ISCO

International Symposium on Combinatorial Optimization

March 24-26, 2010

Hammamet, Tunisia

Booklet of Abstracts

Message from the ISCO 2010 Co-Chairs

It is a pleasure to welcome you to the first International Symposium on Combinatorial Optimization in Hammamet during March 24-26, 2010. We are proud to host this meeting that will provide a unique opportunity of intellectual excitement and social reunion for renowned scholars. We have been motivated by the interest of the Combinatorial Optimization community. The total number of accepted presentations is now far above our initial expectations. A total of plenary 194 papers are scheduled in 55 invited and contributed sessions along with 5 plenary sessions, and the authors come from 36 countries. All the papers were peer reviewed by a team of 142 reviewers.

Our sincere thanks go to all those who supported us setting this conference program. We are grateful to the members of the Scientific Program Committee, to the Reviewers, and to the Invited Sessions' Organizers who managed to attract so many renowned researchers. And we thank you for joining us at this unique conference.

We hope you will also have some time to experience the splendors of Tunisia, discover the traditional Tunisian hospitality and make this opportunity a lasting memory in your life.

Mohamed Haouari
A. Ridha Mahjoub
Co-Chairs

Conference Organization

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Many thanks to all the reviewers for their fundamental role in selecting valuable and interesting papers.

Conference Structure

Plenary sessions

		Chair
Wednesday		
8:25-9:25	Laurence A. Wolsey	Jean-François Maurras
14:00-15:00	András Recski	Gérard Cornuejols
Thursday		
9:55-10:55	Gérard Cornuejols	Laurence A. Wolsey
Friday		
10:10-11:10	Ibrahim Osman	Paolo Toth
14:00-15:00	Franz Rendl	Nelson Maculan

Invited sessions

		Chair	**Organizers**
Wednesday			
09:55-11:10	Polyhedral combinatorics 1	Annegret Wagler	Annegret Wagler
09:55-11:10	Reformulations and relaxations for nonlinear MIPs with applications	Franz Rendl	Michel Minoux, Hacène Ouzia
09:55-11:10	Topics in networks and graphs	Gerd Reneilt	Michael Juenger, Gerd Reneilt
09:55-11:10	Edge-colorings, scheduling	Andras Sebo	Andras Sebo
11:15-12:30	Computational integer programming	Michael Juenger	Michael Juenger, Gerd Reneilt
11:15-12:30	Approximation algorithms connected with matroids and submodular functions	Jon Lee	Jon Lee
15:05-16:45	Recent developments in scheduling theory	Ammar Oulamara	Ammar Oulamara, Ameur Soukhal
15:05-16:45	Inverse combinatorial optimization	Rainer E. Burkard	Rainer E. Burkard
15:05-16:45	Oiks and games	Jack Edmonds	Jack Edmonds
15:05-16:45	Mathematical programming reformulations and applications	Leo Liberti	Leo Liberti
17:15-18:55	Telecommunication network design	Walid Ben-Ameur	Michal Pioro
17:15-18:55	Progress in scheduling	Anis Gharbi	Anis Gharbi
17:15-18:55	Extended formulations in combinatorial optimization	Volker Kaibel	Volker Kaibel
17:15-18:55	Graphs and combinatorial optimization problems 1	Arnaud Pêcher	Arnaud Pêcher
Thursday			
8:00-9:40	Engineering applications of combinatorial optimization	Andras Recski	Andras Recski
8:00-9:40	Network design 1	Valeria Leggieri	Chefi Triki, Valeria Leggieri
11:00-12:15	Polyhedral combinatorics 2	Pierre Bonami	Annegret Wagler
11:00-12:15	Matchings and paths	Kathie Cameron	Andras Sebo
Friday			
8:00-9:40	Using metaheuristics for solving combinatorial optimisation problems	Jacques Teghem	Taicir Loukil, Jacques Teghem
11:15-12:30	VRP and applications	Emmanuel Néron	Nora Touati
11:15-12:30	Quadratic programming and applications	Sourour Elloumi	Sourour Elloumi

