VII ALIO/EURO

Workshop on Applied Combinatorial Optimization

Porto, Portugal, May 4 – 6, 2011

Institutional Support:

ALIO

EURO
The Association of European Operational Research Societies

U.PORTO
FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO

INESCPORTO
LABORATÓRIO ASSOCIADO

Apdio
associação portuguesa de investigação operacional

Sponsors:

PORTO Câmara Municipal – Câmara Municipal do Porto

PORTO SOCIAL FUNDAÇÃO – Fundação para o Desenvolvimento Social do Porto

PORTO Cidade de Ciência – Porto Cidade de Ciência

U.PORTO – Universidade do Porto

FCT Fundação para a Ciência e a Tecnologia – Fundação para a Ciência e a Tecnologia

Institutional support:

ALIO – Asociación Latino-Iberoamericana de Investigación Operativa

EURO The Association of European Operational Research Societies – Association of European Operational Research Societies

INESCPORTO LABORATÓRIO ASSOCIADO – Instituto de Engenharia de Sistemas e Computadores do Porto

U.PORTO FC FACULDADE DE CIÊNCIAS UNIVERSIDADE DO PORTO – Faculdade de Ciências da Universidade do Porto

Apdio associação portuguesa de investigação operacional – Associação Portuguesa de Investigação Operacional

Table of Contents

Local Organizing Committee:

Ana Viana (chair), Instituto Politécnico do Porto / INESC Porto

A, Miguel Gomes, Faculdade de Engenharia da Universidade do Porto / INESC Porto

João Pedro Pedroso, Faculdade de Ciências da Universidade do Porto / INESC Porto

Maria Teresa Costa, Instituto Politécnico do Porto / INESC Porto

Program Committee:

Ana Viana (Portugal)

Andrés Weintraub (Chile)

A. Miguel Gomes (Portugal)

Celso C. Ribeiro (Brazil)

Chris Potts (UK)

Hector Cancela (Uruguay)

Horacio Yanasse (Brazil)

Irene Loiseau (Argentina)

J. Valério de Carvalho (Portugal)

João Pedro Pedroso (Portugal)

M. Grazia Speranza (Italy)

Margarida Vaz Pato (Portugal)

Maria Teresa Costa (Portugal)

Maria Urquhart (Uruguay)

Olivier Hudry (France)

Paolo Toth (Italy)

Rafael Martí (Spain)

Ramon Alvarez-Valdes (Spain)

Richard F. Hartl (Austria)

Rolf Möhring (Germany)

Welcome Note

Dear Conference Participant,

It is our great pleasure to welcome you to Porto and to the 7th edition of the ALIO-EURO workshop in Applied Combinatorial Optimization.

Porto is a city full of tradition and contrasting modernity. House of some of the most awarded contemporary architects in the world, here you can find modern vibrating buildings side by side with walls that preserve centuries of History. You can make a toast (always with Port Wine) at the modernist concert hall building of Casa da Música (House of the Music) or at the old cellars in Vila Nova de Gaia, on the left bank of river Douro. You can explore the renowned contemporary art museum of Serralves and enjoy its wonderful gardens. A stroll in the city park, towards the seaside and the mouth of river Douro is also a must for those who like walking. Plenty of interesting activities that we expect will contribute for good moments of leisure after the workshop.

In ALIO-EURO 2011 there will be presentations covering a wide range of subjects – over 70 high quality presentations and 4 keynote talks by distinguished researchers. We are very grateful to all authors for contributing to the success of the workshop. We hope that this selection will provide each of you with opportunities to learn something new, to discuss and exchange research ideas with other colleagues and to start new collaborations.

The high quality of the program is also due to the strong engagement of the Program Committee and Cluster Organizers in a thorough reviewing process. To all of them we address our sincere acknowledgment.

To conclude, we are grateful to the Faculty of Sciences of the University of Porto for hosting the workshop and for providing all the required facilities, and to all sponsors for the financial support provided.

We wish you a pleasant and fruitful stay in Porto.

The Organizing Committee

General Information

THE CITY OF PORTO

Porto, Oporto in English, is Portugal's second city and capital of the North region. The city is located in the Atlantic coast in the estuary of the Douro river in northern Portugal.

The major touristic attraction is the old city center, classified by UNESCO as a World Heritage. Architectural highlights include the iron bridges of D. Luís and D. Maria, the Cathedral, Igreja de São Francisco (São Francisco Chruc) and Torre dos Clérigos (Tower of Clérigos). The Stock Exchange Palace (Palácio da Bolsa), with its magnificent Arab Room, and São Bento Train Station are also masterpieces of the city. Modern architecture is well represented by Museu de Serralves (contemporary art museum) and Casa da Música.

If the weather is good, a stroll in the City Park, seafront and riverside will definitely provide the visitor with pleasant moments.

No visit to Porto is complete without a visit to the Port Wine Cellars in Vila Nova de Gaia.

If you have the opportunity to extend your stay for a couple of days, you can visit Guimarães (the city centre is also classified as World Heritage Site) and Braga. Or go up the river and visit the home of Port Wine: the Alto Douro wine region, with its beautiful terraced vineyards along the Douro valley.

USEFUL INFORMATION

- **Public Transportation**
  An extensive public transportation network covers the whole city of Porto. Tickets, called *Andante* card, are valid for metro and buses and can be bought at metro stations and major bus stops. You can buy a card with a single ticket (Z2: 1 €) or with 10 + 1 tickets (Z2: 10 €). You need to buy the first *Andante* card (0.50 €), afterwards you can recharge it with additional tickets. The lowest fare is Z2, which is valid to travel within the city limits. There are also 24 hour travel passes (3.60 €, if Z2). The metro runs from 6:00 am to 01:00 am.
  Please note: each *Andante* card can only be used by one person per trip and must always be validated – whenever a journey is commenced, whenever the means of transport changes and independently of ticket type. As you cannot have more than one type of ticket charged in your *Andante*, if coming from the Airport we advise the following procedure: buy the ticket at the airport metro station and charge it with a single Z4 ticket (1.50 €). At the arrival station, charge it with additional tickets (now Z2 fare, if your plan is to stay within the city limits).
  Further details: `http://www.metrodoporto.pt/`.

- **Shopping Hours**
  Shops are generally open from 10.00 to 13.00 and from 14.30 to 19.00 hours, Mondays through Saturdays. Department stores and malls usually open from 10.00 to 23.00 and do not close for lunch.

- **Banks**
  Banks open from Monday to Friday from 8.30 to 15.00. ATM machines can be easily found anywhere in town.

- **Electricity Supply**
  Electricity is supplied at 220 V - 50 Hz AC with European norm plugs.

HOW TO REACH PORTO

- **by plane**
  Getting to Porto is easy and convenient. The airport (Francisco Sá Carneiro International Airport) offers convenient flight connections with most European capitals and cities. There are also direct flights to other major cities, such as New York and Rio de Janeiro. Additional connections via

Lisbon are facilitated by an air bridge between the cities and a train connection between Lisbon and Porto (2h35 trip).

The airport is about 15 km from the city centre to which it is connected by taxi, metro and bus.

A taxi ride to the conference hotels and city centre should be around 25.00 €. Volumes exceeding 55x36x20cm needing to be carried in the luggage compartment have an extra charge.

By metro you should pick line E (violet). To reach the conference venue area leave at Casa da Música. The station is around 20 minutes walking from the conference venue. To go to the city center get out at Trindade Station (Estação da Trindade). The metro runs from 6:00 am to 01:00 am and you must buy a Z4 ticket (1.50 €) for the run from the airport to the centre. For moving within the city, Z2 tickets are required (further details are provided in section Public Transportation).

- **by train**
  There are comfortable trains from Lisbon, *Alpha* and *Intercidades*. The train station is *Estação de Campanhã*, where you can take the metro to the city centre. For information about timetables and prices visit the site of CP (http://www.cp.pt).

CONFERENCE VENUE

The venue for the ALIO-EURO 2011 is the Faculty of Sciences of the University of Porto, Department of Biology, building FC4 (building `I` in Map 1), located in Campo Alegre area and very close to the conference hotels.

Address:

Faculdade de Ciências da Universidade do Porto
Edifício FC4 – Departamento de Biologia
Rua do Campo Alegre, 817
4169 - 007 PORTO

Main entry at Rua do Campo Alegre

FC4 building

HOW TO REACH *FACULDADE DE CIÊNCIAS*

- **by metro**
  The closest Metro Station is *Casa da Música*, about 20 minutes walking from the Faculty.
- **by bus**
  There are several bus stops close to the Faculty. The closest ones are *Planetário*, *Casa das Artes*, *Jardim Botânico* and *Gólgota*.

REGISTRATION

The registration desk will be held at the lobby of building FC4, on Wednesday 4th May, from 8:45 am.

GUIDELINES FOR SESSION CHAIRS

So that a correct coordination between parallel sessions is guaranteed, session chairs are kindly asked to:

1. Contact the speakers before the session, to confirm that they will be present.
2. Report last minute cancellations to the Organizing Committee.
3. Arrive to the conference room 5 minutes before the beginning of the session and check if all presentations have been copied to the laptop provided by the organization.
4. Strictly follow the schedule. Each presentation (including Questions & Answers) should not exceed 25 minutes.
5. If a speaker cancels or does not attend, do not move the following talks backwards.

GUIDELINES FOR SPEAKERS

1. Arrive at your session at least 5 minutes before it begins and copy your presentation to the laptop/desktop available in the room.
2. Time your presentation to fit the allotted time (25 minutes, including Questions & Answers)
3. All conference rooms are equipped with a video projector and laptop/desktop computer.

INTERNET ACCESS

Eduroam wi-fi connection is available in building FC4 (building `I` in Map 1). Free wi-fi connection is available inside and nearby the Computer Science building (building `III` in Map 1).

LUNCH

Lunches will be served at *Círculo Universitário do Porto* (building `II` in Map 1), next to the conference venue (access only from Rua do Campo Alegre).

Address:
Círculo Universitário do Porto
Rua do Campo Alegre, 877
4150 - 180 PORTO

SOCIAL PROGRAM

The conference dinner will take place at Caves Cálem, in Vila Nova de Gaia. Dinner will be preceded by a guided tour to Cálem Port Wine cellars.

A bus will depart from the Faculty at 6.45 pm and pass by Ipanema Porto and Ipanema Park to bring participants to the cellars. After dinner the bus will stop at the same places.

Address:
Caves Cálem
Av. Diogo Leite 312
4430 Vila Nova de Gaia

ACCOMMODATION

(A) **HF IPANEMA PARK** *****
(*800 meters from conference venue*)
Rua de Serralves, 124, 4150-702 Porto
Phone: 00351 225 322 100, Fax: 00351 226 102 809
Email: hfipanemapark@hfhotels.com, Website: http://www.hoteisfenix.com

(B) **HF IPANEMA PORTO** ****
(*900 meters from conference venue*)
Rua do Campo Alegre. 156-172, 4150-169 Porto
Phone: 00351 226 075 059, Fax: 00351 226 063 339
Email: hfipanemaporto@hfhotels.com, Website: http://www.hoteisfenix.com

(C) **HF FÉNIX PORTO** ****
(*1 km from conference venue*)
Rua Gonçalo Sampaio, 282, 4150-226 Porto
Phone: 00351 226 071 800, Fax: 00351 226 071 810
Email: hffenixporto@hfhotels.com, Website: http://www.hoteisfenix.com

(D) **HF TUELA PORTO** ***
(*1 km from conference venue*)
Rua Arquitecto Marques da Silva, 200, 4150-483 Porto
Phone: 00351 226 004 747, Fax: 00351 226 003 709
Email: hftuelaporto@hfhotels.com, Website: http://www.hoteisfenix.com

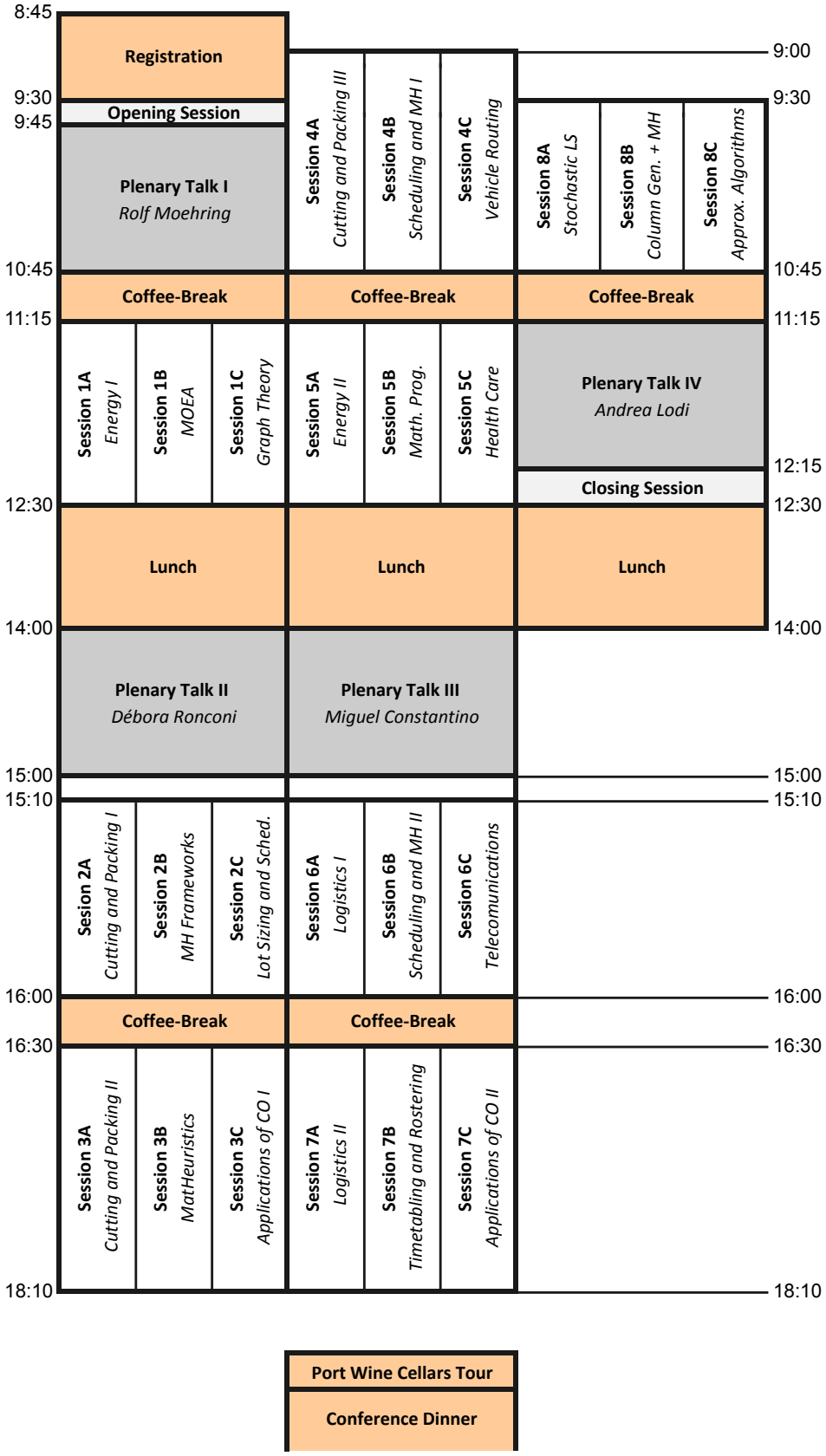
(E) **YOUTH HOSTEL**
(*2 kms from conference venue*)
Rua Paulo da Gama, 551, 4169-006 Porto
Phone: 351 226 177 257, Fax: 351 217 232 101
Email: porto@movijovem.pt, Website: http://microsites.juventude.gov.pt/Portal/en/PPorto.htm

MAPS

Map 1: Campus

Map 2: Campo Alegre area

Program Overview



Scientific Program Schedule

Wednesday, May 4th

9h30 – 9h45

Opening Session (*Room 0.41*)

Welcome Address

9h45 – 10h45

Plenary Talk I (*Room 0.41*)

