EURO PhD School on
Matheuristics

Université de Bretagne-Sud

Lab-STICC, UMR 6285, CNRS

Lorient, France – April 20-28, 2016

Final Report

1 Overview

EPS2016: EURO PhD School 2016 was a gathering of PhD students and young researchers working on the field of Operations Research. During one week, participants have explored the challenging domain of Matheuristics along with its application to the Vehicle Routing Problem (VRP). Additionally, participants have learnt how to make their algorithms available to the research community by means of web services. The EPS2016 has been hosted by the Operations Research Group of the Université de Bretagne-Sud in Lorient, France from April 20th to 28th, 2016. This event was organized with the main financial support of EURO (The Association of European Operational Research Societies).

During EPS2016, experts in the domains of metaheuristics and mathematical programming have joined the participants in an attempt to discover some of the best ways to create optimization algorithms. A computer architect has demonstrated how to implement web services efficiently in order to make the algorithms accessible to other users. The academic programme consisted of a series of lectures together with practical hands-on sessions. In these sessions, participants have developed their own approach to solve one variant of the VRP, and have been able to compare their approach to those implemented by other students.

1.1 Matheuristics

Matheuristics combine the best of two radically different approaches to optimization: mathematical programming and metaheuristics. On the one hand, mathematical programming focuses on understanding and exploiting the underlying structure of the optimization problem, and is generally used to create exact methods (i.e., methods that guarantee to find the optimal solution). On the other hand, metaheuristics are more pragmatical in that they focus on finding good solutions in a small amount of computing time, and for this reason forsake the guarantee of optimality.

In recent years, both schools of optimization have grown towards each other. Researchers in the field of metaheuristics has been attracted towards the sturdy mathematical and theoretical underpinning of the field of mathematical programming, to the existence of ever more powerful solvers, and to the ability of mathematical programming approaches to solve a large number of well-defined problems to optimality. On the other hand, the field of mathematical programming has been attempting to integrate ideas from the field of metaheuristics in an attempt to render its algorithms more efficient and approach the usability of metaheuristics on real-life optimization problems.

1.2 Applications in Vehicle Routing

For many years, vehicle routing problems have attracted researchers and they have developed several methods to solve a large number of variants of these problems. With this EURO PhD School, we would like to contribute to the field as well by developing some matheuristics algorithms for specific variants of the VRP.

1.3 Web-services

Another important aspect of the development of optimization tools is their availability. In most cases, researchers develop their own computer programs and optimization solvers, perfectly tailored to solve one specific class of problems. As soon as they (or somebody else) need to adapt their solver to another type/class of problems, they have to start over again and most probably, they will throw away 80% of the work done previously to keep only small pieces of former computer programs. To make these programs available, one possibility is to transform them in web-services, reachable from any platform and from anywhere in the world where an Internet connection is open.

2   Application

This section details the instructions given for applying to the EPS.

2.1   Eligibility

Participants must be from a EURO member society country (see list on https://www.euro-online.org/), or must be studying in a EURO member society country. They have to be enrolled in a PhD program and, preferably, in an early stage of their studies (first or second year). A maximum number of 20 participants will be accepted (depending on the number of application, this limit might be extended but should stay in a reasonable range).

2.2   Scientific prerequisites

Interested students should have notions of linear programming, mixed integer linear programming, metaheuristics and a programming language (preferably C++).

2.3   Application

Interested students should send the following documents to eps2016@listes.univ-ubs.fr by November 30th, 2015:

- Curriculum vitae (2-5 pages) with the following information:
    - Name, age, affiliation and email address
    - PhD program they are enrolled in, their current stage of studies, and their supervisor's name
    - Their background in linear programming, mixed integer linear programming, metaheuristics, and programming languages studied at undergraduate/graduate level
    - A complete list of publications
- Motivation to attend the school
- An optional request for financial support (EU/ME may decide to support one or two PhD Student for this event)
- A recommendation letter from the supervisor

2.4   Selection

The selection of the participants will be made by the organizing committee no later than December 15th, 2015. Information will be sent directly to the participants.
More than 80 applications have been received and treated. The number of available places were fixed to 20 + 1 local student (not supported by EURO).

2.5   Selected students

Table 1 lists the names and institutions of the selected students. Thanks to a successful search of sponsors, two students were selected for waiving their fees. As usual in EURO, a special attention was reported on students from low currency countries.