Contributed sessions

		Chair
Wednesday		
09:55-11:10	Integrated scheduling models	Zoltán Szigeti
09:55-11:10	Telecommunication 1	Abdel Lisser
11:15-12:30	Polyhedral combinatorics 3	Francisco Barahona
11:15-12:30	Knapsack problems	Gérard Plateau
11:15-12:30	Computational molecular biology	Eduardo Uchoa
11:15-12:30	Graphs and combinatorial optimization 2	S. Thomas McCormick
15:05-16:45	Network design 2	Eric Gourdin
15:05-16:45	Cutting plane algorithms	Andrea Lodi
17:15-18:55	Packing problems 1	Alain Quilliot
17:15-18:55	Approximation algorithms	Vangelis Paschos
Thursday		
8:00-9:40	Metaheuristics 1	Said Hanafi
8:00-9:40	Applications of combinatorial optimization 1	Naceur Azaiez
8:00-9:40	Applications of combinatorial optimization 2	Mustapha Bouhtou
8:00-9:40	Traveling salesman problem	Paula Zabala
11:00-12:15	Resource constrained scheduling	Christian Artigues
11:00-12:15	Metaheuristics 2	Ibrahim Osman
11:00-12:15	Multiobjective combinatorial optimization	Foued Ben Abdelaziz
11:00-12:15	Telecommunication 2	Olivier Klopfenstein
11:00-12:15	Vehicle routing	Roberto Tadei
Friday		
8:00-9:40	Scheduling 2	Talel Ladhari
8:00-9:40	Graphs and combinatorial optimization 3	Petra Mutzel
8:00-9:40	Scheduling 1	Bernard Gendron
8:00-9:40	Network design 3	Luis Gouveia
8:00-9:40	Stochastic and robust optimization	Mohamed Ali Aloulou
8:00-9:40	Applications of combinatorial optimization 4	Juan José Salazar
11:15-12:30	Computational complexity	Brahim Hnich
11:15-12:30	Metaheuristics 3	Saoussen Krichen
11:15-12:30	Polyhedral combinatorics 4	Paolo Nobili
11:15-12:30	Facility location	François Vanderbeck
15:05-16:45	Metaheuristics 4	Jouhaina Chaouachi
15:05-16:45	Scheduling 3	Lotfi Hidri
15:05-16:45	Packing problems 2	Valerio de Carvalho
15:05-16:45	Survivable networks	A. Ridha Mahjoub
15:05-16:45	Applications of combinatorial optimization 3	Olivier Hudry

Wednesday, March 24

8:00-8:25	Conference opening					
8:25-9:25	Plenary session : Laurence A. Wolsey (Amphi César)					
9:25-9:55	Coffee Break					
9:55-11:10	Parallel sessions					
	César 2	César 3	César 4	César 5	César 6	César 7
	Polyhedral combinatorics 1	Integrated scheduling models	Reformulations and relaxations for nonlinear MIPs with applications	Topics in networks and graphs	Edge-colorings, scheduling	Telecommunication 1
11:15-12:30	Parallel sessions					
	César 2	César 3	César 4	César 5	César 6	César 7
	Polyhedral combinatorics 3	Computational integer programming	Knapsack problems	Computational molecular biology	Approximation algorithms connected with matroids and submodular functions	Graphs and combinatorial optimization 2
12:30-14:00	Lunch					
14:00-15:00	Plenary session : András Recski (Amphi César)					
15:05-16:45	Parallel sessions					
	César 2	César 3	César 4	César 5	César 6	César 7
	Network design 2	Inverse combinatorial optimization	Recent developments in scheduling theory	Oiks and games	Mathematical programming reformulations and applications	Cutting plane algorithms
16:45-17:15	Coffee Break					
17:15-18:55	Parallel sessions					
	César 2	César 3	César 4	César 5	César 6	César 7
	Telecommunication network design	Progress in scheduling	Extended formulation in combinatorial optimization	Graphs and combinatorial optimization problems 1	Packing problems 1	Approximation algorithms

Thursday, March 25

8:00-9:40	Parallel sessions						
	César 2	César 3	César 4	César 5	César 6	César 7	
	Engineering applications of combinatorial optimization	Metaheuristics 1	Applications of combinatorial optimization 1	Network design 1	Applications of combinatorial optimization 2	Traveling salesman problem	
9:40-9:55	Coffee Break						
9:55-10:55	Plenary session : Gérard Cornuéjols (Amphi César)						
11:00-12:15	Parallel sessions						
	César 2	César 3	César 4	César 5	César 6	César 7	César 8
	Polyhedral combinatorics 2	Resource constrained scheduling	Metaheuristics 2	Matchings and paths	Multiobjective combinatorial optimization	Telecommunication 2	Vehicle routing
12:15-13:00	Lunch						
13:00	Social event						