Chair: Ramón Álvarez-Valdés

I – Routing in Graphs with Applications to Logistics and Traffic
Rolf Moehring

11h15 – 12h30

Session 1A – Energy I (*Room 0.41*)

Chair: Manuel Matos

1A.1 – Multi-Objective Evolutionary Algorithms for Reactive Power Planning in Electrical Distribution Systems: A Comparative Case Study
Dulce Costa, C. Henggeler Antunes, A. Gomes Martins

1A.2 – A new MIP based approach for Unit Commitment in power production planning
Ana Viana, João Pedro Pedroso

1A.3 – Dispatch Hydroelectric Power Plant using Genetic Algorithm
Jessica Pillon Torralba Fernandes, Paulo de Barros Correia

Session 1B – Multiobjective Evolutionary Algorithms (*Room 0.40*)

Chair: Michael Emmerich

1B.1 – Algebraic Group Theory driven Divide and Evolve of multi-objective Problems
Nail El-Sourani, Markus Borschbach

1B.2 – Multi-objective Evolutionary Course Timetabling
Antonio L. Márquez, Consolacion Gil, Raul Baños, Antonio Fernández

1B.3 – Automated Design of Software Architectures for Embedded Systems using Evolutionary Multiobjective Optimization
R. Li, R. Etemaadi, M.T.M. Emmerich, M.R.V. Chaudron

Session 1C – Graph Theory (*Room 0.39*)

Chair: Cristina Requejo

1C.1 – New Characterizations for Subfamilies of Chordal Graphs
Lilian Markenzon, Paulo R.C. Pereira, Christina F.E.M. Waga

1C.2 – Efficient Algorithms for Regionalization: an Approach Based on Graph Partition
Gustavo Silva Semaan, Jose Andre de Moura Brito, Luiz Satoru Ochi

1C.3 – Lagrangean based algorithms for the Weight-Constrained Minimum Spanning Tree Problem
Cristina Requejo, Eulália Santos

14h00 – 15h00

Plenary Talk II (*Room 0.41*)

Chair: Margarida Vaz Pato

II – Recent Developments in Optimization Methods for Scheduling Problems
Debora P. Ronconi

15h10 – 16h00

Session 2A – Cutting and Packing I (*Room 0.41*)

Chair: A. Miguel Gomes

2A.1 – A Heuristic and an Exact Method for Pattern Sequencing Problems
Luigi De Giovanni, Gionata Massi, Ferdinando Pezzella, Marc E. Pfetsch, Giovanni Rinaldi, Paolo Ventura

2A.2 – An integer programming framework for sequencing cutting patterns based on interval graph completion
Isabel Cristina Lopes, J.M Valério de Carvalho

Session 2B – Metaheuristics Frameworks (*Room 0.40*)

Chair: Dorabela Gamboa

2B.1 – OPTFRAME: A Computational Framework for Combinatorial Optimization Problems
Igor Machado Coelho, Pablo Luiz Araújo Munhoz, Matheus Nohra Haddad, Vitor Nazario Coelho, Marcos de Melo da Silva, Marcone Jamilson Freitas Souza, Luiz Satoru Ochi

2B.2 – RAMP: An Overview of Recent Advances and Applications
Dorabela Gamboa, César Rego

Session 2C – Lot Sizing and Scheduling (*Room 0.39*)

Chair: Dolores Romero Morales

2C.1 – A Polyhedral Study of Mixed 0-1 Sets
Agostinho Agra, Mahdi Doostmohammadi

2C.2 – Multi-Objective Economic Lot-Sizing Models
Wilco van den Heuvel, H. Edwin Romeijn, Dolores Romero Morales, Albert P.M. Wagelmans

16h30 – 18h10

Session 3A – Cutting and Packing II (*Room 0.41*)

Chair: Ramón Álvarez-Valdés

3A.1 – An Optimization Model for the Traveling Salesman Problem with Three-Dimensional Loading Constraints
Leonardo Junqueira, José Fernando Oliveira, Maria Antónia Carravilla, Reinaldo Morabito

3A.2 – Rect-TOPOS: A constructive heuristic for the rectilinear packing area minimization problem
Marisa Oliveira, Eduarda Pinto Ferreira, A. Miguel Gomes

3A.3 – Local search methods for leather nesting problems
Pedro Brás, Cláudio Alves, José Valério de Carvalho

3A.4 – Nesting Problems: mixed integer formulations and valid inequalities
Antonio Martinez Sykora, Ramón Álvarez-Valdés, Jose Manuel Tamarit

Session 3B – Matheuristics (*Room 0.40*)

Chair: Vittorio Maniezzo

3B.1 – Matheuristics for Traffic Counter Location
Marco A. Boschetti, Vittorio Maniezzo, Matteo Roffilli, Antonio José Bolufé Röhler

3B.2 – A Matheuristic Algorithm for Auto-Carrier Transportation
Mauro Dell'Amico, Simone Falavigna, Manuel Iori

3B.3 – A new MIP Heuristic based on Randomized Neighborhood Search
Davide Anghinolfi, Massimo Paolucci

3B.4 – Towards an Ant Colony Optimization algorithm for the Two-Stage Knapsack problem
Stefanie Kosuch

Session 3C – Applications of Combinatorial Optimization I (*Room 0.39*)

Chair: Luiz Satoru Ochi

3C.1 – Optimal Parts Allocation for Structural Systems via Improved Initial Solution Generation
Yang Zhang, Horst Baier

3C.2 – Partitioning a service region among several vehicles
John Gunnar Carlsson

3C.3 – A bi-objective approach for selection of sugarcane varieties in Brazilian companies
Margarida Vaz Pato, Helenice de Oliveira Florentino

3C.4 – An Imputation Algorithm Applied to the Nonresponse Problem
José Brito, Nelson Maculan, Luiz Ochi, Flávio Montenegro, Luciana Brito

Thursday, May 5th

9h00 – 10h45

Session 4A – Cutting and Packing III (*Room 0.41*)

Chair: Francisco Parreño

4A.1 – Automatic Generation of Algorithms for the Non Guillotine Cutting Problem
J. Alejandro Zepeda, Víctor Parada, Gustavo Gatica, Mauricio Sepúlveda

4A.2 – Enhancements to the best fit heuristic for the orthogonal stock-cutting problem
Jannes Verstichel, Patrick De Causmaecker, Greet Vanden Berghe

4A.3 – Bi-dimensional Bin-packing Problem: A Multiobjective Approach
A. Fernández, C. Gil, R. Baños, A. L. Márquez, M.G. Montoya, M. Parra

4A.4 – A recursive partitioning approach for generating unconstrained two-dimensional non-guillotine cutting patterns
Ernesto G. Birgin, Rafael D. Lobato, Reinaldo Morabito

Session 4B – Scheduling and Metaheuristics I (*Room 0.40*)

Chair: Angel Juan

4B.1 – A Complete Search Method For Relaxed Traveling Tournament Problem
Filipe Brandão, João Pedro Pedroso

4B.2 – A Hybrid Algorithm for Minimizing Earliness-Tardiness Penalties in Parallel Machines
Fulgencia Villa, Ramón Álvarez-Valdés, José Manuel Tamarit

4B.3 – A hybrid algorithm combining heuristics with Monte Carlo simulation to solve the Stochastic Flow Shop Problem
Esteban Peruyero, Angel A. Juan, Daniel Riera

4B.4 – A Simulation-based algorithm for solving the Vehicle Routing Problem with Stochastic Demands
Angel Juan, Javier Faulin, Daniel Riera, Jose Caceres, Scott Grasman

Session 4C – Vehicle Routing Problem (*Room 0.39*)

Chair: Agostinho Agra

4C.1 – Vehicle routing for mixed solid waste collection – comparing alternative hierarchical formulations
Teresa Bianchi-Aguiar, Maria Antónia Carravilla, José Fernando Oliveira

4C.2 – Branch and Cut and Price for the Time Dependent Vehicle Routing Problem with Time Windows
Said Dabia, Stefan Røpke, Tom Van Woensel, Ton De Kok

4C.3 – An algorithm based on Iterated Local Search and Set Partitioning for the Vehicle Routing Problem with Time Windows
Sabir Ribas, Anand Subramanian, Igor Machado Coelho, Luiz Satoru Ochi, Marcone Jamilson Freitas Souza

4C.4 – A medium term short sea fuel oil distribution problem
Agostinho Agra, Marielle Christiansen, Alexandrino Delgado

11h15 – 12h30

Session 5A – Energy II (*Room 0.41*)
Chair: Manuel Matos

5A.1 – Nash Equilibria in Electricity Markets
Margarida Carvalho, João Pedroso, João Saraiva

5A.2 – Application of Combinatorial Optimization in Natural Gas System Operation
Teresa Nogueira

5A.3 – A Multi-objective EPSO for Distributed Energy Resources Planning
Renan S. Maciel, Mauro da Rosa, Vladimiro Miranda, Antonio Padilha-Feltrin

Session 5B – Mathematical Programing (*Room 0.40*)
Chair: Jacques Desrosiers

5B.1 – On using preprocessing: Cuts identification and probing schemes in stochastic mixed 0-1 and combinatorial optimization
Laureano F. Escudero, M. Araceli Garín, María Merino, Gloria Pérez

5B.2 – Scenario cluster lagrangean decomposition in stochastic mixed integer programming
L.F. Escudero, M.A. Garín, G. Pérez, A. Unzueta

5B.3 – Positive Edge: A Pricing Criterion for the Identification of Non-degenerate Simplex Pivots
Vincent Raymond, Francois Soumis, Abdelmoutalib Metrane, Mehdi Towhidi, Jacques Desrosiers

Session 5C – Health (*Room 0.39*)
Chair: Margarida Vaz Pato

5C.1 – On the transition from fluence map optimization to fluence map delivery in intensity modulated radiation therapy treatment planning
Humberto Rocha, Joana M. Dias, Brígida C. Ferreira, Maria do Carmo Lopes

5C.2 – Hybrid large neighborhood search for the dial-a-ride problem
Sophie N. Parragh, Verena Schmid

5C.3 – An integer programming approach for elective surgery scheduling in a Lisbon hospital
Inês Marques, M. Eugénia Captivo, Margarida Vaz Pato

14h00 – 15h00

Plenary Talk III (*Room 0.41*)
Chair: Laureano Escudero

III – Spatial Forest Optimization
Miguel Constantino

15h10 – 16h00

Session 6A – Logistics I (*Room 0.41*)
Chair: Ana Barbosa-Póvoa

6A.1 – Tackling Freshness in Supply Chain Planning of Perishable Products
Pedro Amorim, Hans-Otto Günther, Bernardo Almada-Lobo

6A.2 – Approaching a robust bi-objective supply chain design problem by a metaheuristic procedure
Yajaira Cardona-Valdés, Ada Álvarez, Joaquín Pacheco

Session 6B – Scheduling and Metaheuristics II (*Room 0.40*)
Chair: Jan Riezebos

6B.1 – A Tabu Search Approach for the Hybrid Flow Shop
Nicolau Santos, João Pedro Pedroso

6B.2 – Sequencing approaches in Synchronous Manufacturing
Jan Riezebos

Session 6C – Telecomunications (*Room 0.39*)
Chair: Henrique Pacca Luna

6C.1 – Affine recourse for the robust network design problem: between static and dynamic routing
Michael Poss, Christian Raack

6C.2 – Solving a Hub Location Problem by the Hyperbolic Smoothing Approach
Adilson Elias Xavier, Claudio Martagão Gesteira, Henrique Pacca Loureiro Luna

16h30 – 18h10

Session 7A – Logistics II (*Room 0.41*)
Chair: Maria Isabel Gomes

7A.1 – A hybrid method to solve a multi-product, multi-depot vehicle routing problem arising in a recyclable waste collection system
Tania Rodrigues Pereira Ramos, Maria Isabel Gomes, Ana Paula Barbosa-Povoa

7A.2 – Design and Planning of Supply Chains with Integrated Forward and Reverse Decisions
Sónia R. Cardoso, Ana Paula F. D. Barbosa-Póvoa, Susana Relvas

7A.3 – Reverse Logistics Network Design for Household Plastic Waste
Xiaoyun Bing, Jacqueline Bloemhof, Jack van der Vorst

7A.4 – Reverse Cross Docking
Juan Pablo Soto, Rosa Colomé Perales, Marcus Thiell

Session 7B – Timetabling and Rostering (*Room 0.40*)
Chair: Dario Landa-Silva

7B.1 – Comparing Roster Patterns within a Single Depot Vehicle-Crew-Roster Problem
Marta Mesquita, Margarida Moz, Ana Paias, Margarida Pato

7B.2 – Insights on the exact resolution of the rostering problem
Marta Rocha, José Fernando Oliveira, Maria Antónia Carravilla

7B.3 – Comparing Hybrid Constructive Heuristics for University Course Timetabling
Dario Landa-Silva, Joe Henry Obit

Session 7C – Applications of Combinatorial Optimization II (*Room 0.39*)
Chair: Miguel Constantino

7C.1 – Lower and upper bounds for large size instances of the optimal diversity management problem
Agostinho Agra, Jorge Orestes Cerdeira, Cristina Requejo

7C.2 – Continous Ant Colony System Applied to Optimization Problems with Fuzzy Coefficients
Luiza Amalia Pinto Cantão, Ricardo Coelho Silva, Akebo Yamakami

7C.3 – A tree search procedure for forest harvest scheduling problems addressing aspects of habitat availability
Teresa Neto, Miguel Constantino, João Pedro Pedroso, Isabel Martins

Friday, May 6th

9h30 – 10h45

Session 8A – Stochastic Local Search (*Room 0.41*)

Chair: Luís Paquete

8A.1 – Automatic Configuration of TPLS+PLS Algorithms for Bi-objective Flow-Shop Scheduling Problems
Jérémie Dubois-Lacoste, Manuel López-Ibáñez, Thomas Stützle

8A.2 – Efficient paths by local search
Luís Paquete, José Luis Santos, Daniel Vaz

8A.3 – Solving a Multiobjective Flowshop Scheduling Problem by GRASP with Path-relinking
Iryna Yevseyeva, Jorge Pinho de Sousa, Ana Viana

Session 8B – Column Generation and Metaheuristics (*Room 0.40*)

Chair: Valério de Carvalho

8B.1 – Stabilized Column Generation for the Rooted Delay-Constrained Steiner Tree Problem
Markus Leitner, Mario Ruthmair, Günther R. Raidl

8B.2 – Heuristics for Discrete Power Control – A Case-Study in Multi-Carrier DSL Networks
Martin Wolkerstorfer, Tomas Nordström

8B.3 – A Hybrid Meta-Heuristic for the Network Load Balancing Problem
Dorabella Santos, Amaro de Sousa, Filipe Alvelos

Session 8C – Approximation Algorithms (*Room 0.39*)

Chair: Irene Loiseau

8C.1 – Modeling the collision avoidance for the ATM by a mixed 0–1 nonlinear approach
Antonio Alonso Ayuso, Laureano F. Escudero, Francisco Javier Martín Campo

8C.2 – Low Energy Scheduling with Power Heterogeneous Multiprocessor Systems
Richard Dobson, Kathleen Steinhöfel

8C.3 – A linear programming approach for adaptive synchronization of traffic signals
Pablo Coll, Pablo Factorovich, Irene Loiseau

11h15 – 12h15

Plenary Talk IV (*Room 0.41*)

Chair: Valério de Carvalho

IV – On Bilevel Programming and its Implications for Mixed Integer Linear Programming
Andrea Lodi

12h15 – 12h30

Closing Session (*Room 0.41*)

Closing Notes

Plenary Talks

I

Routing in Graphs with Applications to Logistics and Traffic

Rolf Moehring*

* *Technische Universität Berlin, Germany*

Traffic management and routing in logistic systems are optimization problem by nature. We want to utilize the available street or logistic network in such a way that the total network "load" is minimized or the "throughput" is maximized. This lecture deals with the mathematical aspects of these optimization problems from the viewpoint of network flow theory and scheduling. It leads to flow models in which – in contrast to static flows – the aspects of "time" and "congestion" play a crucial role.
We illustrate these aspects on several applications:

(1) Traffic guidance in rush hour traffic (cooperation with ptv).

(2) Routing automated guided vehicles in container terminals (cooperation with HHLA).

