morineau, David Rivreau

This work introduces different approaches to solve the Multi-Skill Project Scheduling Problem (MSPSP). The aim is to find a schedule that minimizes makespan, considering precedence relationship and resources constraints. In this problem, the performance of each activity requires a given number of workers, with predefined skills. Practical applications of this problem includes buildings construction, production and software development planning. This work is based on the implementation of different MIP models. Also, we discuss their efficiency and limits.

2 - Minimizing Ripple Effect in Single-Machine Rescheduling due to New Operation Insertion – A Branch-and-Bound Approach

Can Akkan, Faculty of Management, Sabanci University, Orhanli, Tuzla, 34956, Istanbul, Turkey, canakkan@sabanciuniv.edu

We assume there are $n-1$ operations already scheduled (with a release-time, a "hard" and a "soft" due-time). The pre-schedule is feasible w.r.t the "soft" due-times. There is a new operation with a given release-time and a "hard" due-time. The objective is to insert the new operation into the schedule so that total tardiness of the operations in the pre-schedule with respect to the "soft" due-times is minimized, such that they do not violate their release-time and "hard" due-time constraints. A branch-and-bound algorithm is designed that makes use of interval algebra.

WE-29

Wednesday, 15:40-17:00

8.2.11

Financial Modeling

Stream: Financial Modeling

Invited session

Chair: Michael Zabarankin, Mathematical Sciences, Stevens Institute of Technology, Castle Point on Hudson, 07030, Hoboken, NJ, United States, mzaraban@stevens.edu

1 - Does Model Framework Matter?

Andrea Roncoroni, Finance, ESSEC, Avenue Bernard Hirsch, BP 105, 95021, Cergy-Pontoise, France, roncoroni@essec.fr

Models are unable to appropriately represent the features owned by the underlying variables. We unveil a more general and ubiquitous source of risk stemming from the discrepancy in performance among alternative frameworks in which a given model can be cast. We consider a market with both spot and futures prices quoted and show that any reasonable pricing model can be equivalently cast by assigning dynamics to the pair or the whole term structure of futures prices. Framework risk can be defined as any assessment of the relative model performance in either framework.

2 - Risk-return portfolio optimization with disutility function

Cristinca Fulga, Department of Mathematics, Academy of Economic Studies, Piata Romana 6, sector 1, 010374, Bucharest, Romania, fulga@csie.ase.ro

We propose a multi-objective model for portfolio selection in which the risk is taken into account by considering first, an utility function which captures the attitude towards risk of the decision maker and second, the Conditional Value at Risk which is minimized such that the risk of high losses is reduced. Practical issues, such as transaction costs, are incorporated in the decision model. Computational results based on real data drawn from the Bucharest Stock Exchange are given.

WE-30

Wednesday, 15:40-17:00

8.2.13

Risk measurement and control in volatile financial markets

Stream: Operational Research and Quantitative Models in Banking

Invited session

Chair: Giorgio Consigli, Mathematics, Statistics and Computer Sciences, University of Bergamo, Via dei Caniana 2, 24127, Bergamo, Italy, giorgio.consigli@unibg.it

1 - Long term financial scenarios, sampling and optimal strategic planning

Giorgio Consigli, Mathematics, Statistics and Computer Sciences, University of Bergamo, Via dei Caniana 2, 24127, Bergamo, Italy, giorgio.consigli@unibg.it

We present a statistical model for long term financial planning under assumptions of random market risk premia and inflation risk adjustment to yield an optimal dynamic control strategy over a 10 year planning horizon. The growing adoption of decision tools, combining the Monte Carlo method for risk assessment purposes, sampling techniques for the derivation of a relevant set of economic scenarios and linear or nonlinear objective function for the solution of complex decision problems shows the practical relevance of stochastic programming approaches in financial management problems. We discuss the key elements of this methodological framework within alternative formulations of real world, practical ALM problems.

2 - A sequential learning method for tracking stochastic volatility

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, Giorgio Consigli, Cristina Manfredotti

In this talk we present a sequential learning approach for estimating risk indicator parameters within a stochastic volatility model. The approach, based on a particle filtering method, is aimed at tracking and forecasting the stochastic volatility through the Bayesian estimation of the parameters of a stochastic process with jumps. In this way we estimate the probability of a jump occurrence and its size distribution on the base of the discrete observation of prices. This technique can be embedded in a portfolio optimization model.

3 - Optimal DC-type pension fund management

Francesco Sandrini, Institutional investments, Pioneer Investments, 16 Appianstrasse, Unterforhing, bei Munchen, 81675, Munchen, Germany, francesco.sandrini@pioneerinvestments.com

Between Defined Benefit and Defined Contribution, the need for safeguarding minimum returns related to inflation and individual liabilities is emerging as a consensus solution across several European Countries, currently involved in changes within their regulatory framework: is this a third way forward for European Pension Fund Schemes? How quantitative techniques such as Dynamic Stochastic Programming, which have been broadly employed in the past to solve problems related to Asset and Liability Management (ALM) can be now employed to structure solutions both in terms of advisory and product development for Defined Contribution Pensionplans? We exploit a scenario-based pension advisory framework simulating Individual Liabilities by using Montecarlo techniques and perform strategic allocations coherent with the achievement of minimum level substitution-rates for the plan members. We solve a dynamic optimization problem where employees' contributions are proportional to their salaries and the final target functions relates to variables traditionally the domain of defined contribution pension funds such as substitution rate (ratio between annuities and last salaries). This framework aims to become over time a new planning and advisory benchmark for the new generation of hybrid DC plans.

4 - Credit Risk Management via Stochastic Programming

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, Antonio Violi, Giorgio Consigli

In this work we propose an integrated approach to manage bond portfolios. With respect to other ALM problems the main difference is the particular nature of financial instruments considered. Bonds are subject to the price volatility caused by market dynamics but also to the default probability of counterparts. Moreover, the presence of (various types of) coupons introduces a more complex cash flow management, since future investment decisions are strongly linked with coupon incomes. The proposed approach integrates two correlated risk sources, market and credit risk, under very general statistical assumptions, by means of a special-purpose scenario generator and a multistage stochastic programming model. Two key issues (consistent risk factors statistical characterization and effective dynamic optimization) have been jointly implemented and tested during the crisis period, in order to provide an integrated decision tool with practical relevance.

■ WE-33

Wednesday, 15:40-17:00
8.2.19

Realistic Production Scheduling I

Stream: Realistic Production Scheduling
Invited session

Chair: *Ruben Ruiz*, Departamento de Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Camino de Vera S/N, 46021, Valencia, Spain, rruiz@eio.upv.es

1 - Estimation of distribution algorithm flow shop scheduling with lot-streaming and setup times

Ruben Ruiz, Departamento de Estadística e Investigación Operativa Aplicadas y Calidad, Universidad Politécnica de Valencia, Camino de Vera S/N, 46021, Valencia, Spain, rruiz@eio.upv.es, *Quan-Ke Pan*

We consider a n -job m -machine lot-streaming flow shop scheduling problem with sequence-dependent setup times under both the idling and no-idling production cases, and the objective is to minimize the makespan. A novel estimation of distribution algorithm (EDA) is proposed with a job permutation based representation. A simple but effective local search is fused to enhance the intensification capability. A speed-up method is presented to reduce the computational effort needed for the local search technique and the NEH-based heuristics.

2 - MILP models and solution approaches for scheduling a chemical batch process

Laura Hege, Laboratoire Génie Industriel, Ecole Centrale Paris, 92290, Chatenay-Malabry, France, laura.hege@gmail.com, *Céline Gicquel*, *Michel Minoux*

We study a production scheduling problem encountered in a chemical plant producing enzymes. The chemical process is a sequential, 4-stage process with parallel production units at each stage. We propose a first MILP formulation based on a discrete time representation and derive a family of valid inequalities to strengthen it. We then investigate a second MILP formulation based on a continuous time representation and use it to devise a neighbourhood-search heuristic algorithm. Finally, we provide computational results showing the efficiency of both approaches.

3 - A Production Scheduling Implementation Using Critical Chain Method

Zeynep Gergin, INDUSTRIAL ENGINEERING DEPARTMENT, ISTANBUL UNIVERSITY, Avcilar Kampusu, Avcilar, 34320, ISTANBUL, Turkey, zgergin@goldenminds.com

In this study, using Critical Chain Project Management (CCPM) Method, a production scheduling is implemented in a print house. Firstly single, secondly concurrent orders are scheduled like a project using Critical Path Method (CPM). In order to apply CCPM, the constraint resource (drum) is determined, all resources are leveled, buffers are calculated manually and the expected delivery time is forecasted. Then, results are confirmed with CC Pulse software. The results support the related literature regarding the consistency of scheduling projects with CCPM instead of CPM.

■ WE-35

Wednesday, 15:40-17:00
6.2.46

Advances in Mixed-Integer Linear and Nonlinear Programming

Stream: Mixed-Integer Non Linear Programming
Invited session

Chair: *Leo Liberti*, LIX, Ecole Polytechnique, LIX, Ecole Polytechnique, 91128, Palaiseau, France, leoliberti@gmail.com
Chair: *Andrea Lodi*, D.E.I.S., University of Bologna, Viale Risorgimento 2, 40136, Bologna, Italy, andrea.lodi@unibo.it

1 - Sampling issues for intensity modulated radiation therapy (IMRT) treatment planning

Humberto Rocha, Inesc - Coimbra, Portugal, hrocha@mat.uc.pt, *Joana Matos Dias*, *Brígida da Costa Ferreira*, *Maria do Carmo Lopes*

Operations research has made significant contributions to the improvement of IMRT optimization. Many mathematical optimization models have been proposed for the intensity problem including mixed integer linear models. Regardless the formulation used, problem size is always the biggest challenge to overcome. The most common strategy to address this problem is sampling which enhances gains in computational time at a cost: the quality of the solution deteriorates. A clinical example of a head and neck cancer case is used to discuss both the need and the influence of sampling in IMRT optimization.

2 - Binet graphs and rank 1 closure

Gautam Appa, Operational Research, London School of Economics, Houghton Street, WC2A 2AE, London, United Kingdom, g.appa@lse.ac.uk, *Konstantinos Papalamprou*, *Leonidas Pitsoulis*

Network matrices arising out of the incidence matrices of directed graphs are the building blocks of totally unimodular matrices. We try to generalise these by starting with incidence matrices of mixed graphs, ie, graphs with directed and undirected edges. They give rise to bi-directed networks or binet graphs and lead to binet matrices B . These are shown to have rank 1 closure, ie, rank one cuts give the convex hull of integer points in the polyhedron $Bx \leq b, x \geq 0$. Theory, applications and generalisations of binet graphs and binet matrices are presented in this talk.

3 - De-convexification tightens CHR bounds on convex 0-1 quadratic programming problems.

Monique Guignard-Spielberg, OPIM, University of Pennsylvania, 5th floor, JMH, 3730 Walnut Street, 191046340, Philadelphia, PA, United States, guignard_monique@yahoo.fr, *Aykut Ahlatcioglu*, *Michael Bussieck*, *Mustafa Esen*, *Alex Meeraus*

Bounds on the optimal value of a convex 0-1 quadratic programming problem with linear constraints can be improved by a preprocessing step that adds to the quadratic objective function terms which are equal to 0 for all 0-1 feasible solutions yet increase its continuous minimum. Using Plateau's QCR method (2005), or one of its predecessors, the methods of Hammer and Rubin (1970) or that of Billionnet and Elloumi (2008), strengthens the CHR as well as the continuous bounds. We present results for convex GQAP problems.

4 - Request Routing and Client Assignment in content Distribution Network

Chris Potts, School of Mathematics, University of Southampton, Highfield, SO17 1BJ, Southampton, Hampshire, United Kingdom, C.N.Potts@soton.ac.uk, *Narges Haghi*, *Tolga Bektas*

A Content Distribution Network (CDN) is a system of servers containing selected objects in the form of data that are placed at selected nodes of a network. We propose an integer programming model to solve the joint problem of request routing and client assignment which explicitly considers delays in transmitting objects. The resulting model is a nonlinear mixed integer programming formulation. We propose a method that is based on Lagrangian relaxation, decomposition, and subgradient optimization to quickly obtain lower bounds for the problem.

■ WE-36

Wednesday, 15:40-17:00

3.1.05

Linear and Conic Programming II

Stream: Linear and Conic Programming

Invited session

Chair: *Mohammad Reza Peyghami*, Mathematics, K.N. Toosi University of Technology, Math. Department, K.N. Toosi University of Technology, P.O.Box 16315-1618, Tehran, Iran, 16315-1618, Tehran, Tehran, Iran, Islamic Republic Of, peyghami@kntu.ac.ir

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - An algorithm for the multiparametric 0-1-integer linear programming problem with interval data

Alejandro Crema, Escuela de Computación, Facultad de Ciencias, Universidad Central de Venezuela, Apartado 47002, 1041-A, Caracas, Venezuela, Caracas, Venezuela, alejandro.crema@ciens.ucv.ve, *Edgar Peraza*

The multiparametric 0-1-Integer Linear Programming (0-1-ILP) problem relative to the objective function is a family of 0-1-ILP problems in which the problems are related by having identical constraint matrix and right-hand-side vector. We present an algorithm to perform multiparametric analysis in the case of an objective function with interval data.

2 - A new complexity result on multiobjective linear integer programming

Victor Blanco, Departamento de Algebra, Universidad de Granada, Facultad de Ciencias, Campus Fuentenueva, 18071, Granada, Granada, Spain, vblanco@ugr.es, *Justo Puerto*

We present algorithms for solving multiobjective integer programming problems. The algorithms uses the Barvinok's rational functions of the polytope that defines the feasible region and provides the entire set of nondominated solutions for the problem. Theoretical complexity results on the algorithm are presented. We prove that encoding the entire set of solutions of the problem in a generating function is polynomially doable, when the dimension is fixed. We also provide polynomial delay algorithms for enumerating this set.

3 - Advertisement Reservation Problem on a Relationship-Based Environment

Ilkay Gultas, Industrial Engineering, Istanbul Kultur University, Atakoy-Istanbul-Turkiye, 34156, Istanbul, Turkey, i.gultas@iku.edu.tr, *Nihan Karaca*

TV networks provide TV programs free of charge but they acquire revenue by telecasting advertisements during programs. A key problem is to determine which reserved advertisements will be accepted, it is complicated by limited time inventory, different GRPs for different demographics, competition avoidance and the relationship between TV networks and clients. A mixed integer linear programming approach is proposed, and an implementation is made to a case from one of the biggest TV networks of Turkey.

4 - A MIP for potential conflicts minimization by speed regulations

David Rey, INRETS, Bron, France, david.rey@inrets.fr, *Christophe Rapine*, *Rémy Fondacci*, *Sophie Constans*

We address the speed regulation problem in air traffic management. Increasing the airspace capacity has become a priority in order to deal with future air traffic demand. We investigate automatic speed modulations for en-route flights. Focusing on aircraft crossing times at intersection points to ensure separation, speed regulation is turned into travel time control. We propose a mixed integer linear model to minimize potential conflicts, i.e. when two or more aircraft are below the separation norm. The promising results pave the way for reducing the air traffic controllers' workload.

■ WE-37

Wednesday, 15:40-17:00

3.1.09

Robustness concerns and multiple criteria decision aid

Stream: MCDA I: New Approaches and Applications

Invited session

Chair: *André Rossi*, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr

1 - On Designing a Robust Electricity Distribution Network

André Rossi, Lab-STICC - UMR 3192, Université de Bretagne-Sud, Centre de Recherche, BP 92116, 56321, Lorient, France, andre.rossi@univ-ubs.fr, *Alexis Aubry*, *Mireille Jacomino*

Power distribution networks are seriously challenged as the gap between production and demand is rapidly decreasing over years. The consequences of demand locally exceeding electricity supply are very likely to have a global impact as most of the networks are now interconnected together. To prevent a blackout to happen, distribution networks must be endowed with robustness features so as to ensure a balanced power distribution despite demand variations. This is achieved by maximizing the minimum supply margin over power suppliers. A cutting plane algorithm is proposed to address this problem.

2 - A robustness indicator in blending problems

Jorge Aguilera, LGI2P, EMA, Site EERIE, Parc Scientifique G. Besse, 30035, Nimes, France, jorge.a.aguilera.c@gmail.com, *Stefan Janaqi*, *Mérian Chébre*

In this paper we explore the Blending Problem feasibility with uncertain data from a geometric point of view. The BP feasibility can be naturally defined as a non empty intersection F of two polytopes: the possible blend's polytope and the target polytope. We define two robustness indicators on the feasibility of a blend based on its depth in F and on an approximation of F 's width. Finally, we explain how to produce a blend with a given depth in F . From a practitioner's point of view, these measures have to be computed efficiently, so linear models are used.

3 - Robust Ordinal Regression of Value Functions Handling Interacting Criteria

Salvatore Greco, Department of Economics and Quantitative Methods, University of Catania, Corso Italia 55, 95129, Catania, Italy, salgrec@unict.it, *Vincent Mousseau*, *Roman Slowinski*

Multiple attribute additive utility does not permit to represent interactions between the considered criteria and for this non-additive integrals, such as Choquet integral and Sugeno integral, have been proposed. The non-additive integrals, however, need that the evaluations on all criteria are expressed on the same scale. In the context of the Robust Ordinal Regression, we propose an aggregation model, called UTAGMS—INT, which modifies the usual additive value model so as to handle interactions between criteria without the necessity of expressing all the evaluations on the same scale.

4 - On the multi-agent job shop scheduling problem

Cyril Briand, LAAS - CNRS, 7, Av. Colonel ROCHE, 31077, Toulouse Cedex 4, France, briand@laas.fr, *Thomas Lehaux*

We focus on job shop scheduling problems wherein each machine is associated with an agent having its own decisional autonomy. An agent only knows the set of tasks it has to deal with, as well as the set of completion time intervals associated with the preceding tasks. The objective is to determine a global schedule satisfying both the agent's objectives and some global (social) objectives collectively shared by the agents. The problem is modeled in such a way that the agent's self organization is relatively robust to the uncertainties arising from the other agents.

■ WE-38

Wednesday, 15:40-17:00

6.2.44

Issues in Inventory Management Applications II

Stream: Inventory Management [c]

Contributed session

Chair: *Kelvin T Chirenje*, Applied Maths, National University of Science and Technology, 10 Rukumbati Rd, Zengeza 3, +263, Chitungwiza, Harare, Zimbabwe, kchirenje@gmail.com

1 - A Study of the Inventory Models for Perishable Products in Aerospace Industry

Ying-Chyi Chou, Department of Business Administration, Tunghai University, 181 Taichung-kang Rd., Sec. 3, Taichung, Taiwan, R.O.C., 407, Taichung, Taiwan, rosechyi@yahoo.com.tw, *Hsiao-Wen Chu*

The research takes Aerospace Industrial Development Corporation (AIDC) as an example to calculate and verify the models, and look for the minimum expected average cost per unit for each situation. Our study is based on industry's characteristics and products' attributes to develop four models. The objectives of these models are to get optimal order quantity and reorder point by calculating the minimum expected average cost per unit time. We provide a suggestion for confronting these situations for managers not only in aerospace industry but also any company related to perishable items.

2 - Improving the Service Level in Grocery Stores: Are You the Right Candidate for Item-Level RFID Tagging

Esma Nur Cinicioglu, School of Business, Quantitative Methods Department, Istanbul University, Istanbul Universitesi, Isletme Fakultesi, Sayisal Yontemler Anabilim Dalı, 34320, Istanbul, Turkey, esmanurc@istanbul.edu.tr

In this research to evaluate the suitability of RFID implementation in a grocery store we developed a factor called beta which is defined as the rate of the unresponded demand compared to the error source. Three different scenarios of a grocery store model is simulated which illustrate the stepwise implementation of the RFID technology. The results indicate that a grocery store with beta values close to 1 is an ideal candidate for RFID implementation. With beta values going down to 0 the service level improvement that is achieved is decreasing.