Table 1: List of selected students

First Name	Last Name	Institution	Country
Emine	Akyol	University of Pardubice	Czech Republic
Lars	Dahle	Norwegian University of Science and Technology	Norway
Michela	Di Lullo	University of Rome, La Sapienza	Italy
Diana	Huerta	Universitat Politécnica de Catalunya, Barcelona	Spain
Donatas	Kavaliauskas	Vilnius University	Lithuania
Charly	Lersteau	Université de Bretagne-Sud	France
Anna	Melchiori	Italian National Research Council / University of Rome La Sapienza	Italy
Stefano	Michelini	University of Liege – HEC Management school	Belgium
Yves	Molenbruch	Hasselt University	Belgium
Fabio	Neves Moreira	Faculty of Engineering of the University of Porto	Portugal
Joao	Paiva Fonseca	Danmarks Tekniske Universitet	Denmark
Joydeep	Paul	Rotterdam School of Management, Erasmus University	Netherlands
Peter	Popoola	University of KwaZulu-Natal	South Africa
Istenc	Tarhan	Koc University, Istanbul	Turkey
Oscar	Tellez	INSA of Lyon	France
Quentin	Tonneau	Ecole des Mines of Nantes	France
Renata	Turkes	University of Antwerp	Belgium
Anastasios	Varias	Athens University of Economics and Business	Greece
Jorge	Victoria	Université de Technologie de Troyes	France
David	Wolfinger	University of Vienna	Austria
Garazi	Zabalo	University of Siena	Italy

3 Registration fee

Thanks to the sponsors and mainly to EURO and EU/ME, we have been able to keep the fees as low as possible for the participants.

The registration fee is 350€ and includes:

- participation to the EPS2016

- coffee breaks

- lunches

- dinners (except on Sunday)

- accommodation in a shared room with twin bed

- outdoor activities

- local transportation from the hotel to the EPS2016 location and to the outdoor activities

Participants will have to cover their expenses for:

- traveling from their home city to Lorient (and return)

- dinner on Sunday evening

Accommodation requests

- Once selected, participants will be asked to send their arrival and departure dates. The arrival should be on April 20th (Wednesday) the latest in order not to miss the first lecture.

- In case of early arrival in Lorient (before April 20th) the accommodation costs will not be supported by the EPS2016 organization.

- In case a participant has to leave before the last day of the school, it should be communicated to the organizing committee as early as possible.

- Those participants who do not want to share a room will have to pay an extra cost (if and only if the hotel capacity allows it)

4 Output of the EPS for the students

At the end of the course, the students should have a deep understanding of how matheuristics work and should possess of the necessary skills and tools to perform research in this fascinating area.

For those who worked already in the field of Vehicle Routing Problems, they are now able to transfer the new knowledge directly to their problem, for the others, they have tackled with the rest of the group this fascinating application domain and learnt a lot from it.

Finally, the participant approached the web-services in a simple and attractive manner and learnt how to develop their own system. Implementations that have been made during the lab sessions will be transfered to the web-service and ready to use for a large community later.

4.1 Benefits

- complete week of intensive classes on the hot topic matheuristics

- lab sessions to immediately apply new knowledge and competences

- creation of a new community of developers around web-services for OR

Moreover, the social program has been specially designed so that a friendship should arise from the school, creating long term links between the participants and establish future professional collaborations.

For the participants who wanted to start an academic career, it has been and will be very beneficial for their future professional life.

4.2 ECTS

Each participant has been granted with 5 ECTS credits and has received a diploma for his/her participation to the EURO PhD School.

5 Organization team, local support and staff members

5.1 Organizing team

- Daniel Palhazi Cuervo
- Andy Reinholz
- André Rossi
- Marc Sevaux
- Kenneth Sörensen
- Pierre Bomel

5.2 Local support

- Asma Benmessaoud Gabis
- Charly Lersteau
- Florence Palin
- Virginie Guillet
- Sandrine Abribat

5.3 Staff members

- Daniel Palhazi Cuervo – Universiteit Antwerpen (Belgium)
- Pierre Bomel – Université de Bretagne-Sud (France)
- Frédéric Gardi – Innovation24 (France)
- Christian Prins – Université de Technologie de Troyes (France)
- Andreas Reinholz – Institute of Solar Research, DLR (Germany)
- Marc Sevaux – Université de Bretagne-Sud (France)
- Kenneth Sörensen – Universiteit Antwerpen (Belgium)
- Claudia Archetti – Università degli Studi di Brescia (Italy)
- André Rossi – Université d'Angers (France)
- Manuel Ruiz – Artelys (France)

6 Courses and organization

6.1 Organization

This EURO PhD School had focused on the exploration of this challenging new research domain, the matheuristics, and together with the development of open web-services. Experts in the domains of metaheuristics and mathematical programming joined the students in an attempt to discover some of the best ways to create optimization algorithms. In addition, a computer architect demonstrated how web-services for OR tools can be implemented efficiently.