(3) Ship Traffic Optimization for the Kiel Canal (cooperation with the German Federal Water-ways and Shipping Administration).

All these applications benefit from new insights into routing in graphs. In (1), it is a routing scheme that achieves traffic patterns that are close to the system optimum but still respect certain fairness conditions, while in (2) it is a very fast real-time algorithm that avoids collisions, deadlocks, and other conflicts already at route computation. Finally, (3) uses techniques from (2) and enhances them with special purpose scheduling algorithms.

II

Recent Developments in Optimization Methods for Scheduling Problems

Debora P. Ronconi*

* *Department of Production Engineering, EP-USP, University of São Paulo, Brazil*

In this talk, the combinatorial optimization scheduling problem will be addressed. A few approaches of exact and heuristic nature developed for different variants of scheduling problems will be described to illustrate the vitality of the topic.
Since the seminal paper by Johnson [4], scheduling problems have received significant attention, particularly in recent years with several publications each year. In general words, the scheduling problem consists of the allocation of resources to tasks over time, considering the physical restrictions of the process while optimizing one or more objectives. Resources can be machines in a workshop, processing units in a computing environment, runways at an airport, and so on; while tasks may be operations in a production process, landings at an airport, or executions of computer programs, just to name a few. A task may have a distinct due date, priority or release date. According to Baker [1], to classify the major scheduling models it is necessary to characterize the configuration of resources and the behavior of tasks. For instance, a model may contain one resource type or several resource types. In addition, if the set of tasks available for scheduling does not change over time, the system is called static, in contrast to cases in which new tasks arise over time, where the system is called dynamic. Generally speaking, the scheduling of jobs is a very complex problem due to its combinatorial nature and, amongst the combinatorial optimization problems, it can be classified as one of the most difficult problems. An overview of scheduling models can be found in [5].
In most theoretical scheduling papers, simple measures of performance have been applied, such as, for example, the completion time of the last job on the last machine, known as makespan. In general, the considered criteria are regular, i.e. nondecreasing with the completion time. Among them, we can mention the total tardiness criterion, whose difficulty arises from the fact that tardiness is not a linear function of completion time. On the other hand, scheduling problems involving not regular measures based on both earliness and tardiness costs have also been addressed in many recent studies. This type of problem became important with the advent of the just-in-time (JIT) concept, where early or tardy deliveries are highly discouraged. A practical example can be found in the chemical industry, where different products can be made through the same process and must be mixed as close as possible to a given instant in time to prevent their deterioration. Comprehensive reviews can be found in [2] and [3].
Due the good performance of optimization methods in several problems that appear in industrial settings, this talk will mainly focus on the application and development of optimization methods for job-scheduling problems in different environments. Selected published papers, which comprise problems addressed by the speaker, will be described.

As the solution of practical models is now largely automated by the use of commercial software, we will initially discuss different mixed-integer models that represent a useful scheduling environment: the flowshop problem with no storage constraints aiming to minimize the sum of earliness and tardiness of the jobs (see [8]). The formulation of combinatorial optimization problems such as mixed-integer models opens the possibility of applying different algorithms developed for general and specific problems. Since the pioneering work of Ralph Gomory in the late 1950s, integer programming is one of the fields in operational research that has made the most progress in the past few years. The most popular approaches are cutting planes and enumerations. Within the second approach, we can highlight the branch-and-bound algorithm, which is basically a sophisticated way to perform an enumeration. With the purpose of illustrating the application of this technique to a scheduling problem, a lower bound which exploits properties of the flowshop problem with blocking will be presented (see [6, 7]). In this environment there are no buffers between successive machines, and, therefore, intermediate queues of jobs waiting in the system for their next operations are not allowed. Some examples of blocking can be found in concrete block manufacturing, which does not allow stock in some stages of the manufacturing process.

On the other hand, there are several combinatorial optimization problems that are difficult to solve through the use of methods that are guaranteed to provide an optimal solution. In these cases, heuristic methods are typically used to quickly find solutions that are not necessarily optimal solutions, but are good quality solutions anyway. Due the practical importance of objectives associated with due dates, we will present heuristic approaches that focus on these performance measures. First, a constructive heuristic that explores specific characteristics of the flowshop problem with blocking will be presented [9]. In this case, performance is measured by the minimization of the total tardiness of the jobs. Then a GRASP-based heuristic is proposed, coupled with a path relinking strategy to search for better outcomes. Next, the minimization of the mean absolute deviation from a common due date in a two-machine flowshop scheduling problem will be addressed [11].

An online version of a single machine scheduling problem to minimize total tardiness will also be described. In this problem, orders get to the system randomly. Jobs have to be scheduled without knowledge of what jobs will come afterwards. The processing times and the due dates become known when the order is placed. A customized approximate dynamic programming method will be presented for this problem [10]. This talk will also comment on new research initiatives under development.

[1] K.R. Baker, *Introduction to Sequencing and Scheduling*, Addison-Wesley, John Wiley & Sons, New York, 1974.

[2] K.R. Baker and G.D. Scudder, Sequencing with earliness and tardiness penalties: A review, *Operations Research* 38, pp. 22–36, 1990.

[3] V. Gordon, J.M. Proth and C. Chu, A survey of the state-of-art of common due date assignment and scheduling research, *European Journal of Operational Research* 139, pp. 1–25, 2002.

[4] S.M. Johnson, Scheduling in a two-machine flowshop for the minimization of the mean absolute deviation from a common due date, *Naval Research Logistics Quartely* 1, pp. 61-67, 1954.

[5] M. Pinedo, *Scheduling: theory, algorithms, and systems*, Prentice-Hall, New Jersey, 2008.

[6] D.P. Ronconi, A Branch-and-Bound Algorithm to Minimize the Makespan in a Flowshop with Blocking, *Annals of Operations Research* 138, pp. 53-65, 2005.

[7] D.P. Ronconi and V.A. Armentano, Lower Bounding Schemes for Flowshops with Blocking In-Process, *Journal of the Operational Research Society* 52, pp. 1289-1297, 2001.

[8] D.P. Ronconi and E.G. Birgin, Mixed-integer programming models for flowshop scheduling problems minimizing the total earliness and tardiness, in *Just-in-Time Systems*, Y.A. Ríos-Solís and R.Z. Ríos-Mercado (Eds.), Springer Series on Optimization and Its Applications, P.M. Pardalos and Ding-Zhu Du (Series eds.), 2011, to appear.

[9] D.P. Ronconi and L.S. Henriques, Some Heuristic Algorithms for Total Tardiness Minimization in a Flowshop with Blocking, *Omega* 37, pp. 272-281, 2009.

[10] D.P. Ronconi and W.B. Powell, Minimizing Total Tardiness in a Stochastic Single Machine Scheduling Problem using Approximate Dynamic Programming, *Journal of Scheduling* 13, pp. 597–607, 2010.

[11] C.S. Sakuraba, D.P. Ronconi and F. Sourd, Scheduling in a two-machine flowshop for the minimization of the mean absolute deviation from a common due date, *Computers and Operations Research* 36, pp. 60–72, 2009.

III

Spatial Forest Optimization

Miguel Constantino*

* *Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, Portugal*

Spatial Forest Optimization is concerned with the design of forest landscapes. Forest landscapes evolve along time under the action of opposing forces. Vegetation growth is counterbalanced by natural hazards such as fire and pests, or through human intervention, such as harvesting. In managed forests usually the main objective is to maximize the value of timber harvested. However, other objectives can be considered, such as soil preservation, aesthetic values, biodiversity and wildlife conservation. Landscapes can be intentionally modified in order to accomplish or help to achieve these goals. For modeling purposes, a forest landscape is a region in the plane, composed of a finite number of smaller management units. A finite horizon divided into periods may be considered. Main decisions are, for each unit, either to harvest in some specific period or not harvesting at all. A set of contiguous units with similar characteristics in some time period is called a patch of the forest. The aim of spatial forest optimization is to optimize an objective function while ensuring certain characteristics of some patches.

In this talk we review a few combinatorial optimization problems that arise in the context of spatial forest optimization: One problem is the so-called "harvest scheduling subject to maximum area restrictions" – large harvested patches are forbidden, to prevent erosion and also for aesthetic reasons. Another one consists of selecting a "patch with a minimum required area." Such a patch may represent an old growth region suitable for wildlife habitat. A related problem consists of selecting a (nearly) convex region in the landscape. We introduce a simplified version of this problem and show it can be solved in polynomial time.

IV

On Bilevel Programming and its Implications for Mixed Integer Linear Programming

Andrea Lodi*

* *DEIS, Università degli Studi di Bologna, Italy*

Bilevel programming is a rich paradigm to express a variety of real-world applications including game theoretic and pricing ones. However, what we are interested in this talk is to discuss the bilevel nature of two of the most crucial ingredients of enumerative methods for solving combinatorial optimization problems, namely *branching* and *cutting*.

Specifically, we discuss a new branching method for 0-1 programs called *interdiction branching* [3] that exploits the intrinsic bilevel nature of the problem of selecting a branching disjunction. The method is designed to overcome the difficulties encountered in solving problems for which branching on variables is inherently weak. Unlike traditional methods, selection of the disjunction in interdiction branching takes into account the best feasible solution found so far.

On the cutting plane side, we examine the nature of the so-called separation problem, which is that of generating a valid inequality violated by a given real vector, usually arising as the solution to a relaxation of the original problem. We show that the problem of generating a maximally violated valid inequality often has a natural interpretation as a bilevel program [2]. In some cases, this bilevel program can be easily reformulated as a single-level mathematical program, yielding a standard mathematical programming formulation for the separation problem. In other cases, no reformulation exists yielding surprisingly interesting examples of problems arising in the complexity hierarchies introduced by Jeroslow [1].

[1] R. Jeroslow, "The polynomial hierarchy and a simple model for competitive analysis", *Mathematical Programming*, 32:146–164, 1985.

[2] A. Lodi, T.K. Ralphs, G. Woeginger, "Bilevel Programming and Maximally Violated Valid Inequalities, *Technical Report* OR/11/3, DEIS - Università di Bologna.

[3] A. Lodi, T.K. Ralphs, F. Rossi, S. Smriglio, "Interdiction Branching", *Technical Report* OR/09/10, DEIS - Università di Bologna.

Abstracts

1A.1

Multi-Objective Evolutionary Algorithms for Reactive Power Planning in Electrical Distribution Systems: A Comparative Case Study

Dulce Costa*, C. Henggeler Antunes†, A. Gomes Martins†
*Department of Electrical Engineering, ESTSetúbal – IPS, Portugal †DEEC, University of Coimbra, Portugal

Installation of capacitors in radial electrical distribution power systems is a generalized practice used by the utilities mainly to reduce power losses, improve system stability, perform power factor correction and get a better voltage profile. These benefits are associated with the ability of choosing the appropriate locations and capacity of the equipments to be installed. This problem has been extensively researched over the past decades. Nowadays more flexible optimization tools allow for the computation of solutions to more realistic models. This extended abstract shows how Multi-Objective Evolutionary Algorithms (MOEAs) are adequate tools to tackle this problem and provides a comparative study between some distinct approaches. Some modifications are introduced into an MOEA in order to tailor it to the characteristics of the multi-objective mathematical model.
Keywords: Reactive power compensation, Quality of service, Multi-objective models, Evolutionary algorithms

1A.2

A new MIP based approach for Unit Commitment in power production planning

Ana Viana*‡, João Pedro Pedroso*†
*INESC Porto, †Faculdade de Ciências, Universidade do Porto, Portugal, ‡Polytechnic Institute of Engineering of Porto, Portugal

This paper presents a new iterative algorithm for optimising thermal unit commitment in power generation planning. The approach, based on a mixed-integer formulation of the problem, considers a piecewise linear approximation of the fuel cost function that is dynamically updated to better reflect problem requirements, converging to the optimal solution. After thorough computational tests in a broad set of instances, it showed to be flexible, capable of easily incorporating different problem constraints, and to be able to solve large size problems.
Keywords: Unit Commitment, Approximation Algorithms, Scheduling

1A.3

Dispatch Hydroelectric Power Plant using Genetic Algorithm

Jessica Pillon Torralba Fernandes*, Paulo de Barros Correia*
*Department of Energy, Faculty of Mechanical Engineering, University of Campinas - UNICAMP, Brazil

This paper presents an optimization model for daily operation of Middle Sao Francisco River hydroelectric system in Brazil. The study considers eight hydroelectric power plants – Sobradinho, Luiz Gonzaga, Apolonio Sales, Paulo Afonso I, II, III, IV e Xingo – witch belongs to the Sao Francisco Hydroelectric Company. Its objective is to maximize the hydroelectric power plant efficiency and, simultaneously, to minimize the number of startups and shutdowns of generating units. The technique of resolution is made in two steps: Step 1 determines the load allocated in each hydroelectric power plant at each per hour and Step 2 defines the number of generating units in operation and the load of particular power plant. The mathematical formulation is non-linear mixed integer programs and solved with a Genetic Algorithm (GA) approad, and Linear Programming . This model was implemented with two computation programs, one a commercial optimization solver, and a in house GA solver coded with a programming language of four generation. One of programs was used as interface, while the fourth generation, the optimization model was implemented.
Keywords: Linear and non-linear optimization, Multiobjective optimization, Hydroeletric system, Generating units, Genetic algorithm

1B.1

Algebraic Group Theory driven Divide and Evolve of multi-objective Problems

Nail El-Sourani*, Markus Borschbach*
*Chair of Optimized Systems, University of Applied Sciences, FHDW, Germany

Most real world problems remain as a multi-objective solution space. To overcome the well known computational complexity of such problems, the divide and evolve is a feasible solution, if the sub-problems remain solvable. This paper envisions a road-map, when and how to apply algebraic group theory structures into a multi stage evolutionary approach. It solves certain combinations of objectives from group stage to group stage in a nested group structure, until the reference problem at hand even reaches the distinct solution of the problem. Further, the quality of the solution, i.e. the overall number of steps to reach the solution results in a low number of steps (albeit not the lowest possible). Performance and integrity of this approach are consequently verified.
Keywords: Group theory, Divide and evolve, Evolution strategy, Discrete optimization

1B.2

Multi-objective Evolutionary Course Timetabling

Antonio L. Márquez*, Consolacion Gil*, Raul Baños*, Antonio Fernández*
*University of Almería, Spain

Multi-Objective Evolutionary Algorithms (MOEAs) are highly flexible procedures capable of producing a set of *optimal compromise* solutions called Pareto Front. These solutions represent the best values that can be obtained for each objective without reducing the optimality of the other objectives of the solution. Taking this into account, timetabling problems that are usually dealt with a weighted sum of penalization functions can be considered a multi-objective problem. This paper presents a study of the use of different MOEAs to solve several instances of a particular type of timetabling problems called Course TimeTabling (CTT).
Keywords: Multi-objective, Timetabling, MOEA

1B.3

Automated Design of Software Architectures for Embedded Systems using Evolutionary Multiobjective Optimization

R. Li*, R. Etemaadi*, M.T.M. Emmerich*, M.R.V. Chaudron*
*Leiden Institute of Advanced Computer Science (LIACS), Leiden University, The Netherlands

The design of software architecture for embedded system is one of the big challenges in the research field of modern software engineering. It requires software architects to address a large number of non-functional requirements that can be used to quantify the operation of system. Furthermore, these quality attributes often conflict with each other, for instance, improving system performance often needs more powerful hardware, which could increase the production cost and power consumption in the meantime. In most cases, software designers try to find a set of good architectures by hand. However because of large and combinatorial design space, this process is very time-consuming and error-prone. As a consequence, architects could easily end up with some suboptimal designs. In this paper, we introduce our AQOSA (Automated Quality-driven Optimization of Software Architecture) toolkit which can improve these aforementioned non-functional properties in an automated manner. More precisely, beginning with some initial architectures, AQOSA toolkit can use its optimizer to not only produce several alternatives, but also apply trade-off analysis to these newly created architectures according to multiple attributes of interests.
Keywords: Component-Based Software Architecture, Evolutionary Multiobjective Optimization

1C.1

New Characterizations for Subfamilies of Chordal Graphs

Lilian Markenzon*, Paulo R.C. Pereira†, Christina F.E.M. Waga‡
*NCE – Universidade Federal do Rio de Janeiro, Brazil, †Instituto Militar de Engenharia, Brazil, ‡IME – Universidade do Estado do Rio de Janeiro, Btazil

In this paper, we give new characterizations for some subfamilies of chordal graphs, such as k-intercats and SC k-trees, based on properties of their minimal vertex separators. We also establish the relationship among these families and interval graphs.
Keywords: Chordal graph, k-tree, ur-chordal

1C.2

Efficient Algorithms for Regionalization: an Approach Based on Graph Partition

Gustavo Silva Semaan*, Jose Andre de Moura Brito†, Luiz Satoru Ochi*

*Instituto de Computação – Universidade Federal Fluminense, IC-UFF, Brazil, †Escola Nacional de Ciências Estatísticas – Instituto Brasileiro de Geografia e Estatística, ENCE-IBGE, Brazil

This paper proposes new approaches based on the GRASP and Evolutionary algorithms for the resolution of a specific regionalization problem. This problem can be mapped on a capacity and connectivity graph partition problem. A review of literature showing that the algorithms work only with the edges of the Minimum Spanning Tree is presented. In this case, the algorithms act on the original graph, in order to increase the possibilities of vertex migration. Results obtained from the application of such algorithms over a set of real data suggested that the use of original graphs through them is a new efficient way to solve this problem.