Friday, March 26

8:00-9:40	Parallel sessions						
	César 2	César 3	César 4	César 5	César 6	César 7	César 8
	Using metaheuristics for solving combinatorial optimisation problems	Scheduling 2	Graphs and combinatorial optimization 3	Scheduling 1	Network design 3	Stochastic and robust optimization	Applications of combinatorial optimization 4
9:40-10:10	Coffee Break						
10:10-11:10	Plenary session : Ibrahim Osman (Salle Hannibal)						
11:15-12:30	Parallel sessions						
	César 2	César 3	César 4	César 5	César 6	César 7	
	Computational complexity	Metaheuristics 3	Polyhedral combinatorics 4	VRP and applications	Facility location	Quadratic programming and applications	
12:30-14:00	Lunch						
14:00-15:00	Plenary session : Frantz Rendl (Salle Hannibal)						
15:05-16:45	Parallel sessions						
	César 2	César 3	César 4	César 5	César 6		
	Metaheuristics 4	Scheduling 3	Packing problems 2	Survivable networks	Applications of combinatorial optimization 3		
16:45-17:15	Coffee Break						

Wednesday, March 24

8:00-8:25 : *Conference opening*

8 :25-9 :25. ***Plenary session : MIP Models for Production/Distribution and Production/Sequencing.***
Laurence A. Wolsey
Chairman : Jean-François Maurras
. ***Amphi César***
After a brief introduction on single item lot-sizing, we present tight formulations for the single item lot-sizing problem with constant capacities and sales and for the two-level uncapacitated production-in-series lot-sizing problem.
We then examine how reformulation results for basic (typically) single-item problems can be used or extended to tackle realistic multi-item, multi-site problems.
As a first application we consider a two-level supply chain, namely a multi-item n-period model with production sites and sales areas with production at the sites and transportation to the areas. We demonstrate the effectiveness of a multi-commodity reformulation combined with the use of inequalities for family set-ups when there are capacities at the transportation level..
The second application is a multi-item parallel machine model with start-up costs and/or sequence dependent changeover costs. Here we show how to extend existing valid inequalities and formulations to deal with identical parallel machines. Some limited computational results are presented.

9:25-9:55 : *Coffee Break*

9:55-11:10 : ***IS : Polyhedral combinatorics 1***
Chairman : Annegret K. Wagler
Organizer : Annegret K. Wagler
. ***César 2***

Row family inequalities for the set covering polyhedron. *Gabriela R. Argiroffo and Silvia M. Bianchi.*
From the polyhedral point of view the set covering polyhedron (SCP) and the set packing polyhedron (SPP) associated with clutter matrices (i.e. 0,1 matrices without dominating rows and zero columns) have strong similarities. Thus, many key concepts have been transferred from SPP to SCP by Balas and Ng (1989), Cornuéjols and Sassano (1989), Nobili and Sassano (1989) and Sassano (1989).
In this work, we present a new class of valid inequalities for the SCP associated with general clutter matrices, called row family inequalities, that can be viewed as the counterpart of the valid clique family inequalities introduced by Oriolo (2004) for SPP.
We show that many valid inequalities for SCP belong to this class. In particular, all the inequalities with coefficients in $\{0, 1, 2\}$ studied by Balas and Ng (1986).

On the k-dominating set polytope of web graphs. *Gabriela R. Argiroffo, Mariana Escalante and Maria Elisa Ugarte.*
In this work we present some results on the polyhedral structure of the convex hull of integer points in polyhedra of the form $\{x \geq 0\colon Mx \geq k1\}$, for a 0,1 matrix M and a positive integer number k. In particular, we consider the k-dominating set problem in a graph. Given a graph $G = (V, E)$, a set $D \subseteq V$ is a k-dominating set if every vertex in V is adjacent to at least k vertices of D. The k-dominating set problem consists in finding a k-dominating set of minimum cardinality.
The k-dominating set polytope is the convex hull of the incidence vectors of k-dominating sets in G and it is a natural generalization of the well-known dominating set polytope of a graph.
We apply our results for general problems to the k-dominating set polytope of some particular families of web graphs.