■ WE-39

Wednesday, 15:40-17:00

6.2.45

Scheduling and lot sizing under uncertainties II

Stream: Scheduling under Resource Constraints

Invited session

Chair: *Mikhail Kovalyov*, Belarus Academy of Sciences, Belarus, koval@newman.bas-net.by

Chair: *Alexandre Dolgui*, IE & Computer Science, Ecole des Mines de Saint Etienne, 158, cours Fauriel, 42023, Saint Etienne, France, dolgui@emse.fr

1 - Dynamic lot sizing problem with stochastic production rates and demands

El-Houssaine Aghezzaf, Industrial Management, Ghent University, Technologiepark 903 -, Campus Ardoyen, 9052, Zwijnaarde, Belgium, ElHoussaine.Aghezzaf@UGent.be

We consider the dynamic lot-sizing problem in which production rates as well as demands are subject to uncertainty. We assume that these production rates can be influenced through preventively acting on the production system. We investigate equivalent deterministic models as well as appropriate solution approaches for the problem when multi-items are produced on a production system having a specific configuration.

2 - Two-supplier inventory systems with resource constraints

Ekaterina Bulinskaya, Dept. Mathematics and Mechanics, Moscow State University, Leninskie gory 1, 119991, Moscow, Russian Federation, ebulinsk@mech.math.msu.su, *Larisa Afanasyeva*, *Elena Yarovaya*

We consider a discrete-time inventory model with periodic ordering. Demand is described by a sequence of iid rv's with a known (or unknown) distribution. There are two suppliers. The first one delivers an order immediately, the second one has a lag. The aim is to minimize n-period expected costs. In contrast with previous papers there are orders size constraints. Optimal policy is proved to be determined by critical levels satisfying Bellman equations. Model stability is established. The research is supported by RFBR grant 10-01-00266.

3 - Selecting Capacity at the Outset and Price after Uncertainty has been Realized

Yigal Gerchak, Dept of Industrial Engineering, Tel-Aviv University, 69978, Tel-Aviv, Israel, ygerchak@eng.tau.ac.il

The standard lot sizing/pricing model has both selected at the outset (before demand curve has become known). We delay the pricing decision to after demand curve becomes known, which is relevant to industries where pricing need no be committed early. We deal with both the Linear-Additive and iso-elastic-multiplicative model. Coordination issues are also discussed.

■ WE-40

Wednesday, 15:40-17:00

6.2.52

Recent Advances in Industrial and Engineering Optimization II

Stream: Engineering Optimization

Invited session

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Stream Mapping Value (MVS) in a Manufacturer of Gearboxes: Procedure Facilitator to Deployment of Lean Production System.

Nivaldo Coppini, Industrial Engineering Post Graduation Program, UNINOVE-Nove de Julho University, Av. Francisco Matarazzo, 612, 05001-100, São Paulo, São Paulo, Brazil, ncoppini@uninove.br, *Luiz Bekesas*, *Milton Vieira Júnior*

A powerful tool for production optimization is the Mapping Value Stream. It makes it possible to identify steps covered by a group of products. This allows planning and changes introducing benefits in productivity and costs: displaying cases for product, identifying waste, directing the information to introduce techniques of lean production, identifying the path to MVS prior to practical application on the basis of performance indicators. We deal with the steps of MVS for a gearboxes manufacturer to make profit or to go towards deciding about a Lean Production System.

2 - Bi-Objective Assembly Line Balancing with Flexible Machines

S.m.t. Fatemi Ghomi, Industrial Engineering, Amirkabir University of Technology, Hafez avenue, Tehran, Tehran, Iran, Islamic Republic Of, fatemi@aut.ac.ir, *U. Bahalke*, *M. Karimi-Nasab*

In most real assembly lines, minimizing the cycle time and the total costs are important issues. But every manager should pay attention to total costs. A new assembly line balancing problem is considered based on 11 assumptions. The problem is formulated by a mixed integer model. For special characteristics, a new simple heuristic method is proposed for obtaining the most of the global Pareto-optimal solutions. At each iteration a floating objective bound is added. Computational experiences illustrate the efficiency and efficacy of the method in comparison with previous solution approaches.

■ WE-41

Wednesday, 15:40-17:00

3.1.06

Financial Mathematics and Simulation

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: *Henry Schellhorn*, mathematics, Claremont Graduate University, 710 N. College Ave, 91711, Claremont, CA, United States, Henry.Schellhorn@cgu.edu

1 - Bayesian and Bootstrapped Maximum Likelihood Estimation Approaches for ARCH and AR-ARCH Models of Brazilian Financial Time Series: A Performance Comparison

Sandra Cristina Oliveira, Business Administration, UNESP - Univ. Estadual Paulista, Av. Domingos da Costa Lopes, 780, 17602-496, Tupã, São Paulo, Brazil, sandra@tupa.unesp.br, *Marinho Gomes Andrade*

This work is concerned with the parameter estimation for autoregressive conditional heteroscedasticity models as well as for autoregressive models with ARCH errors. The estimates are computed by using both Maximum Likelihood and Bayesian approaches. For the ML case reliable confidence intervals are computed via the Bootstrap Resampling Method, while for the Bayesian case we introduce a novel reparametrization strategy to the parameters. The proposed methodology is evaluated by considering two Brazilian financial time series.

2 - Sensitivity Analysis in the Binomial Lattice Approach for Real Options

Babak Jafarizadeh, Dept of Petroleum Engineering, University of Stavanger, Norway, babak.jafarizadeh@uis.no

Binomial lattice methods are an intuitive way of modeling real options and can provide great decision insights. In this approach, the underlying Marketed Asset Disclaimer assumption provides an easy way of consolidating all sources of uncertainty into a single stochastic process used for evaluating the options. It is hard to trace back the effect of each source of uncertainty on option value once the optimal decisions are identified. We explore ways to run sensitivity analysis within this evaluation framework using off-the-shelf spreadsheet and simulation programs.

3 - Studying Value at Risk (VaR) Models in forecasting the Emerging market indices volatilities

Milad Nozari, Graduate school of management and economics (GSME), Sharif University of Technology, Tehran, Iran, Islamic Republic Of, milad_nozari@yahoo.com, *Pedram Jahangiry*, *Sepideh Mohamad Raei Naeni*, *Mohsen Bahramgiri*

We aim to compare Value at Risk models on emerging market indices using parametric and semi-parametric approaches and figure out the one which predict market risk in its best way. Among many parametric models, GARCH was used and enriched through applying Extreme Value Theory. Filtered Historical Simulation was selected among semi-parametric models. Complicated calculations and negligible nuances of our results wipe out the preference of using parametric models to semi-parametric ones.

■ WE-42

Wednesday, 15:40-17:00

3.1.07

Graph Guarding

Stream: Graph Searching and Guarding

Invited session

Chair: *Anthony Bonato*, Mathematics, Ryerson University, 350 Victoria St, M5B2K3, Toronto, ON, Canada, abonato@ryerson.ca

1 - Meyniel's Conjecture

Anthony Bonato, Mathematics, Ryerson University, 250 Victoria St, M6R1T5, Toronto, Ontario, Canada, abonato@ryerson.ca

The game of Cops and Robbers and the cop number of a graph are topics of increasing interest in graph theory and computer science. The minimum number of cops needed to capture the robber is the cop number of a graph G , and is written $c(G)$. Relatively few bounds are known on the cop number. Meyniel's conjecture—which is possibly the deepest problem surrounding the cop number—states that for a connected graph G with n vertices, $c(G) = \sqrt{n}$. We give an introduction to Cops and Robbers, the cop number, and describe some recent approaches to settling the conjecture.

2 - Guarding grids and related graph problems

Pawel Zylinski, Institute of Informatics, University of Gdansk, Wita Stwosza 57, 80-952, Gdansk, Poland, zylinski@inf.ug.edu.pl

The problem of guarding grids was formulated by Ntafos in 1986. A grid P is a connected union of vertical and horizontal line segments, and a point x in P can see a point y in P if the line segment xy is a subset of P . A set of points S , being a subset of P , is a guard set for grid P if any point of P is seen by at least one guard in S . We shall present several variants of the problem, including co-operative guards, fault-tolerant guards, mobile guards, and the pursuit evasion problem, and discuss their relation to the well-known graph theory problems, i.e., matching, coloring, domination.

3 - Graphs with average degree smaller than 30/11 are burning slowly

Pawel Pralat, Department of Mathematics, West Virginia University, 26505, Morgantown, WV, United States, pralat@math.wvu.edu

Suppose that a fire breaks out at a given vertex v of G . In each subsequent time unit, a firefighter protects one vertex which is not yet on fire, and then the fire spreads to all unprotected neighbours of the vertices on fire. The objective of the firefighter is to save as many vertices as possible.

The surviving rate $\rho(G)$ of G is defined as the expected percentage of vertices that can be saved when a fire breaks out at a random vertex of G . Let $\epsilon > 0$. We show that graphs with average degree smaller than 30/11 are burning slowly (the constant 30/11 cannot be improved).

4 - Modeling Firefighting with Graphs

Stephen Finbow, St Francis Xavier University, Canada, sfinbow@stfx.ca

Let G be a connected graph with at least two vertices. Suppose that a fire breaks out at a vertex v of G and a firefighter then protects a vertex not yet on fire. Afterwards, the fire spreads to all its unprotected neighbours in each time interval. The fire and firefighter take turns until the fire can no longer spread. This is the basic model of the spread of a fire on a graph.

We will discuss a variety of results, including computational complexity, optimal strategies on grid graphs and the surviving rate for various classes of graphs.

■ WE-43

Wednesday, 15:40-17:00

8.2.02

Research Aspects Related to Life - Risk and Insurance

Stream: Life Insurance, Risk Management & OR

Invited session

Chair: *Irini Dimitriyadis*, Mathematics and Computer Sciences, Bahcesehir University, Bahcesehir Univ. Dept of Mathematics, and Computer Sciences, 34353, Istanbul, Besiktas, dimitri@bahcesehir.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

1 - Interactive Selection on Multidimensional Interval Data

Kurt Nielsen, Institute of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25 building C, 1958,

Frederiksberg C., Denmark, kun@life.ku.dk, *Jens Leth Hougaard*

We present an outranking procedure that supports selection of alternatives represented by multiple attributes with interval valued data. The procedure is interactive in the sense that the decision maker direct the search for preferred alternatives by providing weights of the different attributes as well as parameters related to risk attitude and weighted dominance. The outranking relation builds on comparisons between optimistic and pessimistic weighted values as well as weighted dominance relations supported by volume based measures.

2 - Cumulative Prospect Theory for the interval of reference points

Renata Dudzinska-Baryla, Operations Research, University of Economics in Katowice, ul. 1 Maja 50, 40-287, Katowice, Poland, dudzinska@ae.katowice.pl, *Donata Kopanska-Brodka*

The behavior of individuals choosing among risky alternatives is described by the Cumulative Prospect Theory. The basic assumption of this theory is that decision maker understands outcomes as gains and losses relative to the reference point. That is why the valuations of risky alternatives most of all depend on this point. In our approach we state that the individuals attitude towards risk in the sense of the EUT is the essential cause which outcomes are considered as gains or losses. We analyze some properties of the valuation of prospects when the interval of reference points changes.

3 - Knowledge discovery vs. domain knowledge: the case of wrong signs

Reza Shahi, School of Management, University of Southampton, Highfield, SO17 1BJ, Southampton, United Kingdom, mrams@soton.ac.uk

Robustness and comprehensibility are two sides of the same coin in model development. Being able to incorporate domain knowledge is one of success elements for any data mining application. The conformity of the sign of model coefficients with the domain knowledge is one aspect of this incorporation; applying data mining techniques without investigating the rational between variables might be misleading even if the technique is robust. This paper studies wrong sign problem in corporate default prediction models and tries to find reasons and solutions.

■ WE-44

Wednesday, 15:40-17:00
8.2.03

Systems and Mathematical Modelling in OR III

Stream: Dynamical Systems and Mathematical Modelling in OR

Invited session

Chair: *Selma Belen*, Mathematics and Computer, CAG University, Adana-Mersin Karayolu Uzeri, Yenice-Tarsus, 33800, TARSUS / Mersin, Turkey, selmabelen@cag.edu.tr

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

Chair: *Erik Kropat*, Department of Computer Science, Universität der Bundeswehr München, Werner-Heisenberg-Weg 39, 85577, Neubiberg, Germany, erik.kropat@unibw.de

1 - Using Absorbing Markov Chain to Evaluate the Slot Customer Experiences

Xiaoming Liu, FBA, University of Macau, University of Macau, Macau, NA, MACAU, China, xmliu@umac.mo, *Zhaotong Lian*

This study derives the conditional sojourn times of a special Absorbing Markov Chain which models the dynamic of slot machines, and uses the theoretical results to obtain the formula for important slot customer experiences: hit frequency, the customer losing probability, the mean and standard deviation of time-on-device per customer, time-on-device per losing customer etc. The results allow slot managers and designers to evaluate the effects of payout table to customer experiences and then help to design the slot machine that gives the best trade-off of customer experience and casino gain.

2 - The analysis of capital stock dynamics by the optimal transformation

Jan Kodera, Center for Basic Research in Dynamic Economics and Econometrics, University of Economics Prague, nam. Winstona Churchilla 4, 130 67, Praha 3, Czech Republic, kodera@vse.cz, *Quang Van Tran*, *Miloslav Vosvrda*

Firstly, we introduce a modified Kalecki model with a time delayed investment function which takes into account the diminishing marginal efficiency of capital and its installation costs. The model is a difference-differential equation. Secondly, we analyze the data generated by the model using the method of optimal transformation in order to reconstruct the original structure. This approach helps us to determine the effectiveness of this method and we find that the optimal transformation seems to be a suitable tool. Then we analyze the empirical data from the time series of capital stock.

■ WE-46

Wednesday, 15:40-17:00
8.2.14

AIMMS User Meeting

Stream: AIMMS User Meeting [c]

Contributed session

Chair: *Frans de Rooij*, AIMMS, Paragon Decision Technology B.V., Schipholweg 1, 2034 LS, Haarlem, Netherlands, frans.de.rooij@aimms.com

1 - AIMMS User Meeting

Frans de Rooij, AIMMS, Paragon Decision Technology B.V., Schipholweg 1, 2034 LS, Haarlem, Netherlands, frans.de.rooij@aimms.com, *Ovidiu Listes*, *Gertjan de Lange*

We invite all current and prospective users of the AIMMS mathematical modeling system to participate in this AIMMS User Meeting at the EURO conference. Please come along to hear about the newest AIMMS features and development plans, for example in Robust Optimization and in Server-Based deployment of optimization applications. Of course, there will also be time to meet other AIMMS Users and to share your experience and feedback.

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): 14
3 sessions

Agent-Based Modeling

Invited

Massimo Genoese
University of Karlsruhe
massimo.genoese@kit.edu

Track(s): 46
2 sessions

Agent-Based Modeling [c]

Contributed

Massimo Genoese
University of Karlsruhe
massimo.genoese@kit.edu

Track(s): 46
1 session

AIMMS User Meeting [c]

Contributed

Frans de Rooij
Aimms
frans.de.rooij@aimms.com

Track(s): 46
1 session

Algorithmic Decision Theory

Invited

Alexis Tsoukiàs
Cnrs - Lamsade
tsoukias@lamsade.dauphine.fr

Ulrich Junker
ILOG, An IBM Company
uli.junker@free.fr

Track(s): 43
2 sessions

Algorithmic Decision Theory [c]

Contributed

Alexis Tsoukiàs
Cnrs - Lamsade
tsoukias@lamsade.dauphine.fr

Ulrich Junker
ILOG, An IBM Company
uli.junker@free.fr

Track(s): 43
2 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

Track(s): 12
14 sessions

Applications in Business Intelligence and Knowledge discovery

Invited

Richard Weber
University of Chile
rweber@dii.uchile.cl

Track(s): 18
2 sessions

Boolean Programming

Invited

Endre Boros
Rutgers University
Endre.Boros@rutcor.rutgers.edu

Track(s): 29
7 sessions

Combinatorial Optimization

Invited

Paolo Toth
University of Bologna
paolo.toth@unibo.it

Track(s): 2
8 sessions

Combinatorial Optimization [c]

Contributed

Paolo Toth
University of Bologna
paolo.toth@unibo.it

Track(s): 2
1 session

Computational Biology, Bioinformatics and Medicine

Invited

Jacek Blazewicz
Politechnika Poznanska
jblazewicz@cs.put.poznan.pl

Metin Turkyay
Koc University
mturkay@ku.edu.tr

Giovanni Felici
Cnr
giovanni.felici@iasi.cnr.it

Track(s): 24
9 sessions

Computational Statistics

Invited

Pakize Taylan
Dicle University
ptaylan@dicle.edu.tr

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Track(s): 17
4 sessions

Container Terminal Operations

Invited

Ceyda Oguz
Koc University
coguz@ku.edu.tr

Track(s): 40
3 sessions

Convex Optimization

Invited

Attila Gilanyi
University of Debrecen
gilanyi@math.klte.hu

Michel Baes
Eth
michel.baes@ifor.math.ethz.ch

Track(s): 34
6 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): 26
9 sessions

Cooperative Game Theory [c]*Contributed*

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): 26
1 session

Cutting and Packing*Invited*

Jose Fernando Oliveira
Universidade do Porto
jfo@fe.up.pt

A. Miguel Gomes
University of Porto
agomes@fe.up.pt

Track(s): 20
9 sessions

Data Mining and Applications [c]*Contributed*

Vadim Strijov
Computing Center of the Russian
Academy of Sciences
strijov@ccas.ru

Track(s): 42
2 sessions

Data Mining and Decision Making*Invited*

Lai-Soon Lee
UPM Serdang
lslee@math.upm.edu.my

Hsin-Vonn Seow
University of Nottingham- Malaysia
Campus
Hsin-Vonn.Seow@nottingham.edu.my

Track(s): 20
2 sessions

Data Mining in Early Warning Systems*Invited*

Gulser Koksall
Middle East Technical University
koksall@ie.metu.edu.tr

Inci Batmaz
Middle East Technical University
ibatmaz@metu.edu.tr

Track(s): 47
2 sessions

Data Mining in the Financial Sector*Invited*

Vadim Strijov
Computing Center of the Russian
Academy of Sciences
strijov@ccas.ru

Track(s): 23
4 sessions

DEA and Performance Measurement*Invited*

Dimitris Despotis
University of Piraeus
despotis@unipi.gr

Ozren Despic
Aston University
o.despic@aston.ac.uk

Meryem Duygun Fethi
University of Leicester
m.fethi@le.ac.uk

Ana Camanho
Universidade do Porto
acamanho@fe.up.pt

Vania Sena
Aston University
v.sena@aston.ac.uk

Track(s): 6 7
19 sessions

Decision Making*Contributed*

Track(s): 42
4 sessions

Decision Support Systems*Invited*

Pascale Zaraté
Toulouse University
zarate@irit.fr

Fatima Dargam
SimTech Simulation Technology
F.Dargam@SimTechnology.com

Track(s): 37
2 sessions

Demand and Supply in Consumer Goods and Retailing*Invited*

Heinrich Kuhn
Catholic University of
Eichstaett-Ingolstadt
heinrich.kuhn@ku-eichstaett.de

Winfried Steiner
Clausthal University of Technology,
Institute of Management and
Economics
winfried.steiner@tu-clausthal.de

Rob Broekmeulen
TU Eindhoven
r.a.c.m.broekmeulen@tue.nl

Track(s): 45
2 sessions

Demand, Pricing and Revenue Management*Invited*

Alf Kimms
University of Duisburg-Essen
alf.kimms@uni-due.de

Robert Klein
Universität Augsburg
robert.klein@wiwi.uni-augsburg.de

Track(s): 43
3 sessions

Discrete and Global Optimization*Invited*

Xiaoling Sun
Fudan University
xls@fudan.edu.cn

Track(s): 20
1 session

Discrete Optimal Control*Invited*

Dmitrii Lozovanu
Academy of Sciences of Moldova
lozovanu@math.md

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Track(s): 47
2 sessions

Dynamic Programming*Invited*

Lidija Zadnik Stirn
University of Ljubljana
lidija.zadnik@bf.uni-lj.si

Moshe Sniedovich
University of Melbourne
m.sniedovich@ms.unimelb.edu.au

Track(s): 45
2 sessions

Dynamical Systems and Game Theory*Invited*

Alberto A. Pinto
University of Minho
aapinto1@gmail.com

Track(s): 19
9 sessions

Dynamical Systems and Mathematical Modelling in OR*Invited*

Selma Belen
CAG University
selmabelen@cag.edu.tr

Track(s): 44
3 sessions

Education, and Social Policy*Invited*

Hanife Akar
Middle East Technical University
hanif@metu.edu.tr

Track(s): 21
2 sessions

Ejor*Invited*

Roman Slowinski
Poznan University of Technology
roman.slowinski@cs.put.poznan.pl

Track(s): 5
1 session

Emerging Applications of OR*Invited*

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Erwin Pesch
University of Siegen
pesch@fb5.uni-siegen.de