Keywords: Graph Partition Problem, Clustering, Regionalization, Metaheuristics

1C.3

Lagrangean based algorithms for the Weight-Constrained Minimum Spanning Tree Problem

Cristina Requejo*, Eulália Santos*†

*Department of Mathematics, University of Aveiro, Portugal, †School of Technology and Management, Polytechnic Institute of Leiria, Portugal

The Weight-Constrained Minimum Spanning Tree problem (WMST) is a NP-hard combinatorial optimization problem having important applications in the telecommunication networks design and communication networks. We use simple but effective Lagrangean based algorithms to compute lower and upper bounds. Computational results show that the algorithms are fast and present small gap values.

Keywords: Weight-constraints, Constrained minimum spanning tree, Lagrangean relaxation, Heuristics

2A.1

A Heuristic and an Exact Method for Pattern Sequencing Problems

Luigi De Giovanni*, Gionata Massi†, Ferdinando Pezzella†, Marc E. Pfetsch‡, Giovanni Rinaldi§, Paolo Ventura§

*Dipartimento di Matematica Pura e Applicata, Università degli Studi di Padova, Italy †Dipartimento di Ingegneria Informatica Gestionale e dell'Automazione, Università Politecnica delle Marche, Italy‡Technische Universität Braunschweig, §Istituto di Analisi dei Sistemi e Informatica - Antonio Ruberti, CNR, Italy

In many applications, a suitable permutation of patterns (electronic circuit nodes, cutting patterns, product orders etc.) has to be found in order to optimize over some given objective function, so giving rise to the so-called Open Stack Problems. We focus on the Gate Matrix Layout Problem, where electronic circuits are obtained by connecting gates and one seeks a gate layout permutation that minimizes connection costs under restrictions on the circuit area. In the literature, the connection costs and the circuit area are also know as Time of Open Stacks and Maximum Number of Open Stacks, respectively. We propose a genetic algorithm providing heuristic solutions, and a branch-and-cut algorithm, based on a new linear integer programming formulation and representing, at our best knowledge, the first exact approach in the literature. The algorithms are under extensive test, and preliminary results on real instances are presented here.

Keywords: Time of Open Stacks, Maximum Number of Open Stacks, Genetic Algorithms, Integer Linear Programming, Branch-and-Cut

2A.2

An integer programming framework for sequencing cutting patterns based on interval graph completion

Isabel Cristina Lopes*†, J.M Valério de Carvalho†

*ESEIG, Polytechnic Institute of Porto, Portugal, †Department of Production and Systems, University of Minho, Portugal

We derived a framework in integer programming, based on the properties of a linear ordering of the vertices in interval graphs, that acts as an edge completion model for obtaining interval graphs. This model can be applied

to problems of sequencing cutting patterns, namely the minimization of open stacks problem (MOSP). By making small modifications in the objective function and using only some of the inequalities, the MOSP model is applied to another pattern sequencing problem that aims to minimize, not only the number of stacks, but also the order spread (the minimization of the stack occupation problem), and the model is tested.
Keywords: Integer programming, Interval graphs, Sequencing cutting patterns

2B.1

OPTFRAME: A Computational Framework for Combinatorial Optimization Problems

Igor Machado Coelho*, Pablo Luiz Araújo Munhoz*, Matheus Nohra Haddad†, Vitor Nazario Coelho†, Marcos de Melo da Silva*, Marcone Jamilson Freitas Souza†, Luiz Satoru Ochi*
Fluminense Federal University, UFF, Brazil, †Federal University of Ouro Preto, Brazil

This work presents OptFrame, a computational framework for the development of efficient heuristic based algorithms. The objective is to provide a simple C++ interface for common components of trajectory and population based metaheuristics, in order to solve combinatorial optimization problems. Since many methods are very common in literature, we provide efficient implementations for simple versions of these methods but the user can develop "smarter" versions of the methods considering problem-specific characteristics. Moreover, parallel support for both shared-memory and distributed-memory computers is provided. OptFrame has been successfully applied to model and solve some combinatorial problems, showing a good balance between flexibility and efficiency.
Keywords: Framework, Metaheuristics, General Variable Neighborhood Search, TSP, Eternity II

2B.2

RAMP: An Overview of Recent Advances and Applications

Dorabela Gamboa*, César Rego†
Escola Superior de Tecnologia e Gestão de Felgueiras, CIICESI, GECAD, Instituto Politécnico do Porto, Portugal, †School of Business Administration, University of Mississippi, USA

The Relaxation Adaptive Memory Programming (RAMP) metaheuristic approach has been applied to several complex combinatorial optimization problems, exhibiting an extraordinary performance by producing state-of-the art algorithms. We describe some of these applications and consider modeling techniques and implementation details that proved effective in enhancing RAMP algorithms.
Keywords: RAMP, Scatter Search, Cross-Parametric Relaxation, Adaptive Memory, Metaheuristics

2C.1

A Polyhedral Study of Mixed 0-1 Sets

Agostinho Agra*, Mahdi Doostmohammadi*
Department of Mathematics and CIDMA, University of Aveiro, Portugal

We consider a variant of the well-known single node fixed charge network flow set with constant capacities. This set arises from the relaxation of more general mixed integer sets such as lot-sizing problems with multiple suppliers. We provide a complete polyhedral characterization of the convex hull of the given set.
Keywords: Mixed Integer Set, Polyhedral Description, Valid Inequality, Convex Hull

2C.2

Multi-Objective Economic Lot-Sizing Models

Wilco van den Heuvel*, H. Edwin Romeijn†, Dolores Romero Morales‡, Albert P.M. Wagelmans*
Econometric Institute, Erasmus University Rotterdam, The Netherlands, †Department of Industrial and Operations Engineering, University of Michigan, USA, ‡Saïd Business School, University of Oxford, UK

Nowadays, companies are forced to think about their environmental impact and their levels of pollution. In the production setting, pollution stems from the setup of the machinery, the functioning of the machinery during

production as well as from holding inventory. Bearing in mind this environmental awareness, the choice of a production plan can be modeled as a Multi-Objective Economic Lot-Sizing problem, in which we aim at minimizing the total lotsizing costs including production and inventory holding costs, as well as minimizing the total production and inventory emission costs. Different multi-objective optimization models can be obtained depending on time horizon in which the emissions are minimized. We can minimize the emission costs for the whole planning horizon, yielding a bi-objective model (BOLS), or we can minimize the emission costs in each period of the planning horizon yielding a truly multi-objective optimization model (MOLS). In this talk, we aim at describing Pareto efficient solutions for both (BOLS) and (MOLS). We first show that, in general, this task is NP-complete. We then present classes of problem instances for which these Pareto efficient solutions can be found in polynomial time.

Keywords: Lot-sizing, Pollution, Pareto efficient solutions

3A.1

An Optimization Model for the Traveling Salesman Problem with Three-Dimensional Loading Constraints

Leonardo Junqueira*, José Fernando Oliveira†, Maria Antónia Carravilla†, Reinaldo Morabito*

**Departamento de Engenharia de Produção, Universidade Federal de São Carlos, Brazil, †Faculdade de Engenharia, Universidade do Porto, Portugal*

In this paper, we present a mixed integer linear programming model for the traveling salesman problem that considers three-dimensional loading constraints. Computational tests with the proposed model were performed with randomly generated instances using an optimization solver embedded into a modeling language. The results validate the model and show that it is able to handle only problems of a moderate size. However, the model can be useful to motivate future research to solve larger problems, especially when this problem appears as a sub-problem of another problem, as well as modeling the more general vehicle routing problem with three-dimensional loading constraints.

Keywords: Traveling salesman problem, Three-dimensional loading, Combinatorial optimization, Mathematical modeling

3A.2

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

Marisa Oliveira*, Eduarda Pinto Ferreira*†, A. Miguel Gomes‡

**ISEP – Instituto Superior de Engenharia do Porto, Portugal, †GECAD – Knowledge Engineering and Decision Support Research Center, Portugal, ‡INESC Porto, Faculdade de Engenharia, Universidade do Porto, Portugal*

In this paper we propose a constructive heuristic, Rect-TOPOS, to solve the problem of minimizing the enclosing rectangular area that contains, without overlapping, a set of rectilinear pieces (e.g., L and T shaped pieces). This is a NP-hard combinatorial optimization problem, which belongs to the class of cutting and packing problems. To evaluate the Rect-TOPOS heuristic computational tests were performed to validate it for the presented problem. In these tests, instances with different characteristics were used, namely the total number of pieces, and the shaped diversity of the pieces. The results show that this is a heuristic that can quickly and easily to deal with all the rectilinear shaped pieces.

Keywords: Combinatorial optimization, Cutting and packing, Constructive heuristic, Area minimization

3A.3

Local search methods for leather nesting problems

Pedro Brás*, Cláudio Alves*, José Valério de Carvalho*

**Centro ALGORITMI / Departamento de Produção e Sistemas, Universidade do Minho, Portugal*

We describe a set of new local search based algorithms for a real leather nesting problem (LNP) arising in the automotive industry. The problem consists in finding the best layouts for a set of irregular shapes within large natural leather hides with highly irregular contours, and which may have holes and quality zones. Our case study comes from a multinational company that produces car seats. The irregular shapes that must be cut from the hides are pieces of these car seats, and they may contain holes and different quality zones. A relevant characteristic of the problem addressed is that the cutting patterns are not subject to any special constraint that may reduce

the set of feasible solutions, and hence simplify the problem. The directionality constraints arising in the shoe industry are an example of such constraints. Very few solution methods were proposed in the literature for this variant of the LNP. The value of the potential savings contrast with this very small number of contributions. Here, we intend to contribute with new solution methods that embeds a new constructive heuristic that we proposed recently in C. Alves, et al., 2011.

Keywords: Leather nesting, Variable neighbourhood search

3A.4

Nesting Problems: mixed integer formulations and valid inequalities

Antonio Martinez Sykora*, Ramón Álvarez-Valdés*, Jose Manuel Tamarit*

** Universidad de Valencia, Departamento de Estadística e Investigación Operativa, Spain*

Cutting and packing problems involving irregular shapes, usually known as Nesting Problems, are common in industries ranging from clothing and footwear to engineering and shipbuilding. The research publications on these problems are relatively scarce, compared with other cutting and packing problems with rectangular shapes, and have been mostly focused on heuristic approaches. In this paper we propose a new mixed integer formulation for the problem and derive some families of valid inequalities, as a first step for developing an exact Branch & Cut Algorithm.

Keywords: Cutting and Packing, Nesting, Integer Programming

3B.1

Matheuristics for Traffic Counter Location

Marco A. Boschetti*, Vittorio Maniezzo†, Matteo Roffilli†, Antonio José Bolufé Röhler‡

** Dept. Mathematics, University of Bologna, Italy, † Dept. Computer Science, University of Bologna, Italy, ‡ Dept. Artificial Intelligence and Computer Systems, University of Habana, Cuba*

Matheuristic algorithms have begun to demonstrate that they can be the state of the art for some optimization problems. This paper puts forth that they can represent a viable option also in an applicative context. The possibility to get a solution quality validation or a model grounded construction may become a significant competitive advantage against alternative approaches. This view is substantiated in this work by an application on the problem of determining the best set of locations for a constrained number of traffic counters, to the end of estimating a traffic origin / destination matrix. We implemented a Lagrangean heuristic and tested it on instances of different size. A real world use case is also reported.

Keywords: Matheuristics, Traffic counters, Location problems, Real world applications

3B.2

A Matheuristic Algorithm for Auto-Carrier Transportation

Mauro Dell'Amico*, Simone Falavigna*, Manuel Iori*

** DISMI, University of Modena and Reggio Emilia, Italy*

We study a real-world distribution problem arising in the automotive field, in which cars and other vehicles have to be loaded on auto-carriers and then delivered to dealers. The solution of the problem involves both the computation of the routing of the autocarriers along the road network and the determination of a feasible loading for each auto-carrier. We solve the problem by means of a heuristic algorithm that makes use of simple greedy and local search strategies for the routing part, and more complex mathematical modeling and branch-and-bound techniques for the loading part. Preliminary computational results show that good savings on the total routing distance can be obtained within small computational efforts.

Keywords: Vehicle routing, Auto-carrier transportation, Matheuristics

3B.3

A new MIP Heuristic based on Randomized Neighborhood Search

Davide Anghinolfi*, Massimo Paolucci*

** Department of Communication, Computer and Systems Sciences, Genova, Italy*

A new simple MIP heuristic, called Randomized Neighborhood Search (RANS) is proposed, whose purpose is to produce within short time bounds high quality solutions especially for large size MIP problems as the ones

characterizing real industrial applications. Starting from a feasible incumbent solution, RANS explores a neighborhood randomly defined by calling a MIP solver as a black box tool. RANS rationale is similar to the one of other MIP heuristics recently appeared in literature but, differently, it exploits only a randomization mechanism to guide the MIP solver. RANS has some self-tuning rules so that it needs as single input parameter the maximum computation time. This paper also presents a procedure for generating a first feasible solution based on the same randomization concepts, that can be used as an initialization alternative for particularly hard instances. RANS effectiveness is shown by an experimental comparison with other respectively MIP heuristics.
Keywords: Mixed Integer Programming, MIP heuristics, Neighborhood search

3B.4

Towards an Ant Colony Optimization algorithm for the Two-Stage Knapsack problem

Stefanie Kosuch*

**Institutionen för datavetenskap (IDA) Linköppings Universitet, Sweden*

We propose an Ant-Colony-Optimization algorithm for the Two-Stage Knapsack problem (TSKP) with discretely distributed weights. Three heuristic utility measures are proposed and compared. We argue why for the proposed measures it is more efficient to place pheromone on arcs instead of vertices or edges of the complete search graph. Numerical tests show that the algorithm is able to find near optimal or even optimal solutions after a relatively small number of generated solutions.
Keywords: Two-stage model, Knapsack problem, Ant-Colony optimization, Meta-heuristic, Utility ratio

3C.1

Optimal Parts Allocation for Structural Systems via Improved Initial Solution Generation

Yang Zhangr*, Horst Baier*

**Institute of Lightweight Structures, TU München, Germany*

In a mechanical structure, it is often the case that many of the parts are nominally identical. But actually they always differ slightly in physical and geometrical properties due to variation of material and manufacturing error. Parts allocation for a structural system aims at optimizing performance of the manufactured structure by assigning each of these parts to a proper position in the structure during the assembling period. In this paper, the parts allocation problem is addressed and the formulation of it as a nonlinear assignment problem (NAP) is presented. A method is developed to generate an initial solution for it. The technique is tested on benchmark examples. All the results show that it could always construct a high quality starting point from both view of objective and constraint violation. Compared to starting with the identity permutation and randomly generated ones, the standard 2-exchange local search algorithm starting with initial solutions generated by this method well solves most of the test problems in the meantime with a large reduction in total number of function evaluations.
Keywords: Initial solution, Nonlinear assignment problem, Local search, Parts allocation

3C.2

Partitioning a service region among several vehicles

John Gunnar Carlsson*

**Industrial and Systems Engineering, University of Minnesota, USA*

We consider an uncapacitated stochastic vehicle routing problem in which vehicle depot locations are fixed and client locations in a service region are unknown, but are assumed to be i.i.d. samples from a given probability density function. We present an algorithm for partitioning the service region into sub-regions so as to balance the workloads of all vehicles when the service region is simply connected (has no holes) and point-to-point distances follow some "natural" metric, such as any L_p norm. This algorithm can also be applied to load-balancing of other combinatorial structures, such as minimum spanning trees and minimum matchings.
Keywords: Location, Geometry, Algorithms, Vehicle routing

3C.3

A bi-objective approach for selection of sugarcane varieties in Brazilian companies

Margarida Vaz Pato*†, Helenice de Oliveira Florentino

*Instituto Superior de Economia e Gestão, Universidade Téecnica de Lisboa, Portugal, †Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, Portugal, ‡Depto. Bioestatística, Instituto de Biociências, Universidade Estadual Paulista, Brazil

The selection of sugarcane varieties is an important problem faced by sugarcane mill companies confronted by the issue of efficiency and the reduction of damage to the environment. Here the authors present the problem of sugarcane variety selection in the light of technical constraints and the aim to minimize collection and transport costs of the residue from sugarcane harvest and maximize energy obtained from the residue. This problem will be resented and formalized within bi-objective binary linear programming. The study is mainly devoted to the application of a bi-objective genetic algorithm to solve real problems addressed in the São Paulo State of Brazil. Results from the computational experiment undertaken will be reported.