The EPS consisted of a series of lectures, as well as a hands-on workshop in which the students have developed their own approach to solve a given optimization problem and compare it to the approaches of the other students. Figure 1 shows a global overview of the courses and the social program.

Wed. 20	Thu. 21	Fri. 22	Sat. 23	Sun. 24	Mon. 25	Tue. 26	Wed. 27	Thu. 28
Arrivals	Introduction Metaheuristics Matheuristics	Advances in routing problems	Introduction to Local Solver tools	Excursion	Strategy & Web services	Lab session	Lab session	Departures
	lunch break				lunch break			
	Introduction to FICO XPress Optimization suite	Matheuristics for routing problems	Beach Party			Lab session	Lab session	Lab session
Welcome Party	Dinner Le Carré	Dinner Entre Terre et Mer	Pizza party	Free time	Dinner La Taverne du Roi Morvan	Crêperie St-Georges	Gala dinner L'Alhambra	

Figure 1: Organization of the week

6.2 Main lectures

The students have followed main lectures on metaheuristics (Marc Sevaux), matheuristics (André Rossi), Introduction to FICO tools (Manuel Ruiz), Advances in Routing Problems (Christian Prins), Matheuristics for Routing Problems (Claudia Archetti), Introduction to LocalSolver tools (Frédéric Gardi) and Introduction to web-services (Pierre Bomel). During the main lectures on matheuristics, the students will learn some important information about mathematical programming (CPLEX/GUROBI/FICO), about a new mathematical optimization solver (LocalSolver), and how to embed these tools in a C++ programming code.

6.3 Team work

For the interactive workshop, the students have been divided in small teams that have been coached by an experienced researcher. Each team has developed an optimization method for the same and given optimization problem (with variants), using a different approach: e.g., one team may used LocalSolver in combination with other metaheuristics techniques, another team integrated Gurobi/CPLEX together in a matheuristic framework. All these strategies have been proposed by the teams and supervised by the experienced researcher.

All these techniques will be implemented in a web-service platform that is ready for use at a large scale. Implementation and action continue after the EPS.

7   Financial report

First, we want to express our gratitude to the sponsors who have contributed to make this event a success. The most important sponsor is EURO who has implemented the EURO PhD School (EPS) instrument.

Table 2 presents the balanced budget for this event. Income is separated between EURO, the institutions, and private sponsors. Expenses are separated in different categories

Among all the 21 participants, we have been able to waive the fees for two of them, and one local participant did not pay because he was using his own accommodation (he was not sponsored by EURO neither).

Table 2: Add caption

Income		Expenses	
Details	**Amount**	**Details**	**Amount**
Participants		Participants	
Fees	6,300.00 €	accomodation	7,500.00 €
Extra fees for single room	300.00 €	lunches and dinners	2,900.00 €
Accompagny persons	315.00 €		
OR-Groups		Staff	
EURO	10,000.00 €	travel speakers	3,105.00 €
EU/ME	1,500.00 €	accomodation	6,950.00 €
		lunches and dinners	400.00 €
OR societies		Activities	
ROADeF	600.00 €	outdoor activities	1,100.00 €
		gala dinner	1,300.00 €
Institutions		welcome party	360.00 €
Université de Bretagne Sud	1,500.00 €		
		Logistic costs	
Research fondations		Room rental	500.00 €
Lab-STICC	1,000.00 €		
GDR MACS	500.00 €	Other costs	
GDR RO	500.00 €	Sofware licences	1,500.00 €
GDR SOC-SIP	500.00 €		
GDR MOA	600.00 €		
Industrial sponsors			
LocalSolver	1,000.00 €		
Artelys	1,000.00 €		
Total	**25,615.00 €**	**Total**	**25,615.00 €**

8 Sponsors

The organizing committee is very thankful to all the sponsors that have made this event a great success. The following figure lists all the sponsors.