Track(s): 10 11
15 sessions

Energy, Environment and Climate*Invited*

Hans-Jakob Lüthi
Ethz
luethi@ifor.math.ethz.ch

Wolf Fichtner
Kit
wolf.fichtner@wiwi.uni-karlsruhe.de

Track(s): 33
7 sessions

Energy, Environment and Climate [c]*Contributed*

Hans-Jakob Lüthi
Ethz
luethi@ifor.math.ethz.ch

Wolf Fichtner
Kit
wolf.fichtner@wiwi.uni-karlsruhe.de

Track(s): 33
7 sessions

Engineering Optimization*Invited*

Moritz Diehl
K. U. Leuven
moritz.diehl@esat.kuleuven.be

Volker Schulz
University of Trier
Volker.Schulz@uni-trier.de

Track(s): 40
4 sessions

EURO Doctoral Dissertation Award*Invited*

Mikael Rönnqvist
Department of Finance and
Management Science
mikael.ronnqvist@nhh.no

Track(s): 5
1 session

EURO Excellence in Practice Award 2010*Invited*

M. Grazia Speranza
University of Brescia
speranza@eco.unibs.it

Track(s): 5
2 sessions

EURO Management Science Strategic Innovation Prize (MSSIP 2010) on the topic of Optimization in Telecommunications*Invited*

Eric Gourdin
Orange Labs
eric.gourdin@orange-ftgroup.com

Track(s): 2
1 session

Experimental Economics and Game Theory*Invited*

Ulrike Leopold-Wildburger
Karl-Franzens-University
ulrike.leopold@uni-graz.at

Stefan Pickl
Universität der Bundeswehr München
stefan.pickl@unibw.de

Track(s): 38
4 sessions

Facilitated Modelling in OR*Invited*

L. Alberto Franco
University of Warwick
alberto.franco@warwick.ac.uk

Gilberto Montibeller
London School of Economics
g.montibeller@lse.ac.uk

Track(s): 35
5 sessions

Facility Logistics*Invited*

René de Koster
Erasmus University Rotterdam
rkoster@rsm.nl

Track(s): 45
2 sessions

Financial Mathematics and OR*Invited*

Mustafa Pinar
Bilkent University
mustafap@bilkent.edu.tr

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Track(s): 25
9 sessions

Financial Modeling*Invited*

Georg Pflug
University of Vienna
georg.pflug@univie.ac.at

Rita D'Ecclesia
Università di Roma
rita.decclesia@uniroma1.it

Ronald Hochreiter
WU Vienna University of Economics
and Business
ronald.hochreiter@wu.ac.at

Track(s): 29
6 sessions

Financial Optimization*Invited*

Gautam Mitra
Brunel University
gautam.mitra@brunel.ac.uk

J. E. Beasley
Brunel University
john.beasley@brunel.ac.uk

Track(s): 27
4 sessions

Fuzzy Systems, Neural Networks & Artificial Intelligence*Invited*

Heinrich Rommelfanger
J. W. Goethe University
rommel@wiwi.uni-frankfurt.de

Rasmus Fonseca
University of Copenhagen
rfonseca@diku.dk

Track(s): 36
6 sessions

Fuzzy Systems, Neural Networks & Artificial Intelligence [c]*Contributed*

Heinrich Rommelfanger
J. W. Goethe University
rommel@wiwi.uni-frankfurt.de

Rasmus Fonseca
University of Copenhagen
rfonseca@diku.dk

Track(s): 36
3 sessions

Geometric Clustering*Invited*

Andreas Brieden
Universität der Bundeswehr München
andreas.brieden@unibw.de

Peter Gritzmann
TU München
gritzman@ma.tum.de

Track(s): 45
1 session

Global Optimization*Invited*

Mirjam Duer
Rijksuniversiteit Groningen
M.E.Dur@rug.nl

Eligius M.T. Hendrix
Universidad de Málaga
eligius.hendrix@wur.nl

Janos D. Pinter
PCS Inc. & Dalhousie University
jdpinter@hfx.eastlink.ca

Track(s): 43
3 sessions

Graph Searching and Guarding*Invited*

Boting Yang
University of Regina
boting@cs.uregina.ca

Track(s): 42
3 sessions

Graphs and Networks*Invited*

Dominique de Werra
Epfl
dominique.dewerra@epfl.ch

Track(s): 10
8 sessions

Health Care Management*Invited*

Marion Rauner
University of Vienna
marion.rauner@univie.ac.at

Stefan Nickel
Universitaet Karlsruhe
Stefan.Nickel@kit.edu

Teresa Melo
University of Applied Sciences
teresa.melo@htw-saarland.de

Sally Brailsford
University of Southampton
s.c.brailsford@soton.ac.uk

Track(s): 22
3 sessions

Health Care Management [c]*Contributed*

Marion Rauner
University of Vienna
marion.rauner@univie.ac.at

Stefan Nickel
Universitaet Karlsruhe
Stefan.Nickel@kit.edu

Teresa Melo
University of Applied Sciences
teresa.melo@htw-saarland.de

Sally Brailsford
University of Southampton
s.c.brailsford@soton.ac.uk

Track(s): 22
3 sessions

IBM Research Applications*Invited*

Eleni Pratsini
IBM Zurich Research Lab
pra@zurich.ibm.com

Track(s): 14
1 session

Ill-posed Variational Problems - Theory, Methods and Applications*Invited*

Xiaoqi Yang
The Hong Kong Polytechnic University
mayangxq@polyu.edu.hk

Track(s): 48
2 sessions

Inventory Management*Invited**Dolores Romero Morales*University of Oxford
dolores.romero-morales@sbs.ox.ac.uk**Track(s): 38****4 sessions****Inventory Management [c]***Contributed**Dolores Romero Morales*University of Oxford
dolores.romero-morales@sbs.ox.ac.uk**Track(s): 38****1 session****Iterative Methods for Economic Models***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): 48****2 sessions****Keynote Speakers***Invited**José Paixão*Faculty of Sciences - University of Lisbon
jpaixao@fc.ul.pt**Track(s): 1 2****14 sessions****Knowledge Discovery and Data Mining***Invited**Julie Greensmith*University of Nottingham
jqg@cs.nott.ac.uk*Luís Cavique*Universidade Aberta
lcavique@univ-ab.pt**Track(s): 20****1 session****Life Insurance, Risk Management & OR***Invited**Angelika May*Carl von Ossietzky Universität
Oldenburg
angelika.may@uni-oldenburg.de*Irina Dimitriyadis*Bahcesehir University
dimitri@bahcesehir.edu.tr**Track(s): 43****2 sessions****Linear and Conic Programming***Invited**François Glineur*Université catholique de Louvain
(UCLouvain)
Francois.Glineur@uclouvain.be*Tibor Illes*University of Strathclyde
tibor.illes@strath.ac.uk**Track(s): 36****2 sessions****Location Analysis***Invited**Stefan Nickel*Universitaet Karlsruhe
Stefan.Nickel@kit.edu*Francisco Saldanha-da-Gama*University of Lisbon
fsgama@fc.ul.pt*Alfredo Marín*University of Murcia
amarin@um.es**Track(s): 5 13****16 sessions****Long Term Financial Decisions***Invited**Thomas Burkhardt*Universitaet Koblenz-Landau
tburkha@uni-koblenz.de**Track(s): 41****3 sessions****Long Term Planning in Energy, Environment and Climate***Invited**Nadia Maïzi*MINES ParisTech
nadia.maizi@mines-paristech.fr**Track(s): 32 37****4 sessions****Lot-sizing and Scheduling, Economic Order Quantity***Invited**Anders Segerstedt*Luleå University of Technology
anders.segerstedt@ltu.se*Christian Almeder*Vienna University of Economics and
Business
christian.almeder@wu.ac.at*Bernardo Almada-Lobo*Faculty of Engineering of Porto
University
almada.lobo@fe.up.pt**Track(s): 34****7 sessions****Machine Learning and Its Applications***Invited**Sureyya Ozogur-Akyuz*Bahcesehir University
sureyya.akyuz@bahcesehir.edu.tr*Zakria Hussain*Unvertsity College London
Z.Hussain@cs.ucl.ac.uk**Track(s): 26****5 sessions****Maritime Logistics***Invited**Marielle Christiansen*Norwegian University of Science and
Technology
Marielle.Christiansen@iot.ntnu.no**Track(s): 22****4 sessions****Mathematical Programming***Invited**Sandor Zoltan Nemeth*The University of Birmingham
nemeths@for.mat.bham.ac.uk*Armin Fügenschuh*Zuse Institut Berlin
fuegenschuh@zib.de*Gerhard-Wilhelm Weber*Middle East Technical University
gweber@metu.edu.tr*Tamas Terlaky*Lehigh University
terlaky@lehigh.edu**Track(s): 9****14 sessions**

Mathematical Programming [c]*Contributed*

Gerhard-Wilhelm Weber
Middle East Technical University
gweber@metu.edu.tr

Armin Fügenschuh
Zuse Institut Berlin
fuegenschuh@zib.de

Sandor Zoltan Nemeth
The University of Birmingham
nemeths@for.mat.bham.ac.uk

Tamas Terlaky
Lehigh University
terlaky@lehigh.edu

Track(s): 7
3 sessions

MCDA I: New Approaches and Applications*Invited*

Salvatore Greco
University of Catania
salgreco@unict.it

Bernard Roy
Université Paris-Dauphine
roy@lamsade.dauphine.fr

Track(s): 37
6 sessions

MCDA II: Axiomatic Basis, Meaningfulness, and other Issues*Invited*

José Rui Figueira
Technical University of Lisbon
figueira@ist.utl.pt

Denis Bouyssou
Cnrs-lamsade
bouyssou@lamsade.dauphine.fr

Track(s): 30
8 sessions

MCDA II: Axiomatic Basis, Meaningfulness, and other Issues [c]*Contributed*

José Rui Figueira
Technical University of Lisbon
figueira@ist.utl.pt

Denis Bouyssou
Cnrs-lamsade
bouyssou@lamsade.dauphine.fr

Track(s): 30
3 sessions

Metaheuristics*Invited*

Marc Sevaux
Université de Bretagne Sud - UEB
marc.sevaux@univ-ubs.fr

Kenneth Sörensen
Universiteit Antwerpen
kenneth.sorensen@ua.ac.be

Andreas Reinholz
University Dortmund
andreas.reinholz@gmx.de

Track(s): 3 4 5
33 sessions

Methodology of Societal Complexity*Invited*

Dorien DeTombe
Chair Euro Working Group
detombe@nosmo.nl

Track(s): 31
4 sessions

Mixed-Integer Non Linear Programming*Invited*

Andrea Lodi
University of Bologna
andrea.lodi@unibo.it

Leo Liberti
Ecole Polytechnique
leoliberti@gmail.com

Track(s): 35
6 sessions

Multi-Objective Optimization*Invited*

José Rui Figueira
Technical University of Lisbon
figueira@ist.utl.pt

Jacques Teghem
Faculté Polytechnique de Mons
jacques.teghem@fpms.ac.be

Kathrin Klamroth
University of Wuppertal
klamroth@math.uni-wuppertal.de

Track(s): 23
10 sessions

Network Optimization*Invited*

Bernard Fortz
Université Libre de Bruxelles
bfortz@euro-online.org

Luis Gouveia
University of Lisbon
legouveia@fc.ul.pt

Track(s): 40
4 sessions

Network Optimization [c]*Contributed*

Bernard Fortz
Université Libre de Bruxelles
bfortz@euro-online.org

Luis Gouveia
University of Lisbon
legouveia@fc.ul.pt

Track(s): 40
2 sessions

Nonconvex Programming: Local and Global Approaches*Invited*

Tao Pham Dinh
INSA Rouen
pham@insa-rouen.fr

Hoai An Le Thi
University Paul Verlaine - Metz
lethi@univ-metz.fr

Track(s): 45
3 sessions

Nonlinear Programming*Invited*

Edite M.G.P. Fernandes
University of Minho
emgpf@dps.uminho.pt

Track(s): 48
3 sessions

Nonlinear Programming [c]*Contributed*

Edite M.G.P. Fernandes
University of Minho
emgpf@dps.uminho.pt

Track(s): 48
2 sessions

Nonsmooth Optimization*Invited**Adil Bagirov*University of Ballarat
a.bagirov@ballarat.edu.au*Albert Ferrer*Technological University of Catalonia
alberto.ferrer@upc.edu*Antonio Fuduli*Universita' della Calabria
antonio.fuduli@unical.it**Track(s): 19****4 sessions****Numerical Methods in Finance***Invited**Ömür Ugur*Middle East Technical University
ougur@metu.edu.tr*Susanne Kruse*Hochschule der
Sparkassen-Finanzgruppe
susanne.kruse@dsgv.de**Track(s): 46****2 sessions****Operational Research and
Quantitative Models in Banking***Invited**Constantin Zopounidis*Technical University of Crete
kostas@dpem.tuc.gr**Track(s): 30****4 sessions****Optimal Control***Invited**Erik Kropat*Universität der Bundeswehr München
erik.kropat@unibw.de*Gustav Feichtinger*Vienna University of Technology
gustav@eos.tuwien.ac.at*Gerhard-Wilhelm Weber*Middle East Technical University
gweber@metu.edu.tr*Ursula Felgenhauer*Brandenburg University of Technology
Cottbus (Germany)
felgenh@tu-cottbus.de*Vladimir Veliov*Vienna University of technology
veliov@tuwien.ac.at*Sabine Pickenhain*BTU Cottbus
sabine.pickenhain@tu-cottbus.de**Track(s): 39****9 sessions****Optimization and Data Mining***Invited**Emilio Carrizosa*Universidad de Sevilla
ecarrizosa@us.es*Theodore Trafalis*University of Oklahoma
ttrafal@ou.edu*Renato De Leone*Università di Camerino
renato.deleone@unicam.it**Track(s): 42****2 sessions****Optimization for Sustainable
Development***Invited**Nora Touati Moun gla*LIX, Ecole Polytechnique
touati@lix.polytechnique.fr*Vincent Jost*CNRS - Ecole Polytechnique
vjost@lix.polytechnique.fr**Track(s): 48****2 sessions****OR and Ethics***Invited**Fred Wenstøp*BI Norwegian School of Management
fred.wenstop@bi.no**Track(s): 31****2 sessions****OR and Real Implementations***Invited**Hans-Jürgen Zimmermann*Inform
zi@or.rwth-aachen.de*Istvan Maros*Imperial College London
i.maros@imperial.ac.uk**Track(s): 36****4 sessions****OR Applications in Industry***Invited**Jens Wollenweber*Fraunhofer SCS
jens.wollenweber@scs.fraunhofer.de*Geir Hasle*Sintef Ict
Geir.Hasle@sintef.no**Track(s): 31****6 sessions****OR for Development and
Developing Countries***Invited**Gerhard-Wilhelm Weber*Middle East Technical University
gweber@metu.edu.tr*Honora Smith*University of Southampton
honora.smith@soton.ac.uk*Leroy White*University of Bristol
leroy.white@bris.ac.uk*Hans W. Ittmann*CSIR Built Environment
hittmann@csir.co.za**Track(s): 37****5 sessions****OR for Madeira (and related
challenges)***Invited**Gerhard-Wilhelm Weber*Middle East Technical University
gweber@metu.edu.tr**Track(s): 46****3 sessions**

OR for Sustainable Development*Invited*

Leonidas Sakalauskas
Institute of Mathematics&Informatics
sakal@ktl.mii.lt

Edmundas Zavadskas
Vilnius Gediminas Technical University
edmundas.zavadskas@adm.vtu.lt

Tatjana Vilutiene
Vilnius Gediminas Technical
University
tatjana.vilutiene@vgtu.lt

Vida Maliene
School of the Built Environment,
Liverpool John Moores University
v.maliene@ljmu.ac.uk

Track(s): 43
3 sessions

OR in Agriculture and Forest Management*Invited*

Lluís M Pla
University of Lleida
lmpa@matematica.udl.es

Manfred Gronalt
University of Natural Resources and
Applied Life Sciences
Manfred.Gronalt@boku.ac.at

Track(s): 32
8 sessions

OR in Agriculture and Forest Management [c]*Contributed*

Lluís M Pla
University of Lleida
lmpa@matematica.udl.es

Manfred Gronalt
University of Natural Resources and
Applied Life Sciences
Manfred.Gronalt@boku.ac.at

Track(s): 32
3 sessions

OR in Fisheries, Maritime Sciences and Related Aspects*Invited*

Pall Jensson
University of Iceland
pall@hi.is

Track(s): 46
1 session

OR in Military*Invited*

Ana Isabel Barros
TNO - Defense, Security and Safety
ana.barros@tno.nl

Track(s): 45
2 sessions

OR in Oil Sector*Invited*

Irina Dolgoplova
Middle East Technical University
irina.dolgoplova@gmail.com

Track(s): 47
2 sessions

OR in Sports*Invited*

Michael Trick
Carnegie Mellon University
trick@cmu.edu

Sigrid Knust
TU Clausthal
knust@math.tu-clausthal.de

Track(s): 10
2 sessions

OR in Water Management*Invited*

Halil Önder
Middle East Technical University
onde@metu.edu.tr

Track(s): 47
2 sessions

OR/MS: Beyond Mathematics*Invited*

Heiner Müller-Merbach
Universität Kaiserslautern
hmm@bior.de

Track(s): 48
1 session

Portfolio Decision Analysis*Invited*

Ahti Salo
Aalto University School of Science and
Technology
ahti.salo@tkk.fi

Alec Morton
London School of Economics
a.morton@lse.ac.uk

Jeffrey Keisler
University of Massachusetts Boston
jeff.keisler@umb.edu

Track(s): 44
3 sessions

Preference Learning*Invited*

Roman Slowinski
Poznan University of Technology
roman.slowinski@cs.put.poznan.pl

Track(s): 29
1 session

Project Management and Scheduling*Invited*

Erwin Pesch
University of Siegen
erwin.pesch@uni-siegen.de

Track(s): 7 8
19 sessions

Project Management and Scheduling [c]*Contributed*

Erwin Pesch
University of Siegen
erwin.pesch@uni-siegen.de

Track(s): 7
2 sessions

Public Transport*Invited*

Leo Kroon
Erasmus University Rotterdam
lkroon@rsm.nl

Anita Schoebel
Georg-August Universität Göttingen
schoebel@math.uni-goettingen.de

Track(s): 16
11 sessions

Public Transport [c]*Contributed*

Leo Kroon
Erasmus University Rotterdam
lkroon@rsm.nl

Anita Schoebel
Georg-August Universität Göttingen
schoebel@math.uni-goettingen.de