Keywords: Selection of sugarcane varieties, Bi-objective genetic algorithm

3C.4

An Imputation Algorithm Applied to the Nonresponse Problem

José Brito*, Nelson Maculan†, Luiz Ochi‡, Flávio Montenegro§, Luciana Brito°

*ENCE, Escola Nacional de Ciências Estatísticas, Rio de Janeiro,Brazil, †COPPE, Universidade Federal do Rio de Janeiro, Brazil, ‡UFF, Universidade Federal Fluminense, Instituto de Computação, Brazil, §IBGE, Instituto Brasileiro de Geografia e Estatíística, DPE/COMEQ, Brazil, |circ UNIPLI, Centro Universitário Pllínio Leite, Niterói, Brazil

This work describes an imputation algorithm to solve the nonresponse problem in surveys. The nonresponse is associated the occurrence of missing values in at least one variable of at least registry or unit of the survey. In order to prevent the negative effects of nonresponse, an intense research has been produced in this area and many procedures have been implemented. Among these,we detach the imputation methods, that consist basically of substituting a missing value by some suitable one, according some criterion or rule. In this work we propose a new imputation algorithm that combines the clustering method and GRASP metaheuristic.To evaluete its performance we present a set of computational results considering data from Brazilian Demographic Census 2000.

Keywords: Nonresponse, Imputation, Cluster Analysis, GRASP, Survey

4A.1

Automatic Generation of Algorithms for the Non Guillotine Cutting Problem

J. Alejandro Zepeda*, Víctor Parada*, Gustavo Gatica†, Mauricio Sepúlveda*

*Informatics Engineering Department, University of Santiago of Chile, Chile, †Universidad Andrés Bello, Santiago, Chile

There exist several optimization problems for which an efficient solution algorithm have not been found, they are used in decision making for a lot of production and service processes. In practice, hard problems must be solved in an operational, tactical and strategically way inside several organizations. Using this assumption, developing algorithms for finding an approximate solution or "a good solution" is encouraging. The automatic generation of optimization programs is an emerging field of research. The construction of programs is developed through several evolving-nature hyper-heuristics or local search method. We used Genetic Programming to find algorithms rewritten as pseudo-code and analyze them to get new knowledge. The experiment evolved individuals to solve the Non-Guillotine Cutting Stock Problem, a NP-Hard Problem. We tested the population obtained over a data set of instances from literature, the fittest individual averaged 5.4% of material waste and was the object of our analysis. We found interesting blocks of genetic code that resemble intuitive human solutions, and we believe that crafting the terminal and functional elements to facilitate the comparison may help to find interesting even human-competitive algorithms.

Keywords: Genetic programming, Cutting Stock Problem, Algorithms

4A.2

Enhancements to the best fit heuristic for the orthogonal stock-cutting problem

Jannes Verstichel*†, Patrick De Causmaecker†, Greet Vanden Berghe*
*CODeS, KAHO Sint Lieven, Gent, Belgium, †CODeS, KU Leuven Campus Kortrijk, Belgium

We present several enhancements to the best fit heuristic for the orthogonal stock-cutting problem. The solution quality of the heuristic is improved by applying additional placement policies and new orderings of the items. These additions are combined with an optimal time implementation of the heuristic to improve the heuristic's scalability. Experiments on a large test set from the literature show significantly better results in shorter calculation times compared to the original best fit heuristic.
Keywords: Orthogonal stock-cutting, Best fit heuristic

4A.3

Bi-dimensional Bin-packing Problem: A Multiobjective Approach

A. Fernández*, C. Gil*, R. Baños*, A. L. Márquez*, M.G. Montoya*, M. Parra*
*University of Almería, Spain

The bin-packing problem (BPP) and its multi-dimensional variants, have a large number of practical applications, including production planning, project selection, multiprocessor scheduling, packing objects in boxes, etc. The two-dimensional bin packing (2D-BPP) consists of packing a collection of objects (pieces) in the minimum number of bins (containers). This paper works with an extending of the classical single-objective formulation to cope with other designing objectives. It presents a new multi-objective memetic algorithm that uses a population of individuals (agents) that are optimized using evolutionary operators (mutation and crossover) and a local-search optimizer specially designed to solve the MO-2DBPP. The Pareto-optimization concept is used in the selection process. Results obtained in several test problems show the good performance of the memetic algorithm in comparison with other previously proposed approaches.
Keywords: Two-dimensional bin packing problem, Memetic algorithm, Multi-objective optimization

4A.4

A recursive partitioning approach for generating unconstrained two-dimensional non-guillotine cutting patterns

Ernesto G. Birgin*, Rafael D. Lobato*, Reinaldo Morabito†
*Department of Computer Science, Institute of Mathematics and Statistics, University of São Paulo, Brazil,
†Department of Production Engineering, Federal University of São Carlos, Brazil

In this study, a dynamic programming approach to deal with the unconstrained two-dimensional non-guillotine cutting problem is presented. The method extends the recently introduced recursive partitioning approach for the manufacturer's pallet loading problem. The approach involves two phases and uses bounds based on unconstrained two-staged and non-staged guillotine cutting. The method is able to find the optimal cutting pattern of a large number of problem instances of moderate sizes known in the literature and a counterexample for which the approach fails to find known optimal solutions was not found. For the instances that the required computer runtime is excessive, the approach is combined with simple heuristics to reduce its running time. Detailed numerical experiments show the reliability of the method.
Keywords: Cutting and packing, Two-dimensional non-guillotine cutting pattern, Dynamic programming, Recursive approach, Distributor's pallet loading problem

4B.1

A Complete Search Method For Relaxed Traveling Tournament Problem

Filipe Brandão*, João Pedro Pedroso*†
*Faculdade de Ciências, Universidade do Porto, Portugal, † INESC Porto, Portugal

The Traveling Tournament Problem (TTP) is a sports scheduling problem that includes two major issues in creating timetables: home/away pattern feasibility and travel distance. In this problem the schedule must be

compact: every team plays in every time slot. However, there are some sports leagues that have both home/away pattern restrictions and distance limits, but do not require a compact schedule. In such schedules, one or more teams can have a bye in any time slot. This leads us to a variant of the problem: the Relaxed Traveling Tournament Problem (RTTP). We present a complete search method to solve this problem based on branchand-bound, metaheuristics and dynamic programming.
Keywords: Complete search, Dynamic programming, Metaheuristics, Branch-and-bound

4B.2

A Hybrid Algorithm for Minimizing Earliness-Tardiness Penalties in Parallel Machines

Fulgencia Villa*, Ramón Álvarez-Valdés†, José Manuel Tamarit†
*Polytechnic University of Valencia, Dept. Applied Statistics and Operations Research and Quality, Spain,
†University of Valencia, Dept. Statistics and Operations Research, Spain

We consider the problem of scheduling a set of jobs on a set of identical parallel machines where the objective is to minimize the total weighted earliness and tardiness with respect to a common due date. We propose a hybrid heuristic algorithm, combining priority rules for assigning jobs to machines, local search and Path Relinking, with exact procedures for solving the one-machine subproblems. These exact procedures have been developed by our group in a previous study. The algorithm is compared with the best reported results on the same instances in order to assess the efficiency of the proposed strategy.
Keywords: Scheduling, Earliness-tardiness, Metaheuristics

4B.3

A hybrid algorithm combining heuristics with Monte Carlo simulation to solve the Stochastic Flow Shop Problem

Esteban Peruyero*, Angel A. Juan*, Daniel Riera*
* *Open University of Catalonia, Spain*

In this paper a hybrid simulation-based algorithm is proposed for the Stochastic Flow Shop Problem. The main idea of the method- ology is to transform the stochastic problem into a deterministic problem and then apply simulation. To achieve this goal we use Monte Carlo simulation and a modified version of the well-known NEH heuristic. This approach aims to provide flexibility and sim- plicity due to the fact that it is not constrained by any previous assumption and relies in well-tested heuristics.
Keywords: Scheduling, Monte-Carlo simulation, Heuristics, Randomized algorithm

4B.4

A Simulation-based algorithm for solving the Vehicle Routing Problem with Stochastic Demands

Angel Juan*, Javier Faulin†, Daniel Riera*, Jose Caceres*, Scott Grasman‡
* *Open University of Catalonia - IN3, Spain,* ‡*Public University of Navarre, Spain,* ‡*Missouri University of Science & Technology, USA*

This paper proposes a flexible solution methodology for solving the Vehicle Routing Problem with Stochastic Demands (VRPSD). The logic behind this methodology is to transform the issue of solving a given VRPSD instance into an issue of solving a small set of Capacitated Vehicle Routing Problem (CVRP) instances. Thus, our approach takes advantage of the fact that extremely efficient metaheuristics for the CVRP already exists. The CVRP instances are obtained from the original VRPSD instance by assigning different values to the level of safety stocks that routed vehicles must employ to deal with unexpected demands. The methodology also makes use of Monte Carlo Simulation (MCS) to obtain estimates of the expected costs associated with corrective routing actions (recourse actions) after a vehicle runs out of load before completing its route.
Keywords: Metaheuristics, Routing, Scheduling

4C.1

Vehicle routing for mixed solid waste collection – comparing alternative hierarchical formulations

Teresa Bianchi-Aguiar*, Maria Antónia Carravilla*, José Fernando Oliveira*
*INESC–Porto, Faculdade de Engenharia, Universidade do Porto, Portugal

The aim of this paper is to present and compare alternative hierarchical formulations for the periodic vehicle routing problem for solid waste collection. The solution of this problem is a one-week plan of daily routes for the transportation of mixed solid waste from containers to disposal facilities, taking into consideration the frequency of collection of each container within the planning horizon, the road network and the resources available. The objective is to minimize operation costs. The real-world case that supported this study was the collection of mixed solid waste in Ponte de Lima, a municipality in the north of Portugal, and the problem was modelled as a Periodic Vehicle Routing Problem (PVRP) with the additional constraint that routes must pass through one of the alternative disposal facilities before returning to the depot. Based on this real case scenario, we propose a framework of MIP models with three hierarchical approaches besides the monolithic model. The hierarchical approaches are identified by the aggregation of the decisions in each level: (1) assign and route together; (2) assign days first - assign vehicles and route second; (3) assign first - route second and (4) assign days first - assign vehicles second - route third. Some new estimates for downstream constraints were developed and integrated in upstream levels in order to guarantee feasibility.
Keywords: Waste collection, Hierarchical formulations, Periodic vehicle routing

4C.2

Branch and Cut and Price for the Time Dependent Vehicle Routing Problem with Time Windows

Said Dabia*, Stefan Røpke†, Tom Van Woensel*, Ton De Kok*
*Eindhoven University of Technology, School of Industrial Engineering, The Netherlangs, †Denmark University of Technology, Department of Transport, Denmark

In this paper, we consider the Time-Dependent Vehicle Routing Problem with Time Windows (TDVRPTW). Travel times are time-dependent (e.g. due to road congestion), meaning that depending on the departure time from a customer a different travel time is incurred. Because of time-dependency, vehicles' dispatch times from the depot are crucial as road congestion might be avoided. Due to its complexity, all existing solutions to the TDVRPTW are based on (meta-) heuristics and no exact methods are known for this problem. In this paper, we propose the first exact method to solve the TDVRPTW. The MIP formulation is decomposed into a master problem that is solved by means of column generation, and a pricing problem. To insure integrality, the resulting algorithm is embedded in a Branch and Cut framework. We aim to determine the set of routes with the least total travel time. Furthermore, for each vehicle, the best dispatch time from the depot is calculated.
Keywords: Vehicle routing problem, Column generation, Time-dependent travel times, Branch and cut

4C.3

An algorithm based on Iterated Local Search and Set Partitioning for the Vehicle Routing Problem with Time Windows

Sabir Ribas*, Anand Subramanian*, Igor Machado Coelho*, Luiz Satoru Ochi*, Marcone Jamilson Freitas Souza†
*Universidade Federal Fluminense, Niterói, Brazil, †Universidade Federal de Ouro Preto, Brazil

The Vehicle Routing Problem with TimeWindows is a well known optimization problem and it has received a lot of attention in operational research literature. This work proposes a hybrid algorithm that combines the Iterated Local Search metaheuristic, the Variable Neighborhood Descent method and an exact Set Partitioning model for solving it. The computational results demonstrate that the proposed hybrid approach is quite competitive, since out of the 56 test problems considered, the algorithm improved the best known solution in 12 cases and equaled the result of another 27.
Keywords: Vehicle Routing Problem with Time Windows, Hybrid Algorithm, Iterated Local Search, Set Partitioning

4C.4

A medium term short sea fuel oil distribution problem

Agostinho Agra*, Marielle Christiansen†, Alexandrino Delgado‡

Department of Mathematics and CIDMA, University of Aveiro, Portugal, †Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Norway, ‡Department of Mathematics, University of Cape Verde, Cape Verde

We consider a real inventory routing problem occurring in the archipelago of Cape Verde, where an oil company is responsible for the inventory management of multiple fuel oil products and for the routing of ships between the islands. Demands are assumed to be constant over the time horizon of several months. We present a formulation for the problem based on the one given by Christiansen (1999), discuss different extended formulations and compare them for a time horizon of fifteen days. In order to obtain feasible solutions for time horizons of several months, we construct a rolling horizon heuristic that uses the extended formulation that provided best computational results.

Keywords: Maritime transportation, Inventory, Routing, Extended Formulations

5A.1

Nash Equilibria in Electricity Markets

Margarida Carvalho*, João Pedroso*, João Saraiva†

INESC Porto and Faculdade de Ciências, Universidade do Porto, Portugal, †INESC Porto and Faculdade de Engenharia, Universidade do Porto, Portugal

Nash equilibria are solutions for many problems arising in Economics. In a restructured electricity sector, the pool market can be seen as a game where some players, the producers, submit their proposals. The profits of each producer depends on the proposals of the others. So, in this context, the strategies reached by the producers in a Nash equilibria are the best solutions for them. Here we present our work in the development of techniques that can be used for determining Nash equilibria for this game.

Keywords: Nash Equilibria, Energy Sector, Adjustmet Process, Electricity Markets

5A.2

Application of Combinatorial Optimization in Natural Gas System Operation

Teresa Nogueira*

ISEP – Instituto Superior de Engenharia do Porto, Institute of Engineering, Polytechnique Institute of Porto, Portugal

The best places to locate the Gas Supply Units on natural gas systems and their optimal allocation to loads are the key factors to organize an efficient upstream gas infrastructure. In this work we use the P-median problem to locate the GSUs on a gas network and the transportation problem to assign gas demand nodes to the source facilities. Due to its mathematical structure, the application of P-median problem to large networks needs heuristic techniques. This paper presents two Lagrangean heuristics, tested on a realistic network - the primary Iberian natural gas network. Computational results are presented, showing the location arrangement and system total costs.

Keywords: Gas supply units – GSUs, Lagrangean heuristic, P-median problem, Relocation heuristic

5A.3

A Multi-objective EPSO for Distributed Energy Resources Planning

Renan S. Maciel*, Mauro da Rosa†‡, Vladimiro Miranda†‡, Antonio Padilha-Feltrin*

Department of Electrical Engineering, São Paulo State University (UNESP), Brazil, †USE – Power System Unit, INESCPorto, Portugal, ‡FEUP, Faculty of Engineering of the University of Porto, Portugal

There is an increasing interest in Multi-objective optimization (MO) meta-heuristics to solve complex problems. In Power Systems, MO is also under intense investigation applied to traditional problems and mainly to the most recent trends like Distributed Energy Resources (DER) integration or SmartGrids. Therefore, it is proposed a MO approach to the hybrid EPSO method in order to take advantage of its performance improvements. The MO EPSO method, called MEPSO, is applied to a discrete problem of DER impact evaluation on electric distribution network. It was observed a general better performance of MEPSO compared to the NSGA-II method. Despite of being an initial evaluation, the results encourage to exploit the best EPSO characteristics in the MO domain.

Keywords: Multi-objective optimization, Meta-heuristics, EPSO, NSGA-II, DER planning

5B.1

On using preprocessing: Cuts identification and probing schemes in stochastic mixed 0-1 and combinatorial optimization

Laureano F. Escudero*, M. Araceli Garín†, María Merino‡, Gloria Pérez‡

*Dpto. Estadística e Investigación Operativa, Universidad Rey Juan Carlos, Spain, †Dpto. de Economía Aplicada III, Universidad del País Vasco, Spain, ‡Dpto. de Matemática Aplicada, Estadística e Investigación Operativa Universidad del País Vasco, Spain

We present a Branch and Fix Coordination algorithm for solving medium and large scale multi-stage mixed 0-1 & combinatorial optimization problems under uncertainty. The uncertainty is represented via a nonsymmetric scenario tree. The basic idea consists of explicitly rewriting the *nonanticipativity constraints (NAC)* of the 0-1 and continuous variables in the stages with common information. As a result an assignment of the constraint matrix blocks into independent scenario cluster submodels is performed by a compact representation. This partitioning allows to generate a new information structure to express the *NAC* which link the related clusters, such that the explicit *NAC* linking the submodels together is performed by a splitting variable representation The new algorithm has been implemented in a C++ experimental code that uses the open source optimization engine *COIN-OR*, for solving the auxiliary *LP* and mixed 0-1 submodels. Some computational experience is reported to validate the new proposed approach. We give computational evidence of the model tightening effect that have preprocessing techniques in stochastic integer optimization as well, by using the probing and Gomory and clique cuts identification and appending schemes of the optimization engine of choice.

Keywords: Integer Programming, Mathematical Programming, Stochastic integer optimization

5B.2

Scenario cluster lagrangean decomposition in stochastic mixed integer programming

L.F. Escudero*, M.A. Garín†, G. Pérez‡, A. Unzueta†

* Dpto. Estadística e Investigación Operativa, Universidad Rey Juan Carlos, Móstoles (Madrid), Spain, † Dpto. de Economía Aplicada III, Universidad del País Vasco, Bilbao (Vizcaya), Spain, ‡ Dpto. de Matemática Aplicada, Estadística e Investigación Operativa, Universidad del País Vasco, Leioa (Vizcaya), Spain

In this paper we introduce a scenario cluster based Lagrangean Decomposition (LD) scheme for obtaining strong lower bounds to the optimal solution of two-stage stochastic mixed 0-1 problems. At each iteration of the Lagrangean based procedures, the traditional aim consists of obtaining the optimal solution value of the corresponding Lagrangean dual via solving scenario submodels once the nonanticipativity constraints have been dualized. Instead of considering a splitting variable representation over the set of scenarios, we propose to decompose the model into a set of scenario clusters. We compare the computational performance of several Lagrangean dual schemes, as the Subgradient Method, the Volume Algorithm and the Progressive Hedging Algorithm for different number of the scenario clusters and different dimensions of the original problem. Our computational experience shows how the bound value and its computational effort depend on the number of scenario clusters to consider. In any case, the computational experience reported in this extended abstract (as well as the extensive one reported in the full paper) shows that the scenario cluster LD scheme outperforms the traditional LD scheme for single scenarios both in lower bounds's quality and computing effort. All the procedures have been implemented in a C++ experimental code that uses the open source optimization engine *COIN-OR*, for solving the auxiliary *LP* and mixed 0-1 cluster submodels. We also give computational evidence of the model tightening effect that preprocessing techniques have in stochastic integer optimization as well, by using the probing and Gomory and clique cuts identification and appending schemes of the optimization engine of choice.

Keywords: Stochastic integer programming, Lagrangean decomposition, Subgradient, Volume, Progressive hedging algorithm, Scenario clusters

5B.3

Positive Edge: A Pricing Criterion for the Identification of Non-degenerate Simplex Pivots

Vincent Raymond†, Francois Soumis*†, Abdelmoutalib Metrane*, Mehdi Towhidi*, Jacques Desrosiers*‡

*GERAD - Montreal, Canada dagger Ecole Polytechnique de Montreal, Canada, ‡HEC Montreal, Canada

The *Positive Edge* is a new pricing rule for the Primal Simplex: it identifies, with a probability error less than or equal to 2^{-62} in double precision binary floating-point format, variables allowing for non-degenerate pivots. These are identified directly from a short calculation on the original coefficients of the constraint matrix. If such

a variable has a negative reduced cost, it strictly improves the objective function value when entered into the basis. Preliminary computational experiments made with CPLEX and COIN-OR show its high potential.
Keywords: Linear programming, Simplex, Degeneracy

5C.1

On the transition from fluence map optimization to fluence map delivery in intensity modulated radiation therapy treatment planning

Humberto Rocha*, Joana M. Dias*†, Brígida C. Ferreira‡§, Maria do Carmo Lopes§
INESC-Coimbra, Portugal, †Faculdade de Economia, Universidade de Coimbra, Portugal, ‡I3N, Departamento de Física, Universidade de Aveiro, Portugal, §Serviço de Física Médica, IPOC-FG, EPE, Portugal

The intensity modulated radiation therapy (IMRT) treatment planning problem is usually divided in three smaller problems that are solved sequentially: geometry problem, intensity problem, and realization problem. There are many models and algorithms to address each of the problems satisfactorily. However, the last two problems can not be seen separately, because strong links exist between them. In practice, the linkage between these problems is done, most of the time, by rounding, which can lead to a significant deterioration of the treatment plan quality. We propose a combinatorial optimization approach and use a binary genetic algorithm to enable an improved transition from optimized to delivery fluence maps in IMRT treatment planning. A clinical example of a head and neck cancer case is used to highlight the benefits of using a combinatorial optimization approach when linking the intensity problem and the realization problem.
Keywords: Radiotherapy, IMRT, Fluence Map Optimization, Combinatorial Optimization

5C.2

Hybrid large neighborhood search for the dial-a-ride problem

Sophie N. Parragh*, Verena Schmid†
INESC Porto / IBM CAS Portugal, Portugal, †Department of Business Administration, University of Vienna, Austria

Demographic change towards an ever aging population entails an increasing demand for specialized transportation systems to compliment the traditional public means of transportation. Typically, users place transportation requests specifying a pickup and a drop off location and a fleet of minibuses or taxis is used to serve these requests. Those systems are usually referred to as demand responsive transportation systems. The underlying optimization problem can be modeled in terms of a dial-a-ride problem. In the dial-aride problem considered in this article, total routing costs are minimized while respecting time window, maximum user ride time, maximum route duration, and vehicle capacity restrictions. We propose a hybrid large neighborhood search algorithm and compare different hybridization strategies on a set of benchmark instances from the literature.
Keywords: Dial-a-ride, Large neighborhood search, Hybrid

5C.3

An integer programming approach for elective surgery scheduling in a Lisbon hospital

Inês Marques*†, M. Eugénia Captivo*‡, Margarida Vaz Pato*§
Centro de Investigação Operational, Faculdade de Ciências, Universidade de Lisboa, Portugal, †Universidade Lusófona de Humanidades e Tecnologias, FCTS/FEG, Portugal, ‡Universidade de Lisboa, Faculdade de Ciências, DEIO, Portugal, §Instituto Superior de Economia e Gestão, Universidade Técnica de Lisboa, Dept. Matemática, ISEG, Portugal

Elective surgery planning is an important problem for any hospital. In particular, in Portugal, this problem reaches a level of great importance as it has direct relation with an efficient use of the operating theater, which also results on reducing waiting lists for surgery. Thus, a better surgical suite planning has economic and social impact. Both outcomes appear as guidelines of the Portuguese National Health Plan for 2004-2010. The authors present an integer linear programming model approach developed to address the elective surgery planning problem of a hospital in Lisbon, as well as results obtained with real data from the hospital. The results are analyzed in view of the impact on productivity indicators of the surgical suite and, as a consequence, on the hospital's waiting list for surgery.
Keywords: Health Care, Operating rooms, Elective case scheduling, Integer Programming

6A.1

Tackling Freshness in Supply Chain Planning of Perishable Products

Pedro Amorim*, Hans-Otto Günther†, Bernardo Almada-Lobo*

*DEIG, Faculty of Engineering, University of Porto, Portugal, †Department of Production Management, Technical University of Berlin, Germany

Integrated production and distribution planning has received a lot of attention throughout the years and its economic advantages over a decoupled approach is well documented. However, for highly perishable products this integrated approach has to include, further than the economic aspects, the intangible value of customers' willingness to pay, which is related to product freshness. Hence, in this work we explore, through a multi-objective framework, the potential advantages of integrating these two intertwined planning problems at an operational level for this kind of products. We formulate integrated and decoupled models for the case where perishable goods have a fixed and a loose shelf-life in order to test our hypothesis. An illustrative example is used to interpret the models and the results show that the economic benefits derived from using an integrated approach are much dependent on the freshness level of products delivered that the planner is aiming at as well as on the type and degree of perishability the product is subject to.

Keywords: Suppy chain planning, Multi-objective, Perishability

6A.2

Approaching a robust bi-objective supply chain design problem by a metaheuristic procedure

Yajaira Cardona-Valdés*, Ada Álvarez*, Joaquín Pacheco†

*Universidad Autónoma de Nuevo León, México, †Universidad de Burgos, España

We consider the design of a two-echelon production distribution network with multiple manufacturing plants, customers and a set of candidate distribution centers. On this study we incorporate uncertainty on the demand of the customers which is represented through scenarios. As well, there are several transportation options available for each pair of facilities between echelons. Each option represents a type of service with associated cost and time parameters leading an inverse correspondence between them. This tradeoff is handled through a bi–objective optimization model, where the involved objectives should be minimized. Following this approach, one criterion, the corresponding to the robust optimization problem, minimizes the expected cost of facility location, transportation, and the penalty for unmet demand. The other criterion looks for the minimum time to transport the product along any path from the plants to the customers. An estimated Pareto robust front is found using several tabu searches. Preliminary experiments show the computational effect.

Keywords: Robust optimization, Multiobjective optimization, Supply chain, Metaheuristic, Tabu search

6B.1

A Tabu Search Approach for the Hybrid Flow Shop

Nicolau Santos*, João Pedro Pedroso*

*INESC Porto and Faculdade de Ciências, Universidade do Porto, Portugal

In this work we present a metaheuristic based on tabu search, designed with the objective of minimizing makespan in a hybrid flow shop problem. In order to assess the performance of the proposed method we performed tests using both well known benchmarks and randomly generated instances; preliminary results indicate that the approach is valid.

Keywords: Scheduling, Metaheuristics, Flow Shop, Combinatorial Optimization

6B.2

Sequencing approaches in Synchronous Manufacturing

Jan Riezebos*

*University of Groningen, The Netherlands

We consider a sequencing problem in a synchronized manufacturing environment. Order release is an essential part of this system. As orders may differ in the amount and distribution of their capacity requirements over subsequent production stages, total capacity load may vary over time. We encountered this problem in a labor-intensive cellular environment. In practice, heuristics are used to solve this problem, but their effectiveness is questioned. This paper examines heuristics that are based on insights from assembly system designand work load control. The heuristics are evaluated in a rolling schedule environment.

Keywords: Synchronous manufacturing, Bottleneck, Employee scheduling

6C.1

Affine recourse for the robust network design problem: between static and dynamic routing

Michael Poss*, Christian Raack*†

* *Department of Computer Science, Faculté des Sciences, Université Libre de Bruxelles, Belgium,* † *Zuse Institute Berlin (ZIB), Germany*

Affinely-Adjustable Robust Counterparts are used to provide tractable alternatives to (two-stage) robust programs with arbitrary recourse. We apply them to robust network design with polyhedral demand uncertainty, introducing the affine routing principle. We compare the affine routing to the well-studied static and dynamic routing schemes for robust network design. It is shown that affine routing can be seen as a generalization of the widely used static routing still being tractable and providing cheaper solutions. We investigate properties on the demand polytope under which affine routings reduce to static routings and also develop conditions on the uncertainty set leading to dynamic routings being affine. We show however that affine routings suffer from the drawback that (even strongly) dominated demand vectors are not necessarily supported by affine solutions. The proofs and computational results are not presented due to the space restriction.

Keywords: Robust optimization, Network design, Recourse, Affine Adjustable Robust Counterparts, Demand polytope

6C.2

Solving a Hub Location Problem by the Hyperbolic Smoothing Approach

Adilson Elias Xavier*, Claudio Martagão Gesteira*, Henrique Pacca Loureiro Luna†

* *Federal University of Rio de Janeiro, Brazil,* † *Federal University of Alagoas, Brazil*

Hub-and-spoke (HS) network designs arise in transportation and telecommunications systems, where one must flow commodities among spatially separate points and where scale economies can be attained through the shared use of high capacity links. As an alter- native for the discrete approach of selecting as hubs a subset of the existing nodes, this paper explores the possibility of a continuous location for the hubs. Therefore, the problem is to find the least expensive HS network, continuously locating hubs and assigning traffic to them, given the demands between each origin-destination pair and the respective transportation costs. The problem leads to a $min - sum - min$ formulation that is strongly non-differentiable. The proposed method overcomes this difficulty with a smoothing strategy that uses a special differentiable function. The approach is a particular application of the hyperbolic smoothing technique, which has been proven to be able to solve quite efficiently large instances of clustering problems. The final solution is obtained by solving a sequence of differentiable unconstrained optimization subproblems which gradually approach the original problem. The most important feature of the methodology is the low dimension of the subproblems, dependent only on the number of hubs. The efficiency of the method is shown through a set of computational experiments with large continuous hub-and-spoke problems.

Keywords: Hub Location, Min-Sum-Min Problems, Global Optimization, Non-differentiable Programming, Hyperbolic Smoothing

7A.1

A hybrid method to solve a multi-product, multi-depot vehicle routing problem arising in a recyclable waste collection system

Tania Rodrigues Pereira Ramos*‡, Maria Isabel Gomes†, Ana Paula Barbosa-Povoa‡

* *Instituto Universitário de Lisboa (ISCTE-IUL), Portugal,* † *CMA - FCT, Universidade Nova Lisboa, Portugal,* ‡ *CEG-IST, Universidade Técnica de Lisboa, Portugal*

The present work aims to support tactical and operational decisions in recyclable waste collection systems, focusing on the delimitation of service areas in systems with more than one depot, and on vehicle routes definition. The problem is modelled as a multi-product, multi-depot vehicle routing problem. Due to problem solution complexity, a hybrid method based on two mathematical formulations and one heuristic procedure is developed as a solution method. The method proposed is applied to a large scale problem based on a real case study of a recyclable waste collection system, where three types of recyclable materials have to be collected.