Track(s): 16
2 sessions

Realistic Production Scheduling*Invited*

Ruben Ruiz
Universidad Politecnica de Valencia
rruiz@eio.upv.es

Track(s): 33
1 session

Revenue Management*Invited*

Houyuan Jiang
University of Cambridge
h.jiang@jbs.cam.ac.uk

Ayse Kocabiyikoglu
Bilkent University
aysekoca@bilkent.edu.tr

Track(s): 41
5 sessions

ROADEF/EURO challenge*Invited*

Christian Artigues
Cnrs
artigues@laas.fr

Track(s): 25
6 sessions

Scheduling*Invited*

Vitaly Strusevich
University of Greenwich
sv02@gre.ac.uk

Jean-Charles Billaut
University of Tours
jean-charles.billaut@univ-tours.fr

Track(s): 28
7 sessions

Scheduling under Resource Constraints*Invited*

Jan Weglarz
Politechnika Poznanska
Jan.Weglarz@put.poznan.pl

Joanna Jozefowska
Poznań University of Technology
jjozefowska@cs.put.poznan.pl

Track(s): 39
5 sessions

SD Modeling in Sustainable Development*Invited*

Pierre Kunsch
Vrije Universiteit Brussel
pkunsch@vub.ac.be

Erik Pruyt
Delft University of Technology
E.Pruyt@tudelft.nl

Track(s): 44
3 sessions

Semi-Infinite Optimization*Invited*

Jan-J Ruckmann
University of Birmingham
J.Ruckmann@bham.ac.uk

Oliver Stein
Karlsruhe Institute of Technology
stein@kit.edu

Track(s): 46
2 sessions

Simulation Based Decision Support*Invited*

Mirosljub Kljajic
University of Maribor
miroljub.kljajic@fov.uni-mb.si

Stig C Holmberg
Mid Sweden University
shbg@ieee.org

Track(s): 44
3 sessions

Simulation Methods in Finance*Invited*

Giray Okten
Florida State University
okten@math.fsu.edu

Track(s): 41
2 sessions

Soft OR and Problem Structuring Methods*Invited*

John Mingers
Kent University
j.mingers@kent.ac.uk

Track(s): 35
4 sessions

Software for OR/MS*Invited*

Robert Fourer
Northwestern University
4er@iems.northwestern.edu

Bjarni Kristjansson
Maximal Software, Ltd.
bjarni@maximalsoftware.com

Track(s): 21
13 sessions

Stochastic Modeling and Simulation*Invited*

Erik Kropat
Universität der Bundeswehr München
erik.kropat@unibw.de

Zeev (Vladimir) Volkovich
Ort Braude Academic College
zeev@actcom.co.il

Track(s): 18
13 sessions

Stochastic Models for Service Operations*Invited*

Ger Koole
VU University Amsterdam
koole@few.vu.nl

Track(s): 47
1 session

Stochastic Programming 1*Invited*

Rüdiger Schultz
University of Duisburg-Essen
schultz@math.uni-duisburg.de

Track(s): 28
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Stochastic Programming 2*Invited*

Andras Prekopa
Rutgers University
prekopa@rutcor.rutgers.edu

Tamas Szantai
Budapest University of Technology and Economics
szantai@math.bme.hu

Track(s): 46
2 sessions

Stochastic Programming 2 [c]*Contributed*

Andras Prekopa
Rutgers University
prekopa@rutcor.rutgers.edu

Tamas Szantai
Budapest University of Technology and Economics
szantai@math.bme.hu

Track(s): 46
1 session

Stochastic Valuation for Financial Markets*Invited**Martin Rainer*

ENAMEC Inst.

martin.rainer@enamedec.de

*Gerhard-Wilhelm Weber*Middle East Technical University
gweber@metu.edu.tr**Track(s): 38****4 sessions****Supply Chain Planning***Invited**Moritz Fleischmann*

University of Mannheim

Moritz.Fleischmann@bwl.uni-mannheim.de

Herbert Meyr

Technical University of Darmstadt

Meyr@bwl.tu-darmstadt.de

Track(s): 14**3 sessions****Supply Chain Planning [c]***Contributed**Moritz Fleischmann*

University of Mannheim

Moritz.Fleischmann@bwl.uni-mannheim.de

Herbert Meyr

Technical University of Darmstadt

Meyr@bwl.tu-darmstadt.de

Track(s): 14**6 sessions****Sustainable Living: Cognitive, Social, Economical, Ecological and World View***Invited**Ali Gökmen*Middle East Technical University
agokmen@metu.edu.tr*Inci Gokmen*Middle East Technical University
igokmen@metu.edu.tr*Pedamallu Chandra Sekhar*

Dana-Farber Cancer Institute

pcs.murali@gmail.com

*Gerhard-Wilhelm Weber*Middle East Technical University
gweber@metu.edu.tr**Track(s): 47****1 session****System Dynamics Modeling***Invited**Markus Schwaninger*

Universität St.Gallen

markus.schwaninger@unisg.ch

Stefan Groesser

University of St. Gallen

stefan.groesser@unisg.ch

Track(s): 41**4 sessions****Teaching OR/MS***Invited**Antonia Carravilla*

FEUP / INESC Porto

mac@fe.up.pt

Track(s): 22**4 sessions****Timetabling and Rostering***Invited**Dario Landa-Silva*

University of Nottingham

dario.landasilva@nottingham.ac.uk

Track(s): 24**6 sessions****Transportation and Logistics***Invited**Maurizio Bielli*

Institute of Systems Analysis and Informatics

bielli@iasi.cnr.it

Track(s): 27**7 sessions****Transportation and Logistics [c]***Contributed**Maurizio Bielli*

Institute of Systems Analysis and Informatics

bielli@iasi.cnr.it

Track(s): 27**2 sessions****Transportation Planning***Invited**Herbert Kopfer*

University of Bremen

kopfer@uni-bremen.de

Knut Haase

Technische Universität Dresden

knut.haase@tu-dresden.de

Track(s): 17**11 sessions****Variational Inequalities, Complementarity Problems and Bilevel Programming***Invited**Stephan Dempe*

Technische Universität Freiberg

dempe@math.tu-freiberg.de

Joaquim Judice

University of Coimbra

Joaquim.Judice@co.it.pt

Track(s): 42**4 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): 44**3 sessions****Vehicle Routing***Invited**Jean-François Cordeau*

HEC Montréal

jean-francois.cordeau@hec.ca

Stefan Ropke

Technical University of Denmark

sr@transport.dtu.dk

Track(s): 15**12 sessions****Vehicle Routing [c]***Contributed**Jean-François Cordeau*

HEC Montréal

jean-francois.cordeau@hec.ca

Stefan Ropke

Technical University of Denmark

sr@transport.dtu.dk

Track(s): 15**3 sessions**

**Young People for System Theory,
Optimization and Education***Invited**Alexis Pasichny*

National Technical University of
Ukraine "Kyiv Politechnic Institute"
alexis.pasichny@gmail.com

Kateryna Pereverza

National Technical University of
Ukraine
pereverza.kate@gmail.com

Alexander Makarenko

National Technical University of
Ukraine "KPI"
makalex@i.com.ua

Ielyzaveta Korotchenko

National Technical University of
Ukraine "Kyiv Politechnic Institute"
Korotchenko.liza@gmail.com

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Clasen, Christian	WA-41	Coudert, David	WD-42	Davtalab Olyaie, Mostafa	TF-09
Clausen, Uwe	TB-21	Coutinho-Rodrigues, João	MB-23	Dérian, Nicolas	MB-24
Clautiaux, François	TB-02, MA-20, TB-20	Couto, Francisco	MC-24	Díaz Díaz, José Carlos	WB-25
Clímaco, João	TC-23, TB-31, TB-35	Covas, Miguel	TD-37	Döyen, Alper	TD-13
Clemente, Mónica	MB-38	Cozzini, Alberto	WD-23	De Almeida, David	TC-16
Clewwell, Les	WD-46	Crainic, Teodor Gabriel	MF-03, TA-15, MF-17, TA-17, TB-19	de Armas, Jesica	MF-20
Cobuloglu, Halil	TB-33	Creemers, Stefan	WA-07	De Asmundis, Roberta	MC-24
Cochran, James	TA-01, TD-10	Crema, Alejandro	WE-36	De Baets, Bernard	TD-04, TD-29
Codina, Esteve	MA-16	Crespi, Giovanni Paolo	TF-34	de Brock, Bert	TB-18, MB-30
Coelho, Antônio	TF-17, MF-18	Crespo Abril, Fortunato	TD-32	De Brucker, Klaas	MC-31
Coelho, Mayk	TF-48	Crespo, Olivier	TF-47	de Carvalho, J. M. Valério	MC-02, TA-02, TB-02, WC-05, WE-15, MA-20, TA-20, TD-20, 21, MB-34
Coelho, Ormeu	TB-48	Cristescu, Gabriela	TD-34	De Causmaecker, Patrick	MA-24, TF-28
Coelho, Paulo	MA-46	Cruz, José	MB-19	De Feyter, Tim	MD-11
Coffrin, Carleton	MC-48				
Cohen, Guy	MC-39, TA-47				
Cojocar, Monica-Gabriela	MB-42				

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|-----------------------------|--------------------------------|---------------------------|----------------------------|------------------------------|---------------------|
| De Francesco, Juan Pablo | MF-06 | Despic, Ozren | TA-06 | Duarte Afonso, Humberto | MD-02 |
| De Giorgi, Enrico | MF-25 | Despotis, Dimitris | MB-06 | Duarte, Alfonso | TB-30 |
| De Giovanni, Pietro | MC-34 | Detienne, Boris | MF-02 | Duarte, António | TD-21, MB-34 |
| de Jong, Cyriel | TD-33 | DeTombe, Dorien | MB-31 | Duarte, Isabel | MC-19 |
| de Kok, Ton | MB-15, MC-15 | Devolder, Olivier | WB-40 | Dudzinska-Baryla, Renata | WE-43 |
| de Koster, René | TF-40, WA-45 | Dhillon, Inderjit | WD-19, WA-34 | Duer, Mirjam | TD-43 |
| de la Croix, David | MA-39 | Dhouib, Emna | TA-23 | Dugardin, Frédéric | TB-04 |
| de La Fortelle, Arnaud | TA-47 | Di Francesco, Massimo | TA-15 | Duggan, Jim | TA-41 |
| de Lange, Gertjan | MD-22, WE-46 | Di Giacinto, Marina | WB-14, MD-39 | Duhamel, Christophe | MB-03, TD-03, TC-04 |
| De Leone, Renato | MF-42 | Di Giacomo, Laura | MB-27, MC-27 | Dulá, José | WE-06 |
| De Maria, Elisabetta | TA-24 | Di Luca, Camilla | TD-26 | Duran, Guillermo | TB-05, MD-29 |
| de Martinis, Valerio | WA-27 | Di Pace, Roberta | WA-27, WD-27 | Duran, Gerhard | TD-13 |
| De Moor, Bart | MA-24 | Di Pillo, Gianni | TD-43 | Duscha, Vicki | MA-47 |
| De Pascale, Gianluca | TF-27 | Di Puglia Pugliese, Luigi | TA-02 | Dussault, Jean-Pierre | TA-21 |
| de Regt, Dorien | TC-22 | Di Vincenzo, Rosalba | WA-48 | Dutta, Joydeep | TF-23, MD-42 |
| De Reyck, Bert | MA-34 | Diallo, Madiagne | WB-06, MD-37 | Duvvuri, Sri Devi | TA-43 |
| de Rooij, Frans | MD-21, WE-46 | Diarrassouba, Ibrahima | TB-10 | Duzdar, Irem | TA-12 |
| De Santis, Marianna | TA-48 | Dias, Gustavo | TB-48 | Duzgun, Ruken | WB-10 |
| De Schemaekere, Xavier | WD-14 | Dias, José G. | MA-07, WC-29 | Dyson, Robert | TF-05, MA-35 |
| De Schepper, Steven | TA-44 | Dias, Luis | MA-13, TF-15 | Dytczak, Miroslaw | MA-12 |
| De Smet, Yves | MF-23, MD-30, TA-30, TC-30 | Dias, Luis C. | MA-06, TB-30, TB-35, TD-37 | | |
| de Smidt-Destombes, Karin | TC-45 | Diaz, Javier | MA-03, TA-21 | E | |
| de Sousa, Amaro | WC-05, MB-40, MC-40 | Diethel, Tom | MD-26 | Ealet, Fabienne | TA-45 |
| de Souza, Cid | MB-02 | Dietz, Simon | MC-30 | Eben-Chaime, Moshe | MD-18 |
| de Vicente, Javier | TD-32 | Dikmen, Onur | WC-08 | Ebrahimian, A.h. | MB-04 |
| de Werra, Dominique | MD-10 | Dimaki, Katerina | WD-18, MB-25 | Ebrahimkhany Ghazy, Soheila | WA-10 |
| Dedoussis, Vassilis | WD-06 | Dimitriou, Vasileios | MD-11 | Eckhause, Jeremy | MC-11 |
| Deelstra, Griselda | WC-46 | Diniz, Milena | MC-35 | Eden, Colin | MB-35 |
| Degerli, Mustafa | TF-11 | Dirsch, Ruth | WA-41 | Edinger Munk Plum, Christian | WD-22 |
| Degraeve, Zeger | MA-34 | Divjak, Blazenka | WD-07 | Edirisinghe, Chanaka | WC-09 |
| Dehghan Krooki, Rafat | WA-12 | Djefal, Elamir | WB-24 | Efendigil, Tugba | WA-30 |
| Dejaeger, Karel | WB-20 | Djefal, Lakhdar | WB-24 | Egan, Michael | MC-30 |
| Dekker, Rommert | MC-01, WD-38, TF-40 | Dobrodolac, Tunde | MC-38 | Eghbaal, Vahid | MB-21 |
| Del Rio Vilas, Victor | MF-35 | Dodin, Bajis | WA-07 | Eglese, Richard | MC-15 |
| Delacote, Philippe | WC-32 | Doerner, Karl | MC-03, TB-03, TC-15 | Egriboyun, Feyzullah | TC-25 |
| Deleris, Lea | WE-14 | Dogan, Ibrahim | TA-14 | Ehmke, Jan Fabian | TD-27, WB-27 |
| Delgado Pineda, Miguel | MB-20 | Dogru, Mustafa | MB-34 | Ehrgott, Matthias | MA-23, WA-44 |
| Delgado, Alexandrino Duarte | WB-22 | Dohn, Anders | WC-24 | Eirinakis, Pavlos | MB-10 |
| Delibasic, Boris | TF-18 | Dokka, Trivikram | MF-10 | Eisenblätter, Andreas | TF-31 |
| Dell'Amico, Mauro | WB-25 | Dolgui, Alexandre | WD-39 | Eisenschmidt, Elke | TB-29 |
| Dell'Olmo, Paolo | WA-13 | Dollevoet, Twan | TC-16, WC-16 | Ejov, Vladimir | MF-18, TA-29 |
| Dell'Orco, Mauro | WC-27 | Dominguez, Enrique | MF-13 | Ekin-Karasan, Oya | WE-13 |
| Dell, Robert | TC-45 | Dominguez, Luis | TF-35 | El Fallahi, Abdellah | MC-03, WD-05 |
| Della Croce, Federico | MC-43 | Domschke, Pia | MB-09 | El Khoury, Hiba | MA-18 |
| Dellaert, Nico | MB-15 | Donchev, Tzanko | MB-39 | El-ga'aly, Ashraf | WB-11 |
| Demange, Marc | TA-10 | Donuk, Bilge | TD-10 | Elbassioni, Khaled | MC-29 |
| Demeulemeester, Erik | WA-07, WA-24 | Dopazo, Esther | MA-12 | Eldabi, Tillal | TD-35 |
| Demir, Aysegul | TA-14 | Doppstadt, Christian | MB-15 | Elhallaoui, Issmail | WC-24, WB-31 |
| Demir, Leyla | WA-04 | Dorbec, Paul | MD-10 | Elhedhli, Samir | MD-02 |
| Demirbaş, Korkut | TD-47 | dos Reis, Amália Faria | MA-11 | Elie, Ghanassia | WB-32 |
| Demirtaş, Kerem | WB-04 | Dotoli, Mariagrazia | TC-27 | Elimam, Abdelghani | WA-07 |
| Demirtaş, Nurgül | TD-11, MB-12 | Doumos, Michael | MD-30 | Ellero, Andrea | TA-47 |
| Dempe, Stephan | MC-42, MD-42 | Dovica, Ivan | MB-16 | Elloumi, Sonda | TA-23 |
| Dempsey, James | TC-22 | Dowart, Moses | MB-37 | Emambocus, Mohammad | TD-42 |
| Denault, Michel | WC-33 | Doğdubay, Murat | MF-37 | Emel, Erdal | MA-03 |
| Denizel, Meltem | MC-41 | Drenovak, Mikica | TF-29 | Emiris, Dimitrios | TF-27, TC-38 |
| Densham, Greta S. | WE-22 | Drewes, Sarah | WA-35, WD-35 | Emmanouilides, Christos | TC-46 |
| Dereniowski, Dariusz | WB-39 | Drigo Filho, Elso | TD-41 | Emrouznejad, Ali | WE-06 |
| Dereu, Guillaume | WA-25, WE-25 | Dris, Djamal | TC-18 | Engau, Alexander | MB-29 |
| Derpich, Ivan | WB-21 | Drosos, Dimitrios | TD-30, TF-30 | Engelbeen, Celine | TF-22 |
| Desaulniers, Guy | WB-22, WC-22, WC-24, 25, WB-31 | Drouet, Laurent | MA-33 | Engell, Sebastian | TB-28 |
| Deshmukh, Abhijit | MC-41 | Drouineau, Mathilde | WB-32 | Engels, Volker | TD-31 |
| | | Drovandi, Guido | TC-24 | Engineer, Famrozze | TA-05 |
| | | Drozdowski, Maciej | TF-07 | Ensor, Andrew | MD-23 |
| | | Du, Bisheng | MD-14 | Ensslin, Leonardo | MC-22, TA-35 |