Keywords: Multi-depot, Vehicle routing, Hybrid method, Recyclable waste collection system

7A.2

Design and Planning of Supply Chains with Integrated Forward and Reverse Decisions

Sónia R. Cardoso*, Ana Paula F. D. Barbosa-Póvoa*, Susana Relvas*
* *CEG-IST, UTL, Portugal*

Markets increasing competition, coupled with a growing concern with the environment has created a need to increase supply chains' sustainability. To achieve this, the supply chain should integrate reverse logistics activities. In this paper, a mixed integer linear programming formulation is developed for the design and planning of supply chains while considering simultaneously production and reverse logistics activities with the goal of maximizing the net present value. The model is applied to a case study where forward and reverse activities are considered. A sensitivity analysis is performed in order to assess the resulting changes on the optimal solution.
Keywords: Reverse Logistics, Optimisation, Design, Planning

7A.3

Reverse Logistics Network Design for Household Plastic Waste

Xiaoyun Bing*, Jacqueline Bloemhof*, Jack van der Vorst*
* *Wageningen University and Research Center, Logistics, Decision and Information Sciences, The Netherlands*

This paper applies MILP methods to improve the network design of reverse logistics for household plastic waste based on the case of Netherlands. The purpose is to provide decision support for various stakeholders in choosing the most suitable recycling collection methods with an optimized network design that both balances their interests and improves the recycling efficiency. Separation method determines whether the quality and quantity of the plastics material is high enough to be economically efficient and environmentally effective. Currently, source separation (separation at households) is dominating as suggested by legislation. However, since the overall collection rate is not satisfying, municipalities are trying different ways to deal with plastic waste. There is a need to adopt the system according to the characteristics of the municipalities. This research follows the approach of scenario study. We start with the simulation of the current situation followed by investigating the impacts of various changes in the collection system. For each scenario, we suggest improvement in the network by repositioning the locations for separation, sorting and reprocessing sites.
Keywords: Reverse logistics, Network design, Mixed integer linear programming, Plastic recycling

7A.4

Reverse Cross Docking

Juan Pablo Soto*, Rosa Colomé Perales†, Marcus Thiell*
* *UniAndes School of Management, Colombia,* † *ESCI, Universitat Pompeu Fabra, Barcelona*

Nowadays companies are facing an important challenge in their distribution, as frequent deliveries and small order sizes are the common rule today. For this type of distribution, cross-docking is a logistics activity that generates several advantages like reduction in lead times and manipulation costs. In addition, Reverse Logistics (RL) has achieved more importance in recent years within the business world. In particular companies with fashion products are introducing RL activities to recover and, in most cases, resale the products through the same or through different channels of distribution like outlets, secondary markets, or internet, with the purpose to recapture value. Despite of the success of cross-docking in distribution, the concept has not been applied for the reverse flow so far. In this paper we propose a linear programming model that allows the use of cross-docking in a Reverse Logistics context, where returned products can be redirected to the outlets chain without storage.
Keywords: Reverse Logistics, Cross-docking

7B.1

Comparing Roster Patterns within a Single Depot Vehicle-Crew-Roster Problem

Marta Mesquita*, Margarida Moz†, Ana Paias‡, Margarida Pato†
* *ISA-UTL, CIO, Portugal,* † *ISEG-UTL, CIO, Portugal,* ‡ *DEIO-FCUL, CIO, Portugal*

The integrated vehicle-crew-roster problem aims to simultaneously determine minimum cost vehicle and daily crew schedules that cover all timetabled trips and a minimum cost roster covering all daily crew duties according

to a pre-defined days-off pattern. This problem is solved by a heuristic approach based on Benders decomposition that iterates between the solution of an integrated vehicle-crew scheduling problem and the solution of a rostering problem. Computational experience with data from two bus companies in Portugal is used to compare two rostering patterns within vehicle-crew-roster solutions.
Keywords: Rostering, vehicle-scheduling, crew-scheduling, Benders decomposition

7B.2

Insights on the exact resolution of the rostering problem

Marta Rocha*, José Fernando Oliveira*, Maria Antónia Carravilla*
**DEIG, Faculdade de Engenharia da Universidade do Porto, Portugal*

The purpose of this paper is to present some findings on the rostering problem resolution through the analysis of a real case study. The problem is initially formulated as a mixed integer problem (MIP) and solved with CPLEX, using the ILOG OPL Studio environment. The achieved findings and results are the basis for the development of a constructive heuristic that consistently reaches a feasible solution, which is the optimal solution in this particular case, in a shorter period of time than the MIP model.
Keywords: Rostering, Staff scheduling

7B.3

Comparing Hybrid Constructive Heuristics for University Course Timetabling

Dario Landa-Silva*, Joe Henry Obit†
**ASAP Research Group, School of Computer Science, University of Nottingham, United Kingdom, †Labuan School of Informatics Science, University Malaysia Sabah, Malaysia*

This extended abstract outlines four hybrid heuristics to generate initial solutions to the University course timetabling problem. These hybrid approaches combine graph colouring heuristics and local search in different ways. Results of experiments using two benchmark datasets from the literature are presented. All the four hybrid initialisation heuristics described here are capable of generating feasible initial timetables for all the test problems considered in these experiments.
Keywords: Course timetabling, Hybrid heuristics, Event scheduling, Constructive heuristics

7C.1

Lower and upper bounds for large size instances of the optimal diversity management problem

Agostinho Agra*, Jorge Orestes Cerdeira†, Cristina Requejo*
**Department of Mathematics, University of Aveiro, Portugal, †Department of Sciences and Engineering of Biosystems, Instituto Superior de Agronomia, Technical University of Lisbon (TULisbon), Portugal*

We give procedures to derive lower and upper bounds for the optimal diversity management problem, especially conceived to deal with real instances that occur in the production of wire harness for the automotive industry. We report computational results to assess the quality of these bounds.
Keywords: Integer programming, Duality, Heuristics, P-median

7C.2

Continous Ant Colony System Applied to Optimization Problems with Fuzzy Coefficients

Luiza Amalia Pinto Cantão*, Ricardo Coelho Silva†, Akebo Yamakami†
**UNESP – Univ. Estadual Paulista, Environmental Engineering Dept., Brazil, †UNICAMP – Univ. Estadual of Campinas, School of Electrical and Computer Engineering, Brazil*

Heuristic algorithms based in ant colonies (named ant system – AS for short) were developed by Marco Dorigo to solve combinatorial optimization problems as the traveling salesman problem. This class of algorithms was also adapted by Seid H. Pourtakdoust and Hadi Nobahari for continuous optimization problems (Continuous Ant Colony Optimization Systems - CACS). In this work, an implementation of CACS was used for nonlinear

continuous optimization problems with coefficients represented by fuzzy numbers. The fuzzy numbers are modelled through symmetric triangular membership functions, Possibility Measure–based on Didier Dubois and Henri Prade's work for comparison of functions with fuzzy values–and centroid defuzzification methods to obtain the ordinary value from function values in the pheromone evaluation step. Experiments with nine benchmark functions show a good agreement – considering the imprecise nature of the problem – between the fuzzy optima and their real counterparts.
Keywords: Ant Colony System, Optimization, Fuzzy Theory, Possibility Theory

7C.3

A tree search procedure for forest harvest scheduling problems addressing aspects of habitat availability

Teresa Neto*, Miguel Constantino†, João Pedro Pedroso‡, Isabel Martins§

*Escola Superior de Tecnologia de Viseu do Instituto Politécnico de Viseu, Portugal, †Centro de Investigação Operacional e Faculdade de Ciências da Universidade de Lisboa, Portugal, ‡INESC Porto e Faculdade de Ciências da Universidade do Porto, Portugal, §Centro de Investigação Operacional e Instituto Superior de Agronomia da Universidade Técnica de Lisboa, Portugal

In the literature, the most referenced approaches for forest harvesting scheduling problems addressing environmental protection issues have focused mainly on including constraints on clearcut area. Nevertheless, these restrictions may not be sufficient to prevent the loss of habitat availability that endangers the survival of many wild species. This work presents a tree search procedure for finding good feasible solutions, in reasonable time, to forest harvest scheduling problems with constraints on clearcut area and habitat availability. We use two measures for habitat availability: the area of all habitats and the connectivity between them. For solving the problem, we use a tree search procedure: a process inspired in branch-and-bound, specifically designed 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 on unreachable objective values. Preliminary computational results are reported.
Keywords: Forest management, Harvest scheduling, Habitat availability, Tree search

8A.1

Automatic Configuration of TPLS+PLS Algorithms for Bi-objective Flow-Shop Scheduling Problems

Jérémie Dubois-Lacoste*, Manuel López-Ibáñez*, Thomas Stützle*

*IRIDIA-CoDE, Université Libre de Bruxelles, Belgium

The automatic configuration of algorithms is a hot research topic nowadays, and it is rapidly having an increasing impact on the way algorithms are designed and evaluated. The main focus of automatic configuration tools has been so far the configuration of single-objective algorithms. However, these tools may be applied to the automatic configuration of multi-objective algorithms for Pareto-optimization by means of unary quality measures such as the hypervolume. This study shows that such an approach is able to outperform state-of-the-art multi-objective optimizers that were manually configured. The results presented here on five variants of multi-objective flow-shop problems show that the automatically configured algorithm reaches at least the same and often better final quality than the current state-of-the-art algorithm.
Keywords: Automatic configuration, Multi-objective, Flow-shop scheduling

8A.2

Efficient paths by local search

Luís Paquete*, José Luis Santos†, Daniel Vaz*

*CISUC, Department of Informatics Engineering, University of Coimbra, Portugal, †CMUC, Department of Mathematics, University of Coimbra, Portugal

In this article, we describe an experimental analysis on a given property of connectedness of optimal paths for the multicriteria shortest path problem. Moreover, we propose a local search that explores this property and compare its performance with an exact algorithm in terms of running time and number of optimal paths found.
Keywords: Multicriteria Optimization, Routing, Local Search, Shortest Path

8A.3

Solving a Multiobjective Flowshop Scheduling Problem by GRASP with Path-relinking

Iryna Yevseyeva*, Jorge Pinho de Sousa*†, Ana Viana*‡
*INESC Porto, Portugal, †Faculdade de Engenharia da Universidade do Porto, Portugal, ‡Instituto Superior de Engenharia do Porto, Portugal

In this work, a hybrid metaheuristic for solving the biobjective flowshop problem with makespan and tardiness objectives is proposed. It is based on the well-known greedy randomized adaptive search procedure (GRASP) with path-relinking adapted to the multiobjective case. The proposed approach is tested on several flowshop instances and compared to existing results from literature with the hypervolume performance measures.
Keywords: Multiobjective, GRASP, Path-relinking, Flowshop, Scheduling

8B.1

Stabilized Column Generation for the Rooted Delay-Constrained Steiner Tree Problem

Markus Leitner*, Mario Ruthmair*, Günther R. Raidl*
*Institute of Computer Graphics and Algorithms, Vienna University of Technology, Austria

We consider the rooted delay-constrained Steiner tree problem which arises for example in the design of centralized multicasting networks where quality of service constraints are of concern. We present a path based integer linear programming formulation which has already been considered in the literature for the spanning tree variant. Solving its linear relaxation by column generation has so far been regarded as not competitive due to long computational times needed. In this work, we show how to significantly accelerate the column generation process using two different stabilization techniques. Computational results indicate that due to the achieved speed-up our approach outperforms so-far proposed methods.
Keywords: Network design, Stabilized column generation, Delay-constrained Steiner tree

8B.2

Heuristics for Discrete Power Control – A Case-Study in Multi-Carrier DSL Networks

Martin Wolkerstorfer*, Tomas Nordström*
*Telecommunications Research Center Vienna (FTW), Austria

The performance of multi-user digital subscriber line (DSL) networks is limited by the electro-magnetic coupling between twisted pair cables. The adverse effect of this coupling can be reduced by controlling the transmit powers of all lines. The corresponding multi-user, multi-carrier power control problem can be modeled as a multi-dimensional nonlinear Knapsack problem which has previously motivated the application of various mathematical decomposition methods. These methods decompose the problem into a large number of combinatorial per-subcarrier problems. Our main contribution lies in the proposal and analysis of various lowcomplexity heuristics for these combinatorial problems. We provide insights in the parameter setting as well as simulation results on a large set of 6 and 30-user DSL scenarios. These show that simple randomized greedy heuristics perform well even in case of a very stringent complexity budget and that the heuristics' average suboptimality is dependent on the targeted data-rate.
Keywords: Power Control, DSL, Metaheuristics, Column Generation

8B.3

A Hybrid Meta-Heuristic for the Network Load Balancing Problem

Dorabella Santos*, Amaro de Sousa†, Filipe Alvelos‡
*Instituto de Telecomunicações, Portugal, †Instituto de Telecomunicações / DETI, Universidade de Aveiro, Portugal, ‡Centro Algoritmi / DPS, Universidade do Minho, Portugal

Given a capacitated telecommunications network with single path routing and an estimated traffic demand matrix, the network load balancing problem is the determination of a routing path for each traffic commodity such that the network load balancing is optimized, i.e., the worst case link load is minimized, among all such solutions, the second worst case link load is minimized, and so on... We discuss a meta-heuristic which runs a GRASP with Path Relinking procedure on a restricted search space defined by Column Generation. We discuss some computational

results showing that, for the network load balancing problem, this approach is successful in obtaining good quality solutions in short running times.
Keywords: Load Balancing, GRASP with Path Relinking, Column Generation, Hybrid Meta-Heuristics

8C.1

Modeling the collision avoidance for the ATM by a mixed 0–1 nonlinear approach

Antonio Alonso Ayuso*, Laureano F. Escudero*, Francisco Javier Martín Campo*
Dpto. Estadística e Investigación Operativa, Universidad Rey Juan Carlos, Spain

A 0–1 nonlinear model for the Collision Avoidance in Air Traffic Management (ATM) problem is presented. The aim of this problem is deciding the best strategy for an arbitrary aircraft configurations such that all conflicts in the airspace are avoided where a conflict is the loss of the minimum safety distance that two aircraft have to keep in their flight plans. A mixed 0–1 nonlinear optimization model based on geometric constructions is developed knowing the initial flight plan (coordinates, angles and velocities in each time period) and minimizing the acceleration variations where aircraft are forced to return to the original flight plan when no aircraft are in conflict. A linear approximation by using iteratively Taylor polynomials is developed to solve the problem in linear terms, as well as a metaheuristic based on Variable Neigbourhood Search (VNS) in order to reduce the resolution time.
Keywords: Air Traffic Management (ATM), Collision avoidance, Mixed 0-1 nonlinear optimization

8C.2

Low Energy Scheduling with Power Heterogeneous Multiprocessor Systems

Richard Dobson*, Kathleen Steinhöfel*
King's College London, Department of Informatics, UK

In this paper we consider low energy scheduling for power heterogeneous multiprocessor systems. This is a fast developing area that is of great importance and is currently being researched by both industry and academia. This problem is of great importance because real life multiprocessor computer systems are often heterogeneous at run time. We have developed an algorithm which transforms any multiprocessor system into a Virtual Single Processor (VSP). Using our VSP platform, existing techniques can be explored for low energy scheduling for heterogeneous multiprocessor scheduling. In this study we focus on applying algorithms which which minimise $\sum$Flow + Energy in conjunction with our VSP approach. $\sum$Flow + Energy have been shown to be very useful in real life situations.
Keywords: Virtual Single Processor, Dynamic Speed Scaling, Energy, Heterogeneous Multiprocessor Systems, Low Energy Scheduling

8C.3

A linear programming approach for adaptive synchronization of traffic signals

Pablo Coll*, Pablo Factorovich*, Irene Loiseau*
Departamento de Computación, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina

As traffic congestion during rush hours is a growing problem for most cities, there is an increasing need for more effective managing traffic signal control and traffic assignment systems. We present here a new adaptive system based on a linear programming model for the signal control problem, having as objective to minimize the total length of the queues of cars waiting at each corner. The model is intended to be fed with traffic information provided by real-time sensors installed at each intersection. In order to compare the performance of our program with that of the current scheduling designed by the transit office of Buenos Aires city, we used a traffic simulation system and real traffic flow data of a pilot area of the city. Preliminary results are very promising.
Keywords: Urban traffic control, Adaptive signal control, Signal timing optimization, Linear programming