Ensslin, Sandra	TA-35	Farias, Ricardo	WC-40	Figlali, Alpaslan	MA-03
Eppe, Stefan	MD-30	Farkhi, Elza	MB-39	Figueira, José Rui	MC-23, MD-23, MF-23, MA-30, MC-43, MB-44
Epprecht, Eugenio	MD-05	Fasano, Giorgio	MA-20	Figueiredo, Francisco	MA-07
Epstein, Rafael	TB-05	Fatemi Ghomi, S.m.t.	WE-40	Figueiredo, Manuel	MD-12, MA-13, TF-15, WA-31
Eraslan, Ergun	MB-12	Fathian, Mohammad	MC-12	Figueiredo, Marisa	MC-23
Erden, Feyza	WD-21	Faulin, Javier	MD-03, WC-19, MA-22	Figueiredo, Rafael M. A. de	MD-37
Erdogan, Gunes	TA-15	Fawzi, Bessaih	TA-40	Figueiredo, Rosa Maria	MC-02, WE-22
Erensal, Yasemin C.	TC-12	Fátima, Marilda	WB-28	Filar, Jerzy	TB-08, 09, MF-25, TA-29, MD-38, WB-42
Ergun, Ozlem	MA-17	Federico, Salvatore	WB-14, TA-39	Finbow, Stephen	WE-42
Eriksson, Ola	MD-32	Fedossova, Alina	MF-26	Findik, Duygu	TF-11
Erismis, Burak	WD-40	Fedotova, Olga	MD-12	Fink, Miloslawa	MF-35
Erjavec, Jure	TD-44	Fehr, Max	WB-33	Finkelstein, Stan	MD-36
Erlwein, Christina	MD-27	Feichtinger, Gustav	TC-39	Finkenstadt, Barbel	MD-19
Ernst, Andreas	TF-08	Feil, Balazs	TC-43	Fiosins, Maksims	TD-27
Erol, Serpil	WA-28	Feillet, Dominique	TA-40, MA-41	Firat, Murat	TD-07, TF-25
Ersoy, Cem	WD-05, MA-40	Felden, Carsten	TF-42	Fischer, Kathrin	MF-14
Erte, Idil	MA-37	Feldmann, Gunnar	MC-41	Fischetti, Matteo	MB-16
Ertek, Gurdal	WB-26	Felici, Giovanni	TC-24	Fizman, Roberto	MF-06, WD-06, MC-35
Ertogral, Kadir	WC-08	Felletti, Daniele	WB-29	Fitzpatrick, Shannon	WC-42
Esbensen, Eystein Fredrik	TC-15	Ferguson, Mark	MC-41	Flachskampf, Paul	MD-35
Escardino-Malva, Alberto	TB-12	Fernandes, Ana	WA-13	Flamini, Marta	TB-08
Escrivá, Gema	MF-04	Fernandes, Edite M.G.P.	TB-48	Flapper, Simme Douwe	MC-07, TA-14, TA-27
Escudero, Laureano Fernando	TC-05, WB-16, MA-28, MD-28, MA-41, TC-48	Fernandes, Kiran	TC-46	Fliedner, Malte	MB-08
Esen, Mustafa	WE-35	Fernandes, Leão	MD-47	Flindt Muller, Laurent	WB-25
Eshghi, Kourosh	WB-05	Fernandes, Luís	MC-40, MF-45	Flisberg, Patrik	TA-05, MB-32
Eshragh Jahromi, Ali	TB-09, WB-42	Fernandes, Sérgio	TC-23	Flitman, Andrew	TA-41
Esperet, Louis	WD-25	Fernandez, Elena	MD-01, TC-05, MD-13, TB-15	Florentino, Helenice	TA-19
Espinoza, Daniel	WE-18	Fernandez, Francisco Ramon	MD-43	Flores, Mauricio	WB-39
Estellita Lins, Marcos	MF-06, WD-06, MC-31, MC-35	Fernandez, Jose	TB-13	Floudas, Christodoulos	TD-15, WA-35
Estellon, Bertrand	WE-05	Fernandez, Raul Eduardo	MD-33	Fodstad, Marte	WC-22, MC-28
Euchi, Jalel	TD-03	Fernández Barberis, Gabriela	TC-30	Fogelholm, Carl-Johan	TD-23
Euler, Reinhardt	MF-10	Ferrandi, Fabrizio	MF-29	Fondacci, Rémy	WE-36
Eusébio, Augusto	MD-23	Ferrante, Anna	TB-47	Fonseca, Maria da Conceicao	MC-32
Evans, Ian	TB-27	Ferrao, Paulo	MF-33, TB-33, TA-44	Fonseca, Raquel	TF-36
Even, Raphaël	TC-08	Ferreira Neto, José Ambrósio	TD-04	Fontes, Dalila	TA-23
Evers, Lanah	TD-45	Ferreira, Ana	TA-21	Fontes, Dalila Martins	TA-04
Ewe, Hendrik	MB-17	Ferreira, Brígida da Costa	WE-35	Fontes, Fernando A. C. C.	TA-23
Ewing, Lee	TC-45	Ferreira, Carlos	TC-23	Formanowicz, Dorota	MD-24
Exler, Oliver	MD-09	Ferreira, Deisemara	TA-34	Formanowicz, Piotr	MD-24
		Ferreira, Fernanda A.	TB-19, TD-19	Forsell, Nicklas	WC-32
		Ferreira, Fernando	MD-12	Forster, Geoffrey	WD-24
		Ferreira, Flávio	TD-19	Fortemps, Philippe	TA-23, TD-29
		Ferreira, Helena	MB-19, TC-19	Fortz, Bernard	MB-40, MD-40, MF-41
		Ferreira, José Vasconcelos	WA-27	Fotakis, Dimitris	WD-26
		Ferreira, Liliana	MD-32	Fourer, Robert	MC-21
		Ferreira, Luis	MD-12, MD-19, TF-22, WA-43	Fra Paleo, Urbano	TD-04
		Ferrer, Albert	WE-19	Fragkos, Ioannis	MA-34
		Ferretti, Ivan	MC-34	Fragnelli, Vito	TF-26
		Ferro, Eduardo	WE-18	Fragoso, Rui	TC-32, TF-32
		Ferrucci, Francesco	TC-15	Framinan, Jose M	MA-04, WC-07, WC-39
		Fertis, Apostolos	MB-09, MF-25	Francesco, Cesarone	MA-27
		Festa, Paola	MC-24, TC-24	Francfort, Stanislas	WA-31
		Fetsun, Andry	WB-41	Francisco, Mario	TC-48
		Feyzioglu, Orhan	WA-05, TD-14, MC-48	Franco, Giuditta	MF-24
		Feyzollahi, Mohammad Javad	WA-10, WC-20, WB-24	Franco, L. Alberto	MF-35, TB-35, TC-35
		Fiala, Petr	TB-12	Frangioni, Antonio	WB-19
		Fialho, Andre	MD-36	Franke, Rüdiger	TD-47
		Fichtner, Wolf	TD-33, WC-33, TB-46	Franko, Ceki	MB-05
		Fideli, Krzysztof	MA-24, MB-24		
		Fiedler, Sebastian	WC-08		
		Fiestras-Janeiro, M ^a Gloria	WA-26		
		Fievez, Veerle	TD-04		

Franquesa, Carles	TB-15	Gaspar, Miguel	WA-06	Ginda, Grzegorz	MA-12
Fröhling, Magnus	MF-13	Gassel, Christian	MC-16	Giner-Bosch, Vicent	TA-48
Freire de Sousa, Jorge	WC-27	Gastaldi, Massimiliano	WD-27	Ginestar, Concepción	TC-32
Freitas, Paulo	TD-18	Gaston, Kevin	MC-46	Giordani, Ilaria	TC-24
Freixas, Josep	WE-26	Gather, Thorsten	MA-08	Giraldo, Fabian	MC-37
French, Alan	TD-42	Gathy, Maude	WD-14	Girard, Thierry	WC-04
Frenk, J.b.g.	MB-45	Gauder, Markus	TD-47	Girginer, Nuray	MD-25
Frey, Andreas	MB-11	Gaudioso, Manlio	WB-19	Gittins, John	TD-08
Fridman, Lea	TB-06	Gavalec, Martin	MF-36	Gkoumas, Konstantinos	WA-16
Friedlander, Ana	MA-42	Gavranis, Andreas	WA-36	Gladysz, Barbara	TD-32
Friedrich, Bernhard	TD-27	Gavranovic, Haris	WD-25	Glass, Celia	WD-28
Fries, Carlos Ernani	TD-06, WE-18	Gay, David M.	MC-21, WD-35	Glau, Kathrin	WC-46
Froyland, Gary	MF-16	Gazzola, Rosaura	TB-32	Glawischnig, Mex	MF-22
Fu, Michael	MF-28	GÜnay, Noyan Sebla	WA-39	Glazebrook, Kevin	WC-45
Fuchsberger, Martin	MC-16	Gómez Ibañez, Alvaro	TD-46	Glensk, Barbara	MA-33
Fukuda, Emiko	MA-19, TD-45	Gómez-Limón, José A.	TC-32	Glineur, François	WB-40
Fukushima, Masao	MF-46	Gönülol, Semiye	MA-03	Gnecco, Giorgio	MF-40
Fulga, Cristina	WE-29	Görmer, Jana	TD-27	Gnudi, Adriana	WA-48
Fulop, Janos	WC-20	Göttlich, Simone	MB-09	Godinho, Ana	TF-24
Funaki, Yukihiko	TB-26	Gebhard, Marina	MB-13, TB-22	Godinho, Maria Teresa	TB-15
Funk, Matthias	WE-20	Gehring, Hermann	MA-17	Godskesen, Steffen	WA-25
Furian, Nikolaus	TB-20	Geiger, Martin Josef	TD-05	Goel, Ankur	WC-14
Furini, Fabio	MD-02	Geipele, Ineta	WB-43	Goensch, Jochen	MF-43
Furmans, Kai	WA-45, WB-45	Geissler, Bjoern	WD-35	Goentzel, Jarrod	MC-28
Fusco, Gaetano	WA-16	Gel, Esma	MC-14, MA-46	Goerdts, Andreas	TA-29
Fuss, Sabine	WC-32	Gelareh, Shahin	WD-22	Goes, Gabriela	MB-19
		Gendreau, Michel	MF-03, TC-15, TD-15, TF-15, MC-17, MF- 17, TA-17, WC-25	Goetz, Renan	MA-39
G		Gendron, Bernard	WC-13	Gogkou, I.	TA-24
Gabay, Daniel	WB-14	Genoese, Massimo	WC-33, TB-46	Gogus, Itir	MD-41
Gabrel, Virginie	TB-10	Genovese, Andrea	TD-17	Gokay, Selim	TC-25
Gabriel, Steven	MC-11	Gentile, Guido	WA-16	Golany, Boaz	MD-19
Gafarov, Evgeny	MD-08	Georgiadis, Patroklos	MC-14	Goldacker, Götz	MB-20
Gaggero, Mauro	MF-40	Georgiou, Andreas	MD-11, WA-12	Goldengorin, Boris	WD-40
Gaivoronski, Alexei	MC-28	Georgiou, Ion	MA-35	Goldschmidt, Olivier	WB-08
Galé, Carmen	MA-42	Ger, Metin	TD-47	Goletsis, Yorgos	TA-24, WA-36
Gallay, Olivier	TF-17, WB-27	Geraghty, John	MA-03	Golias, Mihalis	WA-40
Gallego, Jordi	TC-32	Geraldes, Carla A. S.	MD-14	Gollowitzer, Stefan	WC-13
Galli, Laura	MB-16	Geraldes, Carlos	MA-11	Gomes, A. Miguel	WA-05, MB-20
Gallo, Giorgio	TA-31	Gerchak, Yigal	WE-39	Gomes, Catarina	WB-42
Gallo, Mariano	WB-16, WA-17	Gerdts, Matthias	MD-09, MB-39, MF-39, TB-39	Gomes, Eliane	TB-32
Galvão Dias, Teresa	MD-03, MF-16, MB-23	Gergin, Zeynep	WE-33	Gomes, Maria Isabel	WA-13, TC-17
Gambardella, Luca Maria	WC-25	Gershwin, Stan	WC-28	Gomes, Marta Castilho	MD-33
Gammon, Mark	TD-45	Gettinger, Johannes	MB-44	Gomes, Orlando	MB-19
Gan, Heng-Soon	WE-22	Gevezes, Theodoros	WD-04	Gomes, Rui	MD-03
Günther, Markus	TC-46	Geyer, Alois	WA-29	Gomes, Teresa	MC-40
Gürbüz, Tuncay	TC-12	Gfrerer, Helmut	WB-44	Gomes, Tiago	MA-32
Gürel, Sinan	WC-07	Ghaddar, Bissan	MB-29	Gomez Gonzalez, Daniel	WC-21
Güven, Caglar	MA-33	Ghaemi Nasab, Fateme	TD-36	Gomez, Trinidad	TD-04
Garatti, Simone	WA-21, MD-46	Gharehgozli, Amir Hossein	TF-40	Gomez-Corral, Antonio	WB-18
Garín, María Araceli	MA-28	Ghasem Esfahani, Mostafa	WC-09	Gomez-Navarro, Tomas	TB-12
García Quiles, Sergio	MC-13, MF-13, TC-13	Ghiami, Yousef	WD-45	Gomide, Fernando	MC-36
García, Irma	WB-15	Ghoreyshi, Seyed Mohammad	MB-04, MB-34	Gonçalves, Graça	MB-07
García-Bouso, Ana	MC-39	Ghosh, Diptesh	TF-03, WD-04, MF-40	Gonçalves, José Fernando	TA-20
García-Jurado, Ignacio	TC-26	Ghotbaddini, Maryam	WC-20, WB-24	Gonçalves, José Manuel	TF-32
García-Sanz, María D.	TA-30	Giacometti, Rosella	MB-28	Gonçalves, Michele	WB-28
Garcia, I.	TB-13, TC-43, TF-43	Giallombardo, Giovanni	WA-40	Gonçalves, Rui	TC-19
Garcia-bernabeu, Ana	WD-30	Giannikos, Ioannis	MA-13	Goncalves, Gilles	WB-24
Garcia-Melon, Monica	TB-12	Gicquel, Céline	WE-33, MA-34	Gondek, Verena	WA-28
Garcia_Gonzalo, Jordi	MD-32, TC-32	Giffhorn, Edilson	MC-22, TA-35	Gondzio, Jacek	MC-21
Gardi, Frédéric	WE-05, WC-25	Gila-Arrendo, Aranzazu	TB-13	Gonen, Amnon	MA-38
Gargallo, Pilar	MF-12, TC-37	Gilanyi, Attila	TF-34	Gonzaléz-Olabarria, José	MD-32
Gargano, Francesco	TD-17	GINCHEV, Ivan	TF-34	Gonzalez, Eduardo	TF-06
Garibaldi, Jonathan	MC-24			Gonzalez, Ignacio	WD-30
Garriga, Xavier	WC-07			Gonzalez, Marcela	TB-32
				Gonzalez-R, Pedro L.	MF-21
				González Alastrué, José Antonio	WC-19

Goossens, Dries	MF-10, TD-10	Guinand, Frederic	MB-23	Haoxun, Chen	TF-13, MB-17
Gopaladesikan, Mohan	TC-02	Gujjula, Rico	WC-31	Harper, Paul	MD-37
Gorelik, Viktor	WC-12	Guler, Kemal	WD-26	Hartl, Richard	MC-03, TB-03, TA-08, TC-15, TC-39
Gorgone, Enrico	WB-19	Gulkac, Hande	MA-03, WA-38	Hartmann, Alexandra	MD-17
Gori, Stefano	WA-16, WB-27	Gulli', Daniel	WA-40	Hartnell, Bert	WD-42
Gorski, Jochen	MA-23	Gultas, Ilkay	WE-36	Hasgul, Servet	WB-09
Gotzamani, Katerina	WA-12	Gundogdu, Ceren	TC-11	Hasle, Geir	WA-31
Gounaris, Chrysanthos	TD-15	Gundogdu, Erdem	WA-05	Hassanzadeh, Elmira	MF-44
Gourdin, Eric	MD-40	Guner Goren, Hacer	MA-34	Hassanzadeh, Yousef	MF-44
Gouveia, Luis	MA-02, TB-15, WC-15, WD-15, MB-40, MC-40	Guner, Ali	MB-15	Hassin, Refael	TD-13
Gouveia, Maria	MA-06	Guner, Banu	WB-09	Hattingh, Giel	MA-09
Govaert, Tim	TC-14	Guney, Evren	WD-05	Hatzl, Johannes	TB-02
Gozzi, Fausto	WB-14, MD-39, TA-39	Gungor, Burcu	MB-26	Haurant, Pierrick	WD-37
Grad, Sorin-Mihai	WD-09	Gupta, Arindam	MD-11	Haus, Utz-Uwe	TB-29
Gradisar, Miro	TD-44	Gur Ali, Ozden	MD-26	Hautphenne, Sophie	TB-18
Grahl, Jörn	TA-42	Gurevich, Gregory	WD-07, WE-17, TC-18	Havlik, Petr	WC-32
Granichin, Oleg	MC-18	Gurný, Petr	MD-25	Hayashi, Shunsuke	MF-46
Grapsa, Theodoula N.	TD-48	Gurrieri, Massimo	TD-29	Hayel, Yezekael	MA-41
Grasas, Alex	TA-43	Gurzhiy, Vladimir	TD-46	Hayez, Quantin	TC-30
Grasman, Scott	MD-03	Gusmagg-Pfieggl, Elisabeth	TB-03	Haythorpe, Michael	TA-29
Grass, Dieter	TC-39	Gutiérrez, César	TF-44, WA-44	Hazir, Oncu	WB-07
Grasselli, Martino	WB-14	Gutiérrez, Ester	TD-06	Házy, Attila	TC-34
Gravot, David	MC-21	Gutiérrez, Iliana	MC-37	Höfer, Mathias	TD-47
Gröflin, Heinz	MD-04	Gutierrez, Genaro	WC-14	Hörmann, Wolfgang	WD-41
Greco, Salvatore	TD-29, WA-37, WE-37	Gutierrez, Jose M	WB-38	Hebrard, Emmanuel	WD-25
Gregus, Marie Theres	MB-25	Gutierrez, Marco	TD-13	Heemeryck, Annelies	MA-12, WA-43
Gribkovskaia, Irina	WD-39	Gutierrez, Rafael S.	WD-38	Heerda, Jan	MA-48
Griebsch, Susanne	WD-46	Gutjahr, Walter	WB-15	Hege, Laura	WE-33
Griffa, Simone	WB-37	Gwiggner, Claus	TB-27	Heid, Werner	MD-17
Griffiths, Jeff	TD-28	Găianu, Mihail	TD-34	Heimerl, Christian	MA-08
Grigoroudis, Evangelos	MF-30			Hein, Robert	TA-44
Grimaud, Frédéric	WD-39			Heinimann, Hans Rudolf	MA-21, WD-26, MB-32
Gritzmann, Peter	TB-45			Heinz, Stefan	TA-08, WA-25
Grobleben, Katharina	TA-27			Heipcke, Susanne	TC-21
Groesser, Stefan	TC-41			Hejducki, Jacek	TD-03
Gronalt, Manfred	WA-15, MA-32			Hejducki, Zdzisław	TD-03
Grosso, Andrea	MC-43			Hekimoğlu, Mert Hakan	MD-41
Grothey, Andreas	MC-21, MB-45			Helber, Stefan	MD-34
Grunwald, Jessika	TF-42			Held, Anne	TF-33
Grusho, Alexander	MB-18			Helin, Janne	TF-32
Grzechca, Waldemar	TF-07			Helo, Petri	TC-11
Guardao, Luis	MF-04			Hempsch, Christoph	TC-31
Guarisco, Michael	WE-14			Henao, Felipe	TB-35
Guarracino, Mario	MC-24			Hendrix, Eligius M.T.	TA-13, TC-43, TF-43
Guden, Huseyin	WB-45			Henriques, Carla	TC-33
Gue, Kevin	WA-45			Henriques, Pedro	MB-06
Guedes, Maria do Carmo	TB-39			Hens, Luc	MA-31
Guenther, Hans-Otto	TD-17, WC-31, TA-34			Herdem, Canan	WD-44
Guerrassimoff, Gilles	TA-37			Heredia, F.-Javier	WC-19, MB-28
Gueret, Christelle	MA-15			Hernandez, Miguel	WB-21
Guerrero, Carlos	TB-13			Hernandez, Monica	TD-04
Guerrero, William	MA-15			Hernández, Beatriz	WB-44
Guerrero, Francesca	TA-02, TD-28			Herold, Johannes	MC-11
Guerrin, Francois	TD-41, MD-44			Herrmann, Sascha	TD-31
Guerry, Marie-Anne	MD-11			Herzog, Florian	WB-23
Gueye, Serigne	WC-35			Heyde, Frank	TF-23
Gugenheim, Dan	TB-19			Hiete, Michael	WC-47
Guha, Puja	MA-19			Higuchi, Hideki	TD-45
Guide, Daniel	WA-11			Hijazi, Hassan	WB-35
Guido, Rosita	TD-28			Hildmann, Marcus	WB-23, WC-23
Guignard-Spielberg, Monique	WE-35			Hillebrandt, Julia	TC-31
Guimarães, Luis	MB-34			Hillege, Hans	MB-30
Guimarães, Rui	WD-06			Hindle, Giles	MD-35

Hinojosa, Miguel A.	MA-38	Hvattum, Lars Magnus	TC-15, WE-22	Jhang, Jhu-Ning	MF-07
Hinz, Juri	WB-33, WD-33	Hędrzak, Magdalena	TA-32	Jiang, Houyuan	MD-41
Hiramoto, Megumi	WD-11			Jiang, Xinjia	TF-40
Hirsch, Patrick	WA-15, TA-22, MA-32	I		Jiménez, Bienvenido	TF-44, WA-44
Ho, Sin C.	MF-03	Isljamović, Sonja	TB-11	Jiménez-Losada, Andrés	WA-26
Ho, Ying-Chin	WB-09	Iacobellis, Giorgio	TC-27	Jimenez-Lopez, Mariano	MB-36
Hoai Minh, Le	MD-45	Ibrahimov, Maksud	MC-05	Jlassi, Jihen	MA-37
Hoang Hai, Pham	MA-31	Ikedo, Takeshi	TD-08	Joao, Isabel M.	TD-30
Hochreiter, Ronald	WA-29	Ilk, Ozlem	WD-47	Joerin, Florent	WC-37
Hoda, Samid	TB-29	Imahori, Shinji	TA-20	Johar, Farhana	WA-15
Hogg, Jonathan	MC-21	Imai, Akio	TB-17	Johnson, Johnnie	TF-10, WB-17
Hohzaki, Ryusuke	MA-19, WB-26, TD-45	Improta, Gennaro	TD-17	Joncour, Cédric	WB-09
Hojda, Maciej	TF-08	Inci, Ahmet Can	MA-25	Jones, Dylan	MB-36, MB-44
Holmberg, Kaj	MC-40, TF-42	Inderfurth, Karl	MC-34	Jongen, Hubertus Th.	MB-42, MD-46
Holmberg, Stig C	MB-11, TC-44	Inkaya, Tulin	WD-17, TB-42	Josa-Fombellida, Ricardo	WB-14
Homfeld, Henning	TF-16	Innorta, Mario	MB-28	José Martins Ferreira Filho, Virgílio	TB-48
Hon, Cheng-Chuang	WB-12	Inoue, Eduardo	MB-44	Jost, Vincent	WB-25, MC-48
Hongler, Max-Olivier	TF-17, WB-27	Ioakimidis, Christos	MC-33, MF-33, TA-44	Joubert, Johan	TA-17
Honma, Yudai	WA-13	Ioannou, George	TB-14, WB-31	Jouini, Oualid	WA-24
Hontelez, Jan	TC-45	Ionescu, Lucian	MD-16	Jovanovic, Milos	TF-18
Hoogeveen, Han	TB-16	Ip, W.h.	WD-15	Jozefczyk, Jerzy	MB-04
Hooker, John N.	TB-29, TB-31	Irnick, Stefan	TB-03, MF-15	Jozefowicz, Nicolas	MD-23
Horbach, Andrei	TD-07, TC-08	Ishizaka, Alessio	MB-44	Jozefowska, Joanna	WB-39
Horozoglu, Nayat	TF-26	Isik, Mine	MD-12	Jozefowski, Lukasz	WB-39
Hoseini, Seyed Mohieddin	TD-06	Istvan, Szuts	WA-46	Juan, Angel A.	MD-03, TC-03, WC-19, MA-22
Hosseini, Seyed Ahmad	WB-46	Iyigun, Cem	TB-42	Juan, Pin-Ju	WB-12
Hosseinzadeh Lotfi, Farhad	MB-06, MD-06	Izady, Navid	TC-22	Judice, Joaquim	MB-42, MC-42, TC-43, MF-45
Hotta, Keisuke	WC-09	Izmailov, Alexey	WA-34	Juenger, Michael	MA-02
Hou, Jiang-Liang	TF-18	Izquierdo, Josep M	TD-26	Jung, Gimun	WA-20
Hougaard, Jens Leth	WE-43			Junglas, Daniel	WB-36
Howard, John	WB-26	J		Jurun, Elza	MB-25
Howell, Michael	MD-36	J. W. James, Ross	WC-09	Justino, João	WD-07
Hritonenko, Natali	MA-39	Jabali, Ola	MC-15		
Hsiao, Yuan-Du	WA-10	Jablonsky, Josef	MF-12, MB-43	K	
Hsu, Chun-Chin	MA-11	Jablonsky, Petr	TA-38	Kaňková, Vlasta	MA-28
Hsu, Pi-Fang	WC-12	Jacomino, Mireille	WE-37	Kabak, Özgür	TF-42
Htiouech, Skander	WB-04	Jaehn, Florian	MB-08, WC-36	Kabyl, Kamal	WA-18
Hu, Tung-Cheng	TA-25	Jafarizadeh, Babak	WE-41	Kaci, Souhila	MD-48
Huang, Chiao-Ling	MA-11	Jagannathan, Rupa	TD-22	Kaczmarczyk, Waldemar	TB-34
Huang, Dongbin	WD-26	Jager, Christina	MA-48	Kafash, Mohamad Hosein	TD-34
Huang, Kai-I	WB-11	Jagla, Jan-Hendrik	MD-21	Kaimakamis, George	TB-25
Huang, Mei-Hsiu	TD-18	Jahangiry, Pedram	WE-41	Kainich, Alexandros	WC-44
Huang, Rongbing	MC-13	Jahanshahloo, Gholam Reza	MD-06	Kaiser, Gernot	TB-22
Huang, Shiu-an-Yiang	WB-10	Jain, Manish	TA-05	Kaiser, Markus	TA-13
Huang, Tze Chin	TB-38	Jalali-Naini, S.g.r.	MD-14	Kajiji, Nina	TF-21
Huber, Christian	WB-45	Janaqi, Stefan	WE-37	Kalashnikov, Vyacheslav	MC-09, MC-42
Huber, Sebastian	MC-25	Jang, Jinbong	TC-18	Kalashnykova, Nataliya	MC-09, MC-42
Huchzermeier, Arnd	WD-45	Jang, Steve	TA-41	Kallio, Markku	WC-41
Hudelmaier, Andreas	TF-28	Jans, Raf	MA-34, WB-38	Kamisli Ozturk, Zehra	TA-09
Huelle, Judith	MF-12, TC-35, WC-47	Jansen, Michiel	MF-14	Kamisli, Melik	MD-25, WC-29
Huepping, Bjoern	TB-39	Janssens, Gerrit	TC-03	Kan, Cihangir	MB-05
Hugues, Tchouankem	TD-27	Jütte, Silke	WC-24	Kana, Vivien	MB-43
Huguet, Marie-José	WA-08	Jaramillo, Patricia	MC-37	Kanat, Irfan Emrah	TF-11
Hui-Chih, Hung	WE-24	Jarboui, Bassem	WC-04	Kandakoglu, Ahmet	MC-12
Huisman, Dennis	TC-16, WC-16	Jaschob, Mathias	MA-23	Kang, Boda	WD-46
Hujala, Teppo	TF-30	Jaunzems, Andrejs	WA-42	Kangas, Annika	TF-30
Hulianytskyi, Leonid	WA-18	Javadi, Akbar	MC-47	Kao, Shih-Chou	WD-17, TA-31
Humpola, Jesco	MF-09	Jørgensen, Erik	MF-32	Küfer, Karl-Heinz	MB-17, TD-23, MF-46
Hunjak, Tihomir	WA-30	Jönsson, Petrus	WB-31	Kürüm, Efsun	MD-25
Hunter, Paul	WC-42	Jeannet, Bernard	WA-35	Kapamara, Truword	TD-28
Hurkens, Cor	TD-07, WB-25	Jegelka, Stefanie	TD-02	Kapelko, Magdalena	WA-06
Husain, Iqbal	WC-34	Jenkins, Barbara	MF-41		
Hussain, Deedar	MD-12	Jensen, Thomas Sejr	WA-25		
Huysmans, Johan	WB-20	Jepsen, Mads Kehlet	MD-15, TD-15		
		Jha, Sanchita	MF-21		

Kapoor, Reena	WD-09	Khandelwal, Ankit	TD-09, TB-27	Kolodzey, Alexander	MB-18
Kar, Anirban	TA-26	Khazaei, Javad	MB-28	Komiya, Toru	MA-19, TD-45
Kara, Bahar Yetis	WE-13	Khemakhem, Mahdi	MA-37	Kondrakov, Ivan	WB-23
Karabacak, Bilge	MF-11	Khosravi, Banafsheh	WC-16	Kongo, Takumi	TB-26
Karabulut, Ilayda	MC-15	Khuong, Paul-Virak	WC-13	Konnov, Igor	WA-48
Karabulut, Ozlem	WB-04	Kieffer, Yann	WD-05, WC-20, WD-25	Konstantas, George	WD-18
Karaca, Nihan	WE-36	Kiekintveld, Christopher	TA-05	Koole, Ger	WA-24
Karadayi, Melis Almula	MD-12	Kiesel, Antje	TF-22	Kopanska-Brodka, Donata	WE-43
Karagiannis, Giannis	TA-06	Kiesel, Rudiger	WB-33	Kopfer, Heiko	MB-17
Karakostas, George	WD-26	Kiesling, Elmar	MB-44, TC-46	Kopfer, Herbert	MA-17, MB-17, MC-17, MD-17
Karaman, Hazal	TD-14	Kilic, Kemal	MC-36	Koppang, Haavard	TA-31
Karamanis, Dimitrios	TB-25	Kilic, Okan	MA-31	Korgin, Nikolai	TD-11
Karamzin, Dmitry	TC-39	Kim, Dongmin	WD-19, WA-34	Korotchenko, Ielyzaveta	WB-47
Karasakal, Esra	WB-04, MB-05	Kim, Eun-Seok	WD-28	Korpeoglu, Evren	WD-26
Karimi, Hossein	TD-05	Kim, Kap Hwan	TF-40	Kort, Peter M.	MA-19, TC-39
Karimi-Nasab, M.	MB-04, TA-04, WC-04, MD-14, MB-34, TA-34, WE-40	Kim, Sangho	MF-37	Kortbeek, Nikky	MB-30
Karkazis, John	MA-13, MB-13	Kim, Seokjin	MC-13	Korzilius, Hubert	TB-35
Karmen, Pazek	TB-44	Kim, Seong-Jun	MF-42	Koschtial, Claudia	TF-42
Karmitsa, Napsu	WD-19	Kim, Seongmoon	MB-46	Koseoglu, Pinar	MA-37
Karpak, Birsen	TA-12	Kim, Sung-Shick	WA-11	Kosowski, Adrian	MC-10
Karpov, Igor	WB-28	Kim, Woo Chang	MA-25	Kostarelou, Eftychia	WA-36
Karsten, Frank	WA-26	Kimms, Alf	TF-27, MF-43	Kostoglou, Vassilis	WD-08
Kasap, Nihat	TB-28	Kinoshita, Eizo	WD-12, MB-31	Kostrzewska, Marta	WB-46
Kasimbeyli, Refail	MA-26	Kirchner, Kathrin	TF-18	Kotiadis, Kathy	TD-35
Kaspar, Ralf	MF-12	Kiriakopoulos, Konstantinos	TB-25	Koulis, Alexandros	TF-29
Kasper, Ulf	WC-33	Kirkizlar, Eser	TB-47	Kourentzes, Nikolaos	MC-28
Kasprzyk, Rafal	WA-30	Kis, Tamas	WB-21	Kouvela, Anastasia	MF-10, TC-10
Kassa, Rabah	WA-21	Kjeldsen, Karina	WB-22	Kovacevic Vujcic, Vera	TC-10
Kat, Bora	MA-33	Kjeldsen, Niels	WA-25	Kovacevic, Ivana	TA-18
Katsev, Ilya	TB-26	Klamroth, Kathrin	TD-07, TA-13, MA-23, TD-24	Kovacevic, Raimund	WD-29
Katsis, Christos	TA-24	Klatt, Tobias	MF-12, WC-47	Kovacs, Edith	WA-46
Katsuda, Hideki	TA-38	Klatzmann, David	MB-24	Kovalev, Sergey	WD-39
Kaur, Parmjit	MA-35	Kleber, Rainer	MC-34	Kovriga, Svetlana	MC-35
Kaur, Simranjit	TF-09	Kleindorfer, Paul	MC-33	Kozanidis, George	WA-36
Kaut, Michal	TB-19	Kleine, Oliver	TC-41	Kpoumie, Amidou	WB-37
Kavakli, Halil	TD-24	Klemmt, Andreas	WB-07	Kramer, Alpar Vajk	MA-10
Kawamura, Hidenori	TD-08, WC-12	Klerides, Evelina	MD-02	Kramkowski, Stefan	MD-16
Kawas, Ban	MA-27	Kliwer, Natalia	MD-16, TB-16, TD-40	Krarup, Jakob	MF-48
Kaya, Murat	TB-14, WB-26	Kline, Jeffrey	WE-22	Krasnogor, Natalio	MF-24
Kaya, Onur	TC-14, TF-15	Klinkert, Andreas	WA-24	Krasotkina, Olga	WC-23, WD-23
Kayakutlu, Gulgun	TA-12, TC-12, WC-12, TC-36	Kljajic, Miroljub	TB-44, TC-44	Krass, Dmitry	TC-13
Kayaligil, Sinan	WD-17	Kljajic-Borstnar, Mirjana	TC-44	Kratice, Jozef	TC-10
Kaymak, Uzay	MA-36	Kloster, Oddvar	WA-31	Kratz, Marie	WD-43
Keisler, Jeffrey	MC-44	Knüppel, Peter	TF-42	Kraus, Sarit	MC-18
Keles, Dogan	TD-33	Knauer, Matthias	MD-09	Kravchenko, I. A.	MC-18
Kellerer, Hans	WA-28	Knoke, Thomas	WC-41	Krawczyk, Jacek	MD-38
Kendall, Graham	MD-24	Knust, Sigrid	WC-36	Krejic, Natasa	MD-27, 28, MF-28
Keppo, Ilkka	TF-33	Ko, Hong Seung	WD-11	Kremers, Enrique	TD-46
Kerbache, Laoucine	MA-14, MA-18	Kobayashi, Takashi	TA-25	Krempasky, Thorsten	TA-13
Keren, Baruch	TB-06, TC-18	Koberstein, Achim	MD-16	Kresz, Miklos	TC-04
Kermek, Dragutin	WA-30	Kocabiyikoglu, Ayse	MD-41	Kristensen, Anders Ringgaard	MF-32
Kern, Walter	TC-02	Koch, Ronald	MB-09	Kristjansson, Bjarni	MD-21, TC-21
Kersch, Mike	WA-29	Kochetov, Yury	MA-42	Kritzinger, Stefanie	MC-03
Kesek, Zbigniew	MB-31	Kochetova, Nina	MA-42	Krklec, Natasa	MD-28, MF-28
Keshvari, Abolfazl	TC-07	Kodera, Jan	WE-44	Krkosková, Šárka	MF-37
Keskin, M. Emre	MA-40	Koester, Christian	TB-43	Krokhmal, Pavlo	TC-18, WD-29
Keskinocak, Pinar	TA-05, TD-13, MC-14	Kofjac, Davorin	TB-44, TC-44	Kronek, Louis-Philippe	TC-42
Kezi, Csaba	TF-34	Kogan, Alex	TC-29	Kroon, Leo	MA-16, MB-16, WC-16
Khachay, Michael	MA-18, WA-23	Kokkinis, Basil	MF-39	Kropat, Erik	WD-44, MC-46
Khamisov, Oleg	MC-42	Koksalan, Murat	MC-43	Kruger, Hennie	MA-09
Khan, Mohammed	TA-46	Kolak, Orhan Ilker	MC-48	Krumke, Sven	TB-16
Khanafer, Ali	TB-20	Kolarov, Ivan	WC-11	Kruse, Rudolf	TD-29
		Kolb, Oliver	MB-09	Kruse, Susanne	WC-46
		Kolisch, Rainer	MA-08	Krushinsky, Dmitry	WD-40
		Kolliopoulos, Stavros	WD-26	Krymova, Ekaterina	WA-23

Kubali, Deniz	TC-14	Larsen, Christian	MD-14, TB-47	Li, Yan Chen	TB-07
Kubiak, Wieslaw	WB-39	Larsen, Jesper	WA-15, TB-17, WC-24	Lian, Zhaotong	WE-44
Kubo, Mikio	MA-45	Larsen, Rune	TB-20, WA-25	Liang, Tzu-Yin	TA-31
Kucera, Petr	TC-29	Laslo, Zohar	WD-07, TC-18	Liao, Chia-Chun	WA-42
Kucherenko, Sergei	TC-43	Latouche, Guy	MD-18	Liao, Shuangqing	WA-24
Kuchta, Dorota	TD-32, TC-36	Lau, Hoong Chuin	TF-28	Liao, Ta-Wei	WB-09
Kucuk, Mahide	WC-34	Laugier, Alexandre	TD-07	Liberati, Diego	MF-29
Kucuk, Yalcin	WC-34	Laukkanen, Timo	TD-23	Liberatore, Federico	TC-13, MB-37
Kucukaydin, Hande	MA-09	Laumanns, Marco	MB-09, WE-14, MC-16, WC-16	Liberti, Leo	MC-02, WA-35, WB-35
Kuhn, Daniel	TF-36	Laundy, Richard	WB-36	Libura, Marek	TD-02
Kuhn, Harold W.	TE-01	Lavangananda, Kittichai	MB-23	Lidén, Bertil	MB-32
Kuhn, Heinrich	MB-14, WA-38, WC-45	Lavor, Carlile	MC-02	Lidouh, Karim	MF-23
Kuilman, Jan	MA-31	Layter Xavier, Vinicius	TF-43	Liefooghe, Arnaud	MC-23
Kula, Ufuk	WE-08, WD-45	Lazarev, Alexander	MD-08, WB-28	Lien, Chung-Chang	WB-10, TD-18
Kulak, Osman	TD-17	Lazarin, Daniel	MC-17	Liern, Vicente	MB-36, MC-36
Kumar, Krishna	MA-19	Létocart, Lucas	WD-25, WB-35	Liers, Frauke	MB-29, TB-29
Kumar, Shruthi S	MA-22	López, Jorge	TB-26	Liesiö, Juuso	MA-44
Kumar, Soumojit	MC-25	López-Redondo, Juana	TB-13, TC-43	Lifvergren, Svante	TD-22
Kumaresan, Miles	MD-27	Löhne, Andreas	TF-23	Lilia, Zaourar	WD-05
Kumbaroglu, Gürkan	TB-33	Le Thi, Hoai An	MD-45, MF-45, TA-45	Lillo, Felipe	MD-23
Kunc, Martin	MA-35	Leão, Celina Pinto	TA-21	Lin, Chin-Piao	TC-07
Kunkel, Martin	MD-09	LeBel, Luc	MB-32, TD-32	Lin, Chin-Tsai	TA-25
Kunsch, Pierre	MD-44	Leblebicioğlu, Kemal	WE-17	Lin, Shin-Yi	WB-12
Kurumatani, Koichi	TD-08	Lebrón, Esperanza	WA-26	Linnala, Mikko	MA-45
Kurz, Sascha	MF-02	Lebreiro, Nuno	WA-31	Lino, M.Pilar	WA-39
Kutlu, Ahmet Can	MB-12	Lee, Hong Tau	TB-04, MA-06	Linton, Jonathan	MA-14
Kuula, Markku	WC-41	Lee, Hsu-Hua	TD-18	Lioris, Jennie	TA-47
Kuzmanovic, Marija	TB-42	Lee, Jon	WA-35	Liour, Yuanchau	MA-11, TD-11
Kuzmina, Lyudmila	MC-39	Lee, Lai-Soon	MB-03	Liptrot, Tom	MF-41
Kvasov, Dmitri	TF-43	Lee, Loo Hay	WE-24, TF-40	Lis, Marcin W.	TA-32
Kyngas, Jari	TF-24	Lee, Wen Yi	TA-25	Lisboa, Adriano	TD-48
Kyriazis, Panagiotis	TB-14	Lee, Wen-Chiung	WC-07	Lisse, Nora	WD-43
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Labbé, Martine	TC-01, MC-02, MB-40, MD-40, MF-41	Lee, Wenyih	TB-14	Listes, Ovidiu	TC-21, WE-46
Labbi, Wafaa	WD-28	Lefèvre, Claude	WD-14	Litsardaki, Maria	TD-37
Labib, Ashraf	TB-12	Legato, Pasquale	TD-17, WA-40	Litvak, Nelly	MF-18, MB-30
Lacomme, Philippe	MB-03, TD-03, WA-08	Lehaux, Thomas	WE-37	Liu, Fuh-Hwa	TA-06
Lacroix, Mathieu	TB-10	Lehmann, Thomas	MD-09	Liu, Jiyin	WC-31
Lagarde, Lionel	TF-16	Lehtonen, Heikki	TA-32	Liu, Kuangyi	MF-18
Lahrichi, Nadia	MF-03, TA-17	Lejeune, Miguel	MA-25	Liu, Qian	MB-41
Lai, Guoming	MC-27	Leleur, Steen	TC-37	Liu, Shasha	WD-11
Lai, Tzyy Jane	WD-11	Lemos, Felipe	TD-20	Liu, Xiaoming	WE-44
Laib, Fodil	WD-44	Leon, Coromoto	MF-20	Liu, Yang	MC-38
Lamanna, Rosalba	TC-48	Leon, Maria Amparo	TD-04	Lium, Arnt-Gunnar	WC-22
Lamine, Amine	MA-37	Leon-Rubio, Santiago	TB-12	Ljubic, Ivana	MA-02, WC-13, MB-40
Lamond, Bernard	MB-21	Leoni, Peter	WC-46	Llop, Jose Ignacio	WA-39
Lan, Yu Wen	TB-38	Leopold, Ulrich	MA-33	Llorca, Natividad	TA-26, TB-26
Lancia, Giuseppe	MB-02	Leopold-Wildburger, Ulrike	MA-38	Lo, Mei-Chen	TD-12, MC-38
Landa, Paolo	TA-22	Leow, Mindy	WC-30	Loan, Dinh Thi Phuong	MA-31
Landete, Mercedes	TF-03, TC-05, MF-13	Lesaja, Goran	WB-34	Lobo, Victor	MC-20
Landry, Jean-François	TA-21	Leskinen, Pekka	TF-30	Locatelli, Marco	TA-48
Lang, Jens	MB-09	Leskovar-Špacapan, Gabrijela	WB-47	Lodi, Andrea	WC-35
Lange, Jean-Charles	MB-13	Lessard, François	WC-25	Loeffen, Ronnie	WD-14
Langenberg, Nils	MA-48	Lessmann, Stefan	WA-20	Loher, Marcel	TB-41
Lübbecke, Marco	TA-08	Leung, Kwai-sun	MA-18	Loiseau, Irene	MA-02
Laporte, Gilbert	TA-13, WE-13, MC-15, TA-15, WA- 15, MD-23, TB-23	Leus, Roel	WA-07	Lokman, Banu	MC-43
Larabi, Mohand	WA-08	Levin, Yuri	MB-41	Longo, Giovanni	TD-12, MC-16, WD-27
Lari, Isabella	MC-29	Levina, Tatsiana	MB-41	Lopes, Isabel Cristina	TD-20
Lario Esteban, Francisco	MB-36	Levy, João Quinhones	MD-33	Lopes, Maria do Carmo	WE-35
Larrañaga, Pedro	TA-42	Leyva-Lopez, Juan Carlos	TB-30	Lopes, Maria João	MD-13
		Li, Dan	TC-09	Lopes, Rui Borges	TC-23
		Li, Duan	TD-43	Lopez Montoya, Ruben Luis	WA-44
		Li, Jing-An	TD-40	Lopez, Claudia	MD-20
		Li, Jingpeng	WE-05	Lopez, Francisco	MA-16
		Li, Qing	MC-41	Lopez, Pierre	WA-08
		Li, Tz-Chiang	TB-07	Lopez-Herrero, Mj	WA-46