List of Participants

Agra, Agostinho
Universidade de Aveiro
Portugal
aagra@ua.pt

Alvarez-Valdes, Ramon
University of Valencia
Spain
ramon.alvarez@uv.es

Alvelos, Filipe
Universidade do Minho
Portugal
falvelos@dps.uminho.pt

Amorim, Pedro
IDMEC - Institute of Mechanical Engineering
Portugal
amorim.pedro@fe.up.pt

Anghinolfi, Davide
University of Genova
Italy
anghinolfi@dist.unige.it

Araceli Garin, Maria
University of the Basque Country
Spain
mariaaraceli.garin@ehu.es

Baldo, Tamara
Universidade do Porto / Universidade de São Paulo
Brazil
ta.baldo@gmail.com

Barbosa Póvoa, Ana
Universidade Técnica de Lisboa
Portugal
apovoa@ist.utl.pt

Bianchi-Aguiar, Teresa
Universidade do Porto
Portugal
mtbaguiar@fe.up.pt

Bing, Xiaoyun
Wageningen University and Research Center
The Netherlands
xiaoyun.bing@wur.nl

Birgin, Ernesto
University of São Paulo
Brazil
egbirgin@ime.usp.br

Borschbach, Markus
University of Applied Sciences, FHDW
Germany
mbo@bib.de

Brandão, Filipe
Universidade do Porto
Portugal
fdabrandao@gmail.com

Brás, Pedro
Universidade do Minho
Portugal
bras.pedro@gmail.com

Brito, José
ENCE
Brazil
jambrito@gmail.com

Cáceres, José
Universitat Oberta de Catalunya
Spain
iegeam@uoc.edu

Camargo, Victor
Universidade do Porto
Portugal
victor@fe.up.pt

Cardona Valdés, Yajaira
Universidad Autonoma de Nuevo Leon
Mexico
yaja.carval@gmail.com

Cardoso, Sonia
Instituto Superior Técnico
Portugal
sonia.cardoso@ist.utl.pt

Carlsson, John
University of Minnesota
USA
jgc@isye.umn.edu

Carvalho, Margarida
INESC Porto
Portugal
mmsc@inescporto.pt

Constantino, Miguel
Universidade de Lisboa
Portugal
miguel.constantino@fc.ul.pt

Correia, Helena
Universidade Católica Portuguesa (Porto)
Portugal
mcorreia@porto.ucp.pt

Costa, Teresa
INESC Porto / Instituto Politécnico do Porto
Portugal
mjo@isep.ipp.pt

Costa, Maria da Graça
Instituto Politécnico de Setúbal
Portugal
graca.costa@esce.ips.pt

Costa, Dulce
Instituto Politécnico de Setúbal
Portugal
dulce.costa@estsetubal.ips.pt

Dabia, Said
Eindhoven University of Technology
The Netherlands
s.dabia@tue.nl

Delgado, Alexandrino Duarte
Universidade de Aveiro
Portugal
alexandrino@ua.pt

Desrosiers, Jacques
HEC Montreal
Canada
jacques.desrosiers@hec.ca

di Giovanni, Luigi
Università di Padova
Italy
luigi@math.unipd.it

Dobson, Richard
King's College London
UK
richard.dobson@kcl.ac.uk

Doostmohammadi, Mahdi
University of Aveiro
Portugal
ma.d.mohammadi@gmail.com

Dubois-Lacoste, Jeremie
Université Libre de Bruxelles
Belgium
jeremie.dl@gmail.com

Emmerich, Michael
Leiden University
The Netherlands
emmerix@gmail.com

Escudero, Laureano F.
Universidad Rey Juan Carlos
Spain
laureano.escudero@urjc.es

Falavigna, Simone
Università degli Studi di Modena e Reggio Emilia
Italy
simone.falavigna@unimore.it

Figueira, Luis Gonçalo
Universidade do Porto
Portugal
lgrrf1@gmail.com

Gamboa, Dorabela
ESTGF - Instituto Politécnico do Porto
Portugal
dgamboa@estgf.ipp.pt

Gatica, Gustavo
Universidad Nacional Andrés Bello
Chile
ggatica@unab.cl

Gil, Consolacion
University of Almeria
Spain
cgilm@ual.es

Gomes, A. Miguel
INESC Porto / Universidade do Porto
Portugal
agomes@fe.ip.pt

Gomes, Maria Isabel
Universidade Nova de Lisboa
Portugal
mirg@fct.unl.pt

Gonzalez-Brevis, Pablo
The University of Edinburgh
UK
P.Gonzalez-Brevis@sms.ed.ac.uk

Hodje, Joanne
University of Dundee
UK
d.h.scott@dundee.ac.uk

Juan, Angel Alejandro
Universitat Oberta de Catalunya
Spain
iegeam@uoc.edu

Junqueira, Leonardo
Universidade Federal de São Carlos
Brazil
leo_junqueira@yahoo.com

Kosuch, Stefanie
Linkoepings Universitet
Sweden
stefanie.kosuch@liu.se

Landa Silva, Dario
University of Nottingham
UK
dario.landasilva@nottingham.ac.uk

Leitner, Markus
Vienna University of Technology
Austria
leitner@ads.tuwien.ac.at

Lodi, Andrea
Università degli Studi di Bologna
Italy
andrea.lodi@unibo.it

Loiseau, Irene
Universidade de Buenos Aires
Argentina
irene@dc.uba.ar

Lopes, Isabel Cristina
ESEIG, Instituto Politécnico do Porto
Portugal
cristinalopes@eu.ipp.pt

López Márquez, Antonio
University of Almeria
Spain
almarquez@ual.es

Luna, Henrique
Universidade Federal de Alagoas
Brazil
pacca@ic.ufal.br

Maniezzo, Vittorino
University of Bologna
Italy
vittorio.maniezzo@unibo.it

Markenzon, Lilian
Universidade Federal do Rio de Janeiro
Brazil
markenzon@nce.ufrj.br

Marques, Ines
ULHT - CIO
Portugal
ines.marques2@fc.ul.pt

Martin-Campo, F. Javier
Rey Juan Carlos University
Spain
javier.martin.campo@urjc.es

Martinez, Antonio
University of Valencia
Spain
marsyan@uv.es

Massi, Gionata
Università Politecnica delle Marche
Italy
massi@diiga.univpm.it

Matos, Manuel
INESC Porto / Universidade do Porto
Portugal
manuel.matos@inescporto.pt

Mesquita, Marta
CIO - Universidade Técnica de Lisboa
Portugal
marta@math.isa.utl.pt

Miranda, Vladimiro
INESC Porto / University of Porto
Portugal
vladimiro.miranda@inescporto.pt

Moehring, Rolf
Technische Universität Berlin
Germany
Rolf.Moehring@TU-Berlin.DE

Neto, Teresa
Instituto Politécnico de Viseu
Portugal
tneto@estv.ipv.pt

Nogueira, Teresa
ISEP, Instituto Politécnico do Porto
Portugal
tan@isep.ipp.pt

Ochi, Luiz Satoru
Fluminense Federal University
Brazil
satoru@ic.uff.br

Oliveira, Marisa
ISEP, Instituto Politécnico do Porto
Portugal
mjo@isep.ipp.pt

Ospina Lopez, Diana Yomali
Universidade do Porto
Portugal
deg08015@fe.up.pt

Paolucci, Massimo
University of Genova
Italy
paolucci@dist.unige.it

Paquete, Luis
University of Coimbra
Portugal
paquete@dei.uc.pt

Parragh, Sophie
INESC Porto / University of Vienna
Portugal
sophie.parragh@univie.ac.at

Parreño, Francisco
Universidad de Castilla-La Mancha
Spain
Francisco.Parreno@uclm.es

Pato, Margarida
Universidade Técnica de Lisboa
Portugal
mpato@iseg.utl.pt

Pedroso, João Pedro
INESC Porto / Universidade do Porto
Portugal
jpp@fc.up.pt

Pezzella, Ferdinando
Universitá Politecniva delle Marche - Ancona
Italy
pezzella@diiga.univpm.it

Poss, Michael
Université Libre de Bruxelles
Belgium
mposs@ulb.ac.be

Rahman, Dewan Fayzur
INESC Porto
Portugal
dewan.m.rahman@inescporto.pt

Ramos, Tania
Universidade Técnica de Lisboa
Portugal
tania.ramos@iscte.pt

Requejo, Cristina
Universidade de Aveiro
Portugal
crequejo@ua.pt

Riezebos, Jan
University of Groningen
The Netherlands
j.riezebos@rug.nl

Rocha, Humberto
INESC Coimbra
Portugal
hrocha@mat.uc.pt

Rocha, Marta
Universidade do Porto
Portugal
marta@fe.up.pt

Rocha, Pedro
INESC Porto
Portugal
pedro.f.rocha@inescporto.pt

Romero, Dolores
University of Oxford
UK
Dolores.Romero-Morales@sbs.ox.ac.uk

Ronconi, Debora P.
University of São Paulo
Brazil
dronconi@usp.br

Rosa, Mauro
INESC Porto
Portugal
mauro.rosa@inescporto.pt

Santos, Eulalia
Instituto Politecnico de Leiria - Universidade de Aveiro
Portugal
eulalia.santos@sapo.pt

Santos, Nicolau
INESC Porto
Portugal
nicolau.f.santos@inescporto.pt

Santos, Dorabella
Instituto de Telecomunicações
Portugal
dorabella@av.it.pt

Soto Zuluaga, Juan Pablo
Universidade de Los Andes
Colombia
jps@adm.uniandes.edu.co

Torralba Fernandes, Jessica Pillon
University of Campinas
Brazil
pillon@fem.unicamp.br

Valério de Carvalho, José
Universidade do Minho
Portugal
vc@dps.uminho.pt

Verstichel, Jannes
KaHo Sint-Lieven
Belgium
jannes.verstichel@kahosl.be

Viana, Ana
INESC Porto / Instituto Politécnico do Porto
Portugal
aviana@inescporto.pt

Waga, Christina
UERJ
Brazil
waga@ime.uerj.br

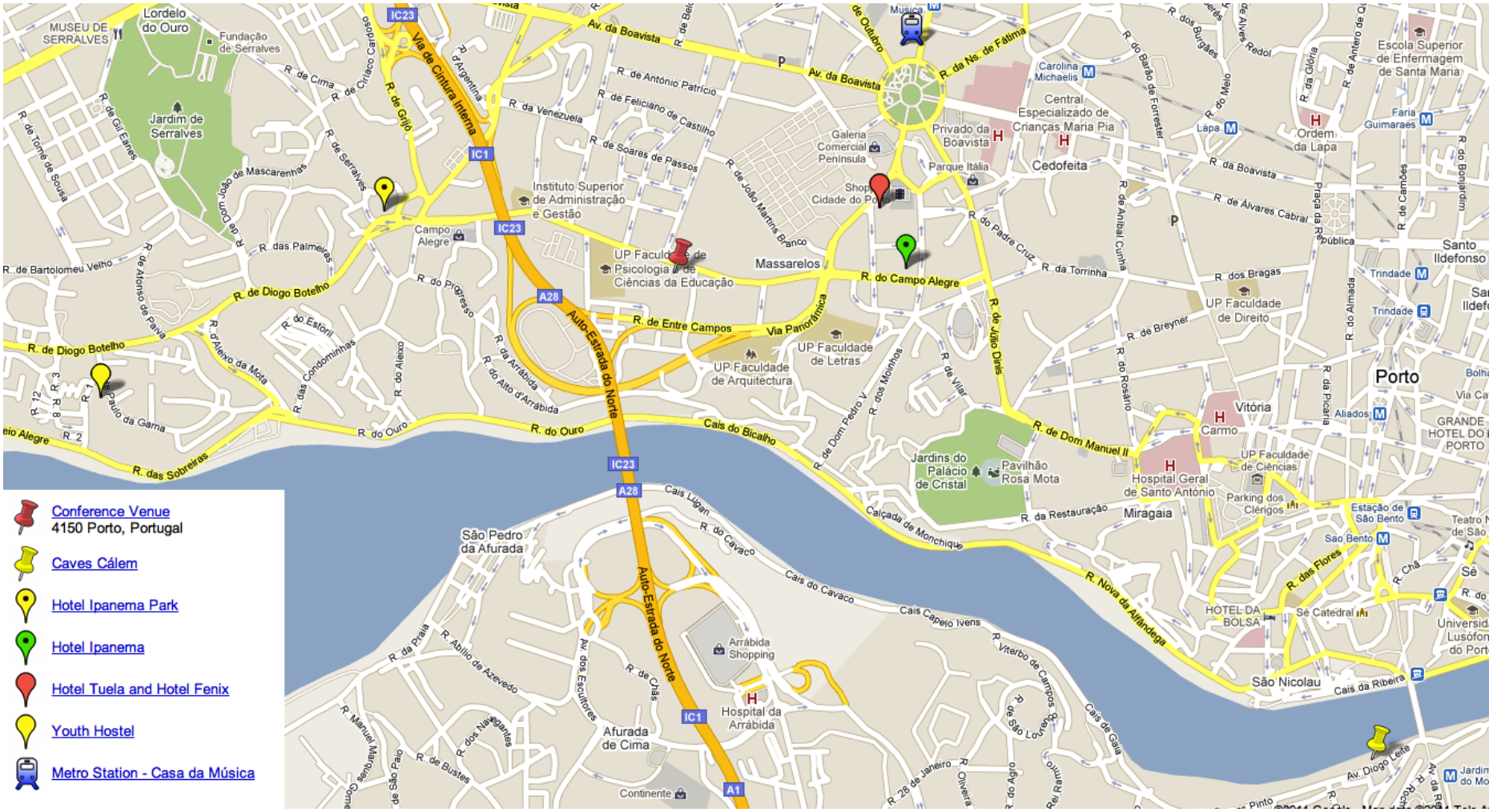
Wolkerstorfer, Martin
The Telecommunications Research Center Vienna
Austria
wolkerstorfer@ftw.at

Yamakami, Akebo
University of Campinas
Brazil
akebo@dt.fee.unicamp.br

Yevseyeva, Iryna
INESC Porto
Portugal
iryna.yevseyeva@inescporto.pt

Zhang, Yang
Institute of Lightweight Structures, TU München
Germany
zhang@llb.mw.tum.de

Notes


Conference Venue
4150 Porto, Portugal
Caves Cálem
Hotel Ipanema Park
Hotel Ipanema
Hotel Tuela and Hotel Fenix
Youth Hostel
Metro Station - Casa da Música
Jardim de Serralves
Fundação de Serralves
MUSEU DE SERRALVES
Lordelo do Ouro
Via de Cintura Interna
Av. da Boavista
R. da Ns. de Fátima
Instituto Superior de Administração e Gestão
Campo Alegre
Massarelos
R. do Campo Alegre
R. de Diogo Botelho
R. de Entre Campos
Via Panorâmica
Auto-Estrada do Norte
R. do Ouro
Cais do Bicalho
R. das Sobreiras
Jardins do Palácio de Cristal
Pavilhão Rosa Mota
Hospital Geral de Santo António
Miragaia
Caiçada de Monchique
R. da Restauração
R. Nova da Alfândega
São Pedro da Afurada
Arrábida Shopping
Hospital da Arrábida
Afurada de Cima
Continente
São Nicolau
Cais da Ribeira
Sé Catedral
HOTEL DA BOLSA
Estação de São Bento
Porto
Vitória
Carmo
Cedofeita
Lapa
Trindade
Santo Ildefonso
Escola Superior de Enfermagem de Santa Maria
Faria Guimarães
Ordem da Lapa
Central Especializado de Crianças Maria Pia
Privado da Boavista
Parque Itália
Galeria Comercial Península
Shopping Cidade do Porto
UP Faculdade de Psicologia e de Ciências da Educação
UP Faculdade de Letras
UP Faculdade de Arquitectura
UP Faculdade de Direito
UP Faculdade de Ciências
Parking dos Clérigos
GRANDE HOTEL DO PORTO
Teatro Nacional de São Carlos
Universidade Lusófona do Porto
Jardim do Morro
IC23
IC1
A28
A1