Lorena, Luiz A. N.	TB-02, MD-47	Mahjoub, A. Ridha	TA-10, TB-10	Martin, Alexander	TB-08, TF-16, MB-24, WD-35, TD-38
Lorenzo, Leticia	TA-26	Mahmoudzadeh, Houra	WB-05	Martin, Arnaud	MD-43
Lorenzo-Freire, Silvia	TA-26	Makajic-Nikolic, Dragana	MD-18	Martin, Quentin	TD-04
Losada, Chaya	MC-13	Makarenko, Dmitry	TD-11	Martin, Sébastien	TB-10
Losch, Nadine	MF-18	Maksa, Gyula	TF-34	Martin, Simon	TD-46
Louati, Hekma	MA-37	Makulska, Joanna M.	MF-32	Martin-Campo, Francisco Javier	TC-48
Loukil, Taicir	TA-23	Makuschewitz, Thomas	MC-14	Martinez de Albeniz, Javier	TC-26
Loulou, Richard	WB-32	Malczewisk, Jacek	MF-23	Martinez Sykora, Antonio	MA-15
Lourenço, Helena Ramalhinho	TC-03, TF-13, WC-19	Malliappi, Fotini	WD-22	Martinez, Carme	WA-09
Lourenço, João Carlos	TD-37	Mallor, Fermin	WA-36	Martinez, Cristian	TB-05
Lourenço, Lúcia	MB-07	Mamasis, Konstaninos	TA-17	Martinez, Maria	MA-22
Louzis, Dimitrios	MF-25	Mammadov, Musa	WE-19	Martinez, Yailen	TF-28
Lova, Antonio	MA-04	Mamon, Rogemar	MD-27	Martins, Ana Alexandra	TF-18
Lozano, Antonio J.	MD-16, TA-16	Manaa, Adel	WC-28	Martins, Isabel	MC-32
Lozano, Sebastián	MC-06, TD-06	Manca, Vincenzo	MF-24	Martins, José	TA-19
Luè, Alessandro	WB-27, MB-43	Maneshi, E.	WC-04	Martins, Luís B.	TA-21
Lucas, Helena	TF-47	Manfredotti, Cristina	WE-30	Martins, M. Joao	MB-07
Lucena, Abílio	MB-02	Manger, Robert	WD-28	Martins, Pedro	TB-24
Lucertini, Giulia	WB-37	Mannini, Livia	WB-27	Mas, Marta	WA-09
Lucheroni, Carlo	TF-29	Manolitzas, Panagiotis	TD-30, TF-30	Massei, Gianluca	WA-37
Lucidi, Stefano	TD-43, TA-48	Mansi, Raid	MC-02	Masseti, Emanuele	TB-33
Luckert, Marty	WA-41	Mansini, Renata	MC-03	Massim, Yamani	WA-04
Luhandjula, Monga K	MD-46	Müller, Johannes	TD-38	Massol, Olivier	MC-11
Lukasiak, Piotr	MA-24, MB-24	Müller, Thomas	TC-31	Masuda, Ryuichi	WB-26
Luna, Mônica M. M.	TD-06, WE-18	Müller-Merbach, Heiner	MF-48	Matallin-Saez, Juan Carlos	WC-06
Lundberg, Kristian	TF-42	Maquera, Gladys	MC-37	Mataracioglu, Tolga	MF-11
Lundell, Andreas	WB-35	Maquera, Jorge	MC-37	Mateo, Manuel	WC-07
Luo, Jiabin	TD-40	Mar Molinero, Cecilio	MC-22, MB-31	Mathieu, Fabien	MD-40
Luo, Kai	MA-14	Maratini, Riccardo	WD-27	Matias, João	WE-19
Luptacik, Mikulas	WC-06	Marí, Laura	WC-19	Matos Dias, Joana	WE-35
Luque, Mariano	TD-23	María, Gómez-Rúa	TA-26	Matos, Henrique	TF-35, MD-47
Lusa, Amaia	WA-09	Marín, Alfredo	MD-13, MF-13	Matsuo, Jun	TD-08
Lusby, Richard	TB-17, WC-24, WB-25	Marín, Ángel	MA-16	Mattfeld, Dirk Christian	WB-27
Lust, Thibaut	MA-23	Marín-Solano, Jesús	WC-14	Mattia, Sara	TF-31
Lustosa, Leonardo	TB-43	Marchant, Thierry	TA-30	Mattoo, Rumana	WC-34
Lutsenko, Mikhail	MF-19	Marchese, Mario	MF-40	Matuszyk, Anna	TB-06
Luz, Carlos J.	MB-07	Marcikic, Aleksandra	MA-38	Maugeri, Antonino	WA-48
Luz, Eduardo	WC-05	Marciniak, Dorota	WE-26	Mauri, Geraldo	TB-02, MD-47
Luzanin, Zorana	WB-19	Marecek, Jakub	MF-02	Mautor, Thierry	TB-18
Lyra, Christiano	WC-40, MB-45	Marenco, Javier	MD-29	Mavralexakis, Theodoros	TB-25
Lyytikäinen, Tapani	TA-32	Marentakis, Charis	TF-27, TC-38	Mavri, Maria	MB-13, WD-18, MB-25
		Mareschal, Bertrand	TC-30, TF-37	Mawengkang, Herman	MD-24, TB-24, TA-46
		Margalida, Antoni	MF-24		
M		Margot, Francois	MC-27	May, Angelika	WD-43
Maassen, Klaus-Christian	TF-27	Mariano Junior, Marcio	WE-06, TB-34	Maya, Pablo	WA-17
Maïzi, Nadia	WB-32, TA-37, TB-37, TD-38	Marinkovic, Boban	MF-47	Mazalov, Vladimir	TF-26
Mabin, Vicky	MB-35	Marins, Fernando	TC-32	Mazauric, Vincent	WB-32
Macedo, Mark	WB-05	Markopoulou, Chrysi	MB-38	Mazur, Christoph	MC-33
Macedo, Rita	WE-15	Markov, Michael	WC-23, WD-23, TB-25	Mazza, Rina Mary	TC-27
MacGillivray, Gary	WD-42	Marmion, Marie-Eléonore	TC-42	Mazzoldi, Laura	MC-34
Machado Cardoso Junior, Moacyr	MF-42	Maroti, Gabor	MA-16, MB-16	Mármol, Amparo	MA-38
Macharis, Cathy	MA-12, MC-31, WA-43	Maroto, Concepcion	TC-32	Mäkelä, Marko M.	WD-19, WA-44
Mack, Alexander	WA-06	Marques, Alexandra	MA-32	Mäkinen, Antti	WC-41
Maculan Filho, Nelson	MC-02, WC-02	Marques, Ana	MB-19	Möhrling, Rolf	TA-08
Madas, Michael	TB-08, WA-42	Marques, Carlos	TF-32	Möst, Dominik	TD-33, WC-33, TB-46
Madlener, Reinhard	MA-33, MC-33	Marques, Inês	TD-28	Mbuntcha-Wuntcha, Calvin	MC-29
Madureira, Ana	WC-31	Marques, Rui	TD-06, WB-06	McCaffrey, David	MF-41
Maenhout, Broos	MF-08	Marques, Vitor	MC-36	McCarney, Geoff	WA-41
Magbagbeola, Joshua	TC-11	Marschner, Andreas	TC-31	McCollum, Barry	TD-39
Maggioni, Francesca	MC-28, MA-40	Martín, Jacinto	MA-43	McComb, Sara	TC-35
Magos, Dimitris	MB-10, MF-10, TC-10	Martein, Laura	TC-34	McDonald, David	WB-17
Mahecha, Nancy	WC-44	Martel, Jean-Marc	TF-37	McGarraghy, Seán	MD-40
Mahey, Philippe	TA-21	Martens, David	WC-30	McGill, Jeff	MB-41
		Martens, David	WC-30	Mckenna, Angela	TD-22
		Martic, Milan	TB-42	McKenny, Dan	WA-41

McMahon, Anne M.	TA-12	Milanovic, Zorica	MC-16	Morabito, Reinaldo	MF-34, TA-34
Medeiros, Helena C.	TD-06	Milioni, Armando	MD-06	Moradinezhad, D.	MB-34
Medeossi, Giorgio	MC-16	Miliotis, Panayiotis	MB-10	Morais, A. Jorge	WE-20
Medina, Afonso Celso	TD-40	Milostan, Maciej	MB-24	Morais, Paulo	TF-06
Medina, Rosa	MF-02	Milstein, Irena	TA-33	Morales Matamoros, Oswaldo	WB-39
Meeraus, Alex	WE-35	Min, Hokey	WD-13	Moreau, Yves	MA-24
Mehrjoo, Razieh	TD-36	Mingers, John	MF-48	Moreira Junior, Fernando	MD-38
Meisel, Frank	TB-17	Mingozzi, Aristide	MB-02, TA-02, MD-15, MF-15	Moreno, Luis	MA-03
Meissner, Joern	WD-38, MA-41, WC-45	Minis, Ioannis	TA-17	Moreno, Placido	TD-06
Mekiker, Cagatay	TD-14	Minner, Stefan	WC-38	Moreno-jimenez, José María	MF-12, TC-37
Melachrinoudis, Emanuel	WD-13	Minoux, Michel	WE-33, MA-34	Moreno-Pérez, José A.	TF-13
Melechovsky, Jan	MC-03, WC-15	Miranda, Gara	MF-20	Moretti, Elena	TA-47
Mellano, Mario	WC-27	Miranda, Jaime	WE-18, WD-24	Moretti, Stefano	TF-26
Melo, Teófilo	TB-09	Miranda, Joao	MD-22	Morita, Hiroshi	TA-07
Melo, Teresa	MB-13	Mirbolooki, Mahnaz	MB-06, MD-06	Morita, Shuhei	MA-19
Melo, Wendel	WD-04	Mishra, Nishant	MC-41	Morozova, Elena	TB-09
Meloni, Carlo	MC-04	Missbauer, Hubert	MD-34	Morsi, Antonio	WD-35
Memmedli, Memmedaga	WC-17, MB-18, TB-36	Mitra, Gautam	MA-27	Morton, Alec	MA-30, MC-30, MB-44
Mendes, Armando	WE-20, TD-21	Mitsakis, Evangelos	TA-47	Moscardini, Alfredo	WB-13
Mendes, Maria Fernanda	MA-35	Mittelmann, Hans	TC-21, WC-35	Moser, Albert	WC-33
Mendes-Moreira, João	WC-27	Miyagawa, Masashi	WA-27	Moser, Robin	TA-29
Mendez, Carlos	WC-19	Miyazaki, Kenji	WC-44	Mosquera Rodríguez, Manuel	Alfredo TA-26
Mendonca, Vitor	TA-19	Mkaouar, Arij	MA-37	Mottl, Vadim	WC-23, WD-23
Meneguzzer, Claudio	WD-27	Mladenovic, Nenad	WB-13	Moura, Ana	MC-20, MA-21
Menezes, Mozart	MC-13, TC-13, MC-28	Moccia, Luigi	TB-17, WA-40	Moura, Pedro	MA-02
Menoncin, Francesco	WB-14	Modarres, Mohammad	WC-20, WB-24	Mourão, Cândida	WC-15
Meral, Sedef	TA-14, MA-47	Moeini, Mahdi	MD-45	Mourão-Miranda, Janaina	MD-26
Mercan, Sinan	TD-14	Moeller, Klaus	MF-12, MF-18, TC-35, WC-47	Mourinho, João	MB-23
Merino, María	MA-28	Moench, Lars	WB-07	Mourtos, Yiannis	MB-10, MF-10, TC-10
Merkuryeva, Galina	WC-43	Moewes, Christian	TD-29	Mousa, Abdelrahim	MB-19
Mersha, Ayalew Getachew	MD-42	Moghaddam, Atefeh	MA-04	Mousa, Mohammad	MB-19
Mert, Erkan	MA-31	Mohafid, Abdelmoula	WD-39	Mousseau, Vincent	MC-23, WE-37
Merz, Mirjam	WC-47	Mohais, Arvind	MC-05	Moutari, Salissou	TD-39
Mesa, Juan A.	MD-16, TA-16	Mohamad Raei Naeeni, Sepideh	WE-41	Moutinho, Alexandra	TC-33
Mesgarpour, Mohammad	MC-08	Mohamed, Nurul	TC-17	Mouysset, Sandrine	TF-18
Mesquita, Marta	MF-16	Mohamed, Reghioui	MC-03	Movahedi, Mohammad Mehdi	TD-06
Messina, Enza	TC-24, WE-30	Mohammadian, Ghazaleh	MF-25	Moz, Margarida	MF-16, TB-23, WB-24
Messine, Frederic	WA-35, WB-35, TD-39, TC-43	Mohd Razali, Noraini	MA-03	Mruczkiewicz, Wojciech	MD-24
Messinger, Margaret-Ellen	WC-42	Mohr, Esther	WA-29	Muñoz, Jose	MF-13, TB-13
Messner, Stephan	TF-22	Mojtahedzadeh Sarjami, Shabnam	TA-36	Muñoz, M. Pilar	MB-28
Mestre, Ana	TB-47	Molenaar, Douwe	MA-09	Mucherino, Antonio	MC-02
Mestre, Pedro	WE-19	Molho, Elena	TF-44, WB-44	Muchnik, Ilya	WC-23, WD-23
Mesyagutov, Marat	MF-20	Molina, Julian	TD-04	Mueller, Marlene	WC-46
Meunier, Frédéric	MB-10	Molina-Pariente, Jose M.	MA-04, WC-07, WC-39	Mues, Christophe	WA-20, WB-20, WC-30
Meyer, Christoph Manuel	MD-17	Monaco, M. Flavia	TC-27	Muga, André	TF-32
Meyr, Herbert	MB-14	Moncel, Julien	MD-10	Muguerza, Javier	MC-26
Mezei, József	WA-44	Monge, Juan Francisco	TF-03, MA-41	Mukhopadhyay, Somnath	WD-38
Mezzadri, Malik	MC-29	Monnot, Jerome	TA-10	Mula, Josefa	MB-36
Miandoabchi, Elnaz	WA-05	Monroy, Luisa	MD-43	Mulder, Harm	TC-45
Michaels, Dennis	WC-35	Monsuur, Herman	TD-45	Mulvey, John	MA-25
Michalewicz, Zbigniew	MC-05	Montalvo Arango, Idel	WA-20	Munapo, Elias	WC-20
Michel, Sophie	WB-09	Montana, Giovanni	WD-23	Mund, Inbal	MD-19
Michelon, Philippe	MF-02, WC-35, TA-40	Monteiro, Helena	MA-22	Muniz, José Norberto	TD-04
Middelkoop, Dick	WC-16	Monteiro, José	TF-47	Mur Torrentó, Rubén Javier	MA-39
Midthun, Kjetil	MC-28	Monteiro, M. Teresa Torres	TC-48	Murat, Alper	TA-13, MB-15
Miettinen, Kaisa	TD-23	Monteiro, Paulo	MC-40	Muraviev, Roman	MB-27
Miglierina, Enrico	TF-44, WB-44	Montella, Bruno	WB-16, WA-17	Murray, Alan	MA-13
Miglionico, Giovanna	WA-40	Montemanni, Roberto	WC-25	Murthy, Ishwar	TF-09
Mijangos, Eugenio	WC-19	Montero, Javier	WC-21, MB-37	Murukan Mypalli, Rishil	MF-21
Mika, Marek	WC-39	Montevechi, José Arnaldo	TC-32	Muselli, Marc	WD-37
Milanic, Martin	MD-29	Montibeller, Gilberto	MF-35, TA-35	Mustajoki, Jyri	MA-43
		Montoya, Carlos	WE-28	Mutlu, Esra	TC-38

Mutzel, Petra	MA-02	Nguyen, Viet Phuong	MA-15	Oberti, Pascal	WD-37
Muyldermans, Luc	TC-04, WA-11	Nguyen, Vu Duc	TF-40	Odegaard, Fredrik	MB-22, TC-22
Muzzioli, Silvia	WB-30	Nickel, Stefan	WE-13	Odile, Pourtallier	TD-38
Myllyviita, Tanja	TF-30	Nicolau, João	TA-44	Oggioni, Giorgia	WA-33
Myndyuk, Olga	TF-46	Nicosia, Giuseppe	MF-24	Oguz, Ceyda	MA-04
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Nabona, Narcis	WC-19	Niedziółka, Jerzy W.	TA-32	Oguz, Saziye Deniz	TD-24
Nacima, Labadi	MB-03, MC-03, WC-15	Nielsen, Kurt	WE-43	Ohya, Takao	WD-12
Nagaoka, Sakae	TB-27	Nielsen, Lars	MA-16	Oikonomidis, Anastasios	TF-10
Nagaraj, Guruprasad	MA-22	Nielsen, Lars Relund	MF-32	Ojalehto, Vesa	TD-23
Nagarajan, Mahesh	TB-42	Niemi, Jarkko	TA-32	Oktem, Hakan	TD-24
Nagel, Andrea	MA-17	Niessner, Helmut	MF-22	Okuno, Takayuki	MF-46
Nagy, Gábor	TC-17	Niknejad, Ali	WE-06	Olaso, Pablo	WB-16, MA-28
Nagy, Mariana	MD-22	Nikolai, Tchernev	WA-08	Olivares, Alberto	TA-21, MC-39
Najid, Najib. M.	WD-39	Nikolakakou, Christina D.	TD-48	Oliveira Moreira, Mayron César	TD-04
Nakagawa, Masashi	WD-11	Nikulín, Yury	WA-44	Oliveira Soares, João	WB-30, TD-37
Nakagawa, Yuji	WC-09	Nilsson, Stefan	TA-05	Oliveira, Amílcar	MA-22
Nakai, Toru	MB-45	Nishihara, Michi	MB-27	Oliveira, Arlindo	MF-29
Nalca, Arcan	MD-14	Nishimura, Etsuko	TB-17	Oliveira, Aurelio	WC-40, MB-48, TF-48
Namboothiri, Rajeev	MF-17	Nisse, Nicolas	WD-42	Oliveira, Bruno M.P. M.	MD-19
Nandy, Debaprosanna	MF-07	Nitsch, Daniela	MA-24	Oliveira, Fabrício	MB-33
Naoum-Sawaya, Joe	MD-02	Niu, Yi-Shuai	MF-45	Oliveira, Fernando	TC-33, TB-43, TB-46
Napalkova, Liana	WC-43	Nizamitdinov, Akhlitdin	WC-17	Oliveira, José	WD-08, MA-13, TF-15, WA-31
Nar, Fatih	WE-05	Noailles, Joseph	TF-18	Oliveira, Jose Fernando	MF-20
Narenji, Masoud	MC-12	Noël, Jean-François	WD-37	Oliveira, Lucas	MD-06
Nascimento, João	TF-47	Nobbe, Christoph	WB-45	Oliveira, Luis	MF-33
Nascimento, Mariá C. V.	WB-05	Nobili, Paolo	MA-10	Oliveira, Luis	MF-33
Nash, Jr., John F.	ME-01	Noorollahi, E.	MB-04, MB-34	Oliveira, Manuela Maria	WA-06
Nasrabadi, Ebrahim	MB-09	Norese, Maria Franca	WB-37	Oliveira, Marisa	MB-20
Nasser-Carvalho, Luiz Felipe	TC-35	Nossack, Jenny	MB-08	Oliveira, Marisa	MB-20
Nassiri, N.	WC-44	Nouioua, Karim	WE-05, WC-25	Oliveira, Mónica	TD-30, TB-47
Natalia, Djellab	WB-18	Nouno, Gilbert	MC-29	Oliveira, Mónica	TD-30, TB-47
Nattero, Cristiano	WC-25	Nova, Tertía Delia	TB-24	Oliveira, Pedro	TC-48
Naumann, Marc	MD-16	Novaes, Antonio G.N.	TD-06, TF-17	Oliveira, Rui	TF-37
Naumova, Mariya	TF-46	Novais, Augusto	MB-04, WC-18	Oliveira, Sandra Cristina	WE-41
Naundorf, Jessica	MA-36	Novak, Andreas	MA-39	Oliveira, Teresa	MA-22
Navabi, M.	TD-39, WC-44	Novello, Chiara	WB-37	Olivella, Jordi	WD-24
Navas, Jorge	WC-14	Novo, Vicente	TF-44, WA-44	Olsson, Fredrik	WC-38
Naves, Guylsain	WD-25	Novokmet, Novak	MD-18	Olsson, Hanna	MB-11
Nazari, Asef	TB-09, MF-25	Nowak, Agnieszka K.	TB-06	Omari, Jawad	MD-03, WB-31
Nazarov, Denis	MC-20	Nowak, Ivo	MB-16	Omelchenko, Vadym	TD-46
Nazif, Habibeh	MB-03	Nowak, Tomasz	MD-24	Omerbegovic-Bijelovic, Jasmina	MF-14, MD-33
Néron, Emmanuel	MD-48	Nowe, Ann	TF-28	Omout, Nicolas	TA-37
Neboian, Andrei	MC-33	Noyan, Nilay	TF-04, MA-25, TA-28, MB-45, MC-48	Onal, Mehmet	WB-38
Nediak, Mikhail	MB-41	Nozari, Milad	WE-41	Oner, Kurtulus Baris	WB-11
Nembhard, David	WD-24	Numanagic, Ibrahim	WD-25	Onggo, Stephan	TB-05
Nemery, Philippe	MB-44	Numminen, Emil	MB-25	Onoda, Takashi	WD-47
Nemeth, Sandor Zoltan	MC-09	Nunes Vicente, Luís	WC-21	Onsel, Sule	MA-21, TF-42
Nemirovski, Arkadi	MA-01	Nunes, Alcina	WE-21	Or, Ilhan	TB-33, WD-47
Nenes, George	TB-05	Nunes, Ana Catarina	WC-15	Orbak, Ali Yurdun	TC-36
Neralic, Luka	TC-07	Nunes, Eusebio	TD-36	Orbay, Berk	MB-05
Nesterov, Yurii	WB-40	Nunes, Luís	TF-47	Ordin, Burak	WE-17
Neto, Teresa	MC-32	Nunes, Manuel	TA-18, TA-21	Ordenez, Fernando	TA-05, TA-16, MC-18
Neumann, Ludmila	MF-06	Nunez, Marina	TC-26	Oreskovich, Anne-marie	TD-08
Newman, Alexandra	TB-21	Nurmi, Kimmo	TF-24	Orlin, Jim	MD-29
Newton, Louise	TD-22	Nutt, Paul	MB-35	Orlov, Alexej	WB-47
Ng, Chi To	MC-38	Nygreen, Bjørn	TC-15	Orlovich, Yury	TA-40
Ng, Chi-Kong	TD-43	Nyström, Christina	MB-11, TC-44	Ormeci, E. Lerzan	TC-14
Ng, Kien-Ming	WE-24	O			
Ng, Suk Fung	MF-16	O'Brien, Brendan	WB-30	Orsenigo, Carlotta	TA-42
Ngoc Khanh, Nguyen	MA-31	O'Brien, Frances	MA-35	Ortega, Eva Maria	TD-24
Ngueveu, Sandra Ulrich	MD-15	O'Hanley, Jesse	MC-13, TC-13	Ortega, Francisco A.	MD-13, TA-16
Nguyen Duc, Manh	MF-45	O'Sullivan, Barry	WD-25	Ortega, Isabel	TD-24
Nguyen, Giang	MD-18, MF-18	O'Kelly, Morton E.	MD-37	Ortega, Manuel	MC-26
		Obersteiner, Michael	WC-32	Ortega-Ardila, Joan-Manuel	TC-04
				Ortigosa, Pilar M.	TB-13, TC-43

Ortobelli, Sergio	WC-29	Pankratova, Yaroslavna	WE-26	Pekár, Juraj	MC-03, WB-13
Ortuno, M. Teresa	MB-37	Pankratz, Giseller	MA-17, TF-17	Pecec, Sasa	MA-43, MD-43
Oruc, Sercan	WD-44	Pantelic, Ognjen	TC-05	Peker, Can	MF-11
Osuna, Edgar Elias	TD-42	Paolotti, Luisa	WA-37	Pekkurnaz, Didem	WD-47
Osuna-Gómez, Rafaela	TF-44, WB-44	Paolucci, Massimo	WC-25, TC-27	Pelikan, Jan	WC-28
Otola, Iwona	MF-37	Papadaki, Katerina	TB-25, TF-26	Pelizzari, Cristian	WA-33
Ouelhadj, Djamila	TD-46	Papadopoulos, Christos	TA-24	Pellegrini, Paola	TD-05
Ouerdane, Wassila	MA-43	Papageorgiou, Lazaros	TF-35	Pena, Gloria	MA-03
Ouorou, Adam	WB-35	Papalamprou, Konstantinos	WE-35	Peraza, Edgar	WE-36
Ovchinnikov, Anton	MB-41	Papanagnou, Christos	TA-18	Perea, Federico	MD-16, TA-16
Ozaydin, Ozay	MD-12, MA-21	Pape, Susanne	MB-24	Pereira de Souza, Marcus Vinicius	WB-06
Ozbas, Birnur	WD-47	Papoila, Ana	MA-11	Pereira, Basílio	MA-11
Ozcan, Ender	WA-25, WE-25, TD-46	Paquete, Luis	MA-23	Pereira, Fabio	WB-28
Ozdemir, Ozer	WC-17, TB-36	Paquette, Julie	TB-23	Pereira, Fernando	MC-23, TC-39
Ozdemir, Oznur	MC-41	Parada, Víctor	MF-02	Pereira, Gonçalo	TC-33
Ozdemirel, Nur Evin	WB-04, WD-17	Paradi, Joseph	TB-06	Pereira, Guilherme	MD-14
Ozdinc, Selin	TD-13	Paraskevopoulos, Dimitris	WB-31	Pereira, Ivo	WC-31
Ozel, Gizem	TD-09	Pardalos, Panos	TC-10	Pereira, Jorge	MA-13, TF-15
Ozen, Ulas	TB-14, MB-34	Pardo, Diego	MC-26	Pereira, Sandra	MB-33
Ozener, Okan	MA-17	Paredes, Paula	TF-32	Pereira, Teresa	MD-30
Ozer, Ihsan	WD-40	Parente, Manuel	WE-14	Pereverza, Kateryna	WA-47, WB-47
Ozgül, Onur	TD-19	Park, Jonghyuck	WA-11	Perez Gonzalez, Paz	MA-04, WC-07, WC-39
Ozkan, Sevgi	MF-11, TF-11	Parker, Kim	MC-22	Perez, Garcia	MB-20
Ozkar, Vildan	WC-40	Parkes, Andrew J.	MF-02, WE-05	Perez, Gerardo	MC-42
Ozlu, Ozgur	MB-41	Parlar, Mahmut	MB-41	Perez, Gloria	MA-28
Ozmutlu, Seda	TC-36	Parragh, Sophie	TB-23	Perez, Marcela	MC-37
Ozogur-Akyuz, Sureyya	MF-05, MB-26, MD-26, MA-31	Parreira, Telmo	TB-19	Peris-Blanes, Jordi	TB-12
Ozsen, Leyla	WB-46	Parreno, Francisco	MC-20	Perić, Tunjo	TA-18
Ozsoy, Aykut	MB-40	Pasalic, Enes	MD-29, MF-29	Perko, Igor	TD-44
Ozsoy, Aysegul	WE-21	Pascoal, Marta	TB-23	Perona, Iñigo	MC-26
Ozsoydan, Burcin	TA-09	Pasichny, Alexis	WA-47	Perrot, Nancy	TA-10
Oztekin, Atakan	MC-12	Patay, Emmanuelle	TC-42	Persona, Alessandro	MD-04
Ozturk, Buse	MA-31	Patie, Pierre	WD-14	Pesch, Erwin	MB-08, WC-36
Ozturk, Gurkan	MA-26	Pato, Margarida	MB-07, MF-16, MA-22, TB-23, WB-24, TD-28	Pesneau, Pierre	TB-15
Ozturk, Mercan	MF-33	Patrício, Pedro	MC-40	Pesquita, Catia	MC-24
Ozturk, Pinar	MA-09	Patriksson, Michael	WD-28	Pessoa, Artur	MD-15
P		Patrizi, Giacomo	MB-27	Pessoa, Leonardo	MF-06, MC-35
Pas, David	TC-04	Patrone, Fioravante	TF-26	Peter, Andrea	TB-08
Pacciarelli, Dario	WC-16	Paucar-Caceres, Alberto	MD-44	Peter, Foldesi	WA-46
Pacheco, Joaquín	WB-15	Paulo, Octavio	MA-05	Petersen, Bjørn	MF-15, TD-15, WB-25
Pacheco, Maria F	MB-07	Pauls-Worm, Karin	WC-38	Petrelli, Marco	WA-16
Padoano, Elio	TD-12	Pavón Mendoza, Ruth	TB-32	Petridis, Ilias	TC-38
Pagnoncelli, Bernardo	TB-28	Pavlovic, Ljiljana	WA-09	Petrovic, Dobrila	TD-28
Pahikkala, Tapio	TD-29	Pavone, Mario	MF-24	Petrovic, Sanja	TD-22
Pai, Fan-Yun	WA-10	Pawlak, Grzegorz	TF-07	Petrovic, Slavica P.	MC-31
Paías, Ana	WD-15, MF-16	Pawlak, Krzysztof	TA-32	Peyghami, Mohammad Reza	WD-36
Paillard, Gabriel	MC-02	Pérez Sánchez, Carlos Javier	MA-43	Peypouquet, Juan	MA-07
Paillat, Jean-Marie	MD-44	Pérez, M. Angeles	WA-39	Pflug, Georg	WD-29
Pais, Tiago	WE-24	Pérez-Hurtado, Ignacio	MF-24	Pham Dinh, Tao	MD-45, MF-45, TA-45
Paiva, João	TB-42	Pérez-Jiménez, Mario J.	MF-24	Pham, Hang Phuong	MB-24
Paiva, Renato	MF-34	Peacock, Stuart	MB-30	Phan, Raksmeay	MB-03
Paixão, José	MB-23, TF-32, MA-44	Peccati, Lorenzo	TF-05	Pi, Wei-Ning	TF-18
Palacios, Daniel	WE-26	Pecin, Diego	MD-15	Pichler, Alois	WD-29
Pales, Zsolt	TF-34	Pedro, João	MC-40	Pickenhain, Sabine	TA-39
Paletta, Giuseppe	MC-04	Pedro, Sílvia	TB-24	Pickering, Larry	TA-05
Palma dos Reis, António	TD-21	Pedroso, João Pedro	MF-04, WB-05, MC-32	Picouleau, Christophe	MD-10
Paltayian, George	WA-12	Pedroso, Joao Pedro	WB-29	Pidd, Michael	TB-05
Pan, Quan-Ke	WE-33	Peharda, Irena	TC-45	Pietrasz, Slawomir	WC-37
Panagiotidou, Sofia	TB-05	Peharda, Petra	WD-07	Pimentel, Carina	WC-05, MB-34
Pandelis, Dimitrios	TB-39	Pehlivan, Canan	MA-47	Pina Martins, Francisco	MA-05
Pang, Gu	TC-04	Peidro, David	MB-36	Pina, Joaquim	WB-30
Pang, James Z.	MD-41	Peinhardt, Matthias	MB-29	Pinar, Mustafa	MD-40
Panic, Biljana	TC-05, TA-18	Peixoto Santos, Cristina	TB-48	Pindoria, Sandip	MD-21, TC-21
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- Restrepo, Juan Esteban MC-37
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- Rezaei, Shaghayegh TA-20
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- Ribeiro, Ana TB-39
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Riesgo, Laura	TC-32	Rosenthal, Edward	TC-18	Sahling, Florian	MD-34
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Rinaldi, Francesco	TD-43, TA-48	Rossi, Riccardo	WD-27	Saidani, Nasreddine	TF-13
Rincon-Zapatero, Juan Pablo	WB-14	Rossi, Roberto	MB-34, WC-38	Saikouk, Tarik	WA-10
Ring, Andreas	TC-44	Rostamy-Malkhalifeh, Mohsen	TD-36	Saito, Susumu	TA-38
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Rivero, Carlos	WB-17	Rothblum, Uriel G.	MD-19, TB-45	Saldanha, Ricardo	TC-16
Rivreau, David	WE-28	Rouger, Jean-Louis	TF-26	Saldanha, Rodney	TD-48
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Robinson, Stewart	TD-35	Rousseau, Louis-Martin	TD-15, TA-17, WC-25	Salhi, Said	TC-17
Rocca, Matteo	TF-34	Rousval, Benjamin	WB-37	Saliaris, Dimitrios	TA-17
Rocchi, Lucia	WA-37	Rouvette, Etienne	TC-35	Saliba, Sleman	TB-21
Roch, Oriol	WC-14	Roy, Bernard	MC-23	Salima, Amrouche	WA-18, MD-28
Rocha, Humberto	WC-21, WE-35	Rozenkop, Antoine	WD-25	Salimifard, Khodakaram	WE-24
Rocha, Paula	TF-36	Rozman, Ārtomir	TB-44	Salles, André	TC-19, MC-27
Rodríguez-puerta, Inmaculada	MD-19	Rozycki, Rafal	WC-39	Salman, Sibel	MA-04, TD-13, TF-15, MA-46
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Rodríguez-Sánchez, Sara Verónica	MF-32	Rudec, Tomislav	WD-28	Salmeron, Jose L.	TD-06
Rodrigues, Ana Maria	WC-15	Rudolf, Gabor	MD-29	Salmon, Ioannis	TD-37
Rodrigues, Antonio	TC-09, TD-18, TA-19	Rudzkién, Vitalija	WA-43	Salo, Ahti	MF-06, MA-30, MA-44
Rodrigues, Carlos Diego	MF-02	Rufián-Lizana, Antonio	TF-44, WB-44	Salomon, Valério	TC-32
Rodrigues, Helena Sofia	TC-48	Rufo Bazaga, María Jesús	MA-43	Salouras, Yiannis	TB-08, WA-42
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Rodriguez, J. Tinguaro	MB-37	Ruiz, Ana Belén	TD-23	Sama, Miguel	WA-44
Rodriguez-Chia, Antonio Manuel	MD-13	Ruiz, Bernardo	WC-19	Samarah, Rasha	MB-19
Rodriguez-Ravines, Romy-Elena	MD-28	Ruiz, Daniel	TF-18	Samà, Albert	MC-26
Rodriguez-Uria, Maria Victoria	MC-36	Ruiz, Francisco	TD-23	Sami, Nadia	TF-30
Roidl, Moritz	WA-45	Ruiz, Jose L.	MC-06	Samii, Behzad	TA-43
Rojas-Medar, Marko A.	WB-44	Ruiz, Rubén	WE-33	Sammarra, Marcello	TC-27
Roknedin Eftekhari, Reza	WA-12	Ruiz-Garzón, Gabriel	TF-44	San Matías, Susana	MB-38, TA-48
Roland, Benoît	MF-22	Ruiz-Gazen, Anne	MD-05	Sanatifar, M.	TD-39
Roland, Julien	MD-30	Ruiz-Tagle, Mauricio	MA-12	Sanchez, Elena	MF-07
Rolando, Diana	WB-37	Rupérez Micola, Augusto	TB-46	Sanchez, Francisca	MA-38
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Romanin-Jacur, Giorgio	TB-47	Rusu, Alin	TD-25	Sanchez, Jose Maria	TB-15
Romanova, Tatiana	MA-20	Ruzika, Stefan	MA-23, MB-46	Sancho, Julia	TB-26
Romeijn, Edwin	TC-22, WB-38	Rychlewski, Jeremi	TC-16	Sand, Guido	TB-21
Romero Morales, Dolores	MA-41			Sandrini, Francesco	WE-30
Romero, David	MC-02	S		Sanguineti, Marcello	MF-40
Romeu de Carvalho, Fábio	MF-26, TD-36	S. Pereira, Luis	TF-32	Santana, Roberto	TA-42
Rommelfanger, Heinrich	MA-36	S. Pinto, Leonor	WC-15, MC-46	Santelices, Hugo	TB-32
Ronconi, Débora	TF-08	Saameño, Juan José	TB-13	Santoro, Miguel Cezar	TD-20
Roncoroni, Andrea	WE-29	Saban, Daniela	MD-29	Santos Silva, Carlos	TD-37
Rondier, Pierre	WC-37	Saber, Ibrahim	WC-04	Santos, Ademilton	MB-44
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Roos, Kees	WB-34	Sacone, Simona	TC-27	Santos, Anesio	TF-48
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Ropke, Stefan	TB-17	Sadeh, Arik	MD-20	Santos, Eulália	TA-40
Roque, Luís	TA-23	Sadjadi, Seyed Jafar	WC-09	Santos, João	MC-40
Rosa, Ana	MC-22	Sadjadi, Seyed jafar	MB-03	Santos, Jorge	TD-21
Rosa, Maria J.	WD-21	Sadoghi, Amirhossein	WD-45	Santos, José	MB-23
Rosa, Silvério	MB-42	Sadoune, Mohamed	WB-31	Santos, Lana Mara	TB-32
Rosário, João	TD-21	Sadres, Natanel	TC-42	Santos, Maristela	MD-34
Rosenberg, Ivo	MC-29	Sadykov, Ruslan	MD-08, WB-09	Santos, Nicolau	MF-04
		Safe, Martin	MD-29	Santos, Paula	MF-19
		Safia, Kedad-sdihoum	WB-07	Santos, Ricardo Henrique	TB-32
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		Saharidis, Georgios	WA-40	Sarabando, Paula	TB-30
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Sarrico, Cláudia S.	WD-21	Schulz, Jens	TA-08	Shangari, Nitish	WD-24
Sashima, Akio	TD-08	Schulz, Volker	WB-40	Shapiro, Alexander	WD-02
Sassano, Antonio	MA-10	Schumacher, Andre	WA-25	SharifYazdi, Mehdi	WB-46
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Savin, Sergei	MD-41	Scolnik, Hugo	TC-09	Shen, Siqian	WB-35
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Schönlein, Michael	MC-14	Seixedo, Cristina	MC-12	Siebert, Johannes	MF-30
Schönung, Frank	WB-45	Seker, Sukran	MA-07	Siepak, Marcin	MB-04
Scheerlinck, Karolien	TD-04	Sellami, Khaled	WA-05, TC-18	Signorelli, Marcelo	WC-40
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