On the Chvatal-rank of Antiwebs. *Holm Eugenia, Luis M Torres and Annegret K. Wagler.*
We present an algorithm for computing both upper and lower bounds on the Chvatal-rank of antiwebs, starting from the edge constraint stable set polytope. With the help of this algorithm we have been able to compute the exact values of the Chvatal-rank for all antiwebs containing up to 5,000 nodes. Moreover, the algorithm can be easily adapted to start from the clique constraint stable set polytope.

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9:55-11:10 : ***Integrated scheduling models***
Chairman : Zoltán Szigeti
. ***César 3***

Integrating job scheduling and constrained network routing. *Mette Gamst.*
This paper examines the NP-hard problem of scheduling jobs on resources such that the overall profit of executed jobs is maximized. Job demand must be sent through a constrained network to the resource before execution can begin. The problem has application in grid computing, where a number of geographically distributed resources connected through an optical network work together for solving large problems. A number of heuristics are proposed along with an exact

solution approach based on Dantzig-Wolfe decomposition. The latter has some performance difficulties while the heuristics solve all instances within minutes and with an average solution value gap as low as 3%.

Simultaneous Balancing and Scheduling of Flexible Mixed Model Assembly Lines with Sequence Dependent Setup Times. *Cemalettin Ozturk, Semra Tunali, Brahim Hnich and Arslan M. Ornek.*
We consider Simultaneous Balancing and Scheduling of Flexible Mixed Model Assembly Lines with Sequence Dependent Setup Times (SBSFMMAL−SDST). We propose alternate Mixed Integer Programming (MIP) and Constraint Programming (CP) formulations. Our experiments show that while the MIP models could not solve relatively small instances, the CP approach seems more promising.

Alternative MIP formulations for an integrated shift scheduling and rostering problem. *João Telhada and Ana Raquel Godinho.*
The problem of Personnel scheduling in a multiskilled environment is addressed. This problem is treated in an integrated manner, modeling shift scheduling and rostering as one problem. Additionally, the integrated approach allows also to better model intraday breaks and days-off scheduling. Alternative MIP formulations are presented which lead to optimal shift schedulings and task assignments. Improved models are obtained by deriving new block-indexed variables. Computational results show the improvement obtained by extended formulations.

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9:55-11:10 : ***IS : Reformulations and relaxations for nonlinear MIPs with applications***
Chairman : Franz Rendl
Organizer : Michel Minoux, Hacène Ouzia
. ***César 4***

Mixed Integer NonLinear Programs featuring "On/Off" constraints :convex analysis and applications. *Hassan Hijazi, Pierre Bonami, Gérard Cornuéjols and Adam Ouorou.*
We call "on/off" constraint an algebraic constraint that is activated if and only if a corresponding boolean variable equals 1. Our main subject of interest is to derive tight convex formulations of Mixed Integer Non-Linear Programs featuring "on/off" constraints. We study the simple set defined by one "on/off" constraint with bounded variables. Using Disjunctive Programming, we introduce convex hull formulations of this set defined in higher dimensional spaces. Because the large number of variables in these formulations appears to be practically disadvantageous, we concentrate our efforts on defining explicit projections into lower dimensional spaces. Based on these results, we present new formulations to a well-known telecommunication problem : routing several commodities subject to multiple delay constraints. Numerical results are presented to assess the efficiency of the new models.

Semidefinite and Conic Programming for Robust wireless OFDMA networks. *Abdel Lisser and Pablo Adasme.*
In this paper, we study three robust optimization approaches. The first one is based on the worst case scenario approach from Kouvelis and Yu. The second, corresponds to a scaled simplex polyhedral approach due to Bertsimas and Sim whilst the third, correspond to an ellipsoidal uncertainty approach proposed by Ben Tal and Nemirovski. The study of the different approaches is made on the basis of a binary quadratic constrained program (BQCP). We derive two semidefinite programming (SDP) relaxations for the first two approaches whilst we use a second order conic program for the last one. Numerical results are given for a resource allocation of OFDMA wireless networks.

Using DRL* relaxations for quadratically constrained pseudoboolean optimization : application to robust Min-Cut . *Michel Minoux and Hacène Ouzia.*
In this work we focus on solving quadratically constrained pseudoboolean optimization problems with quadratic objective as mixed integer linear programs. The standard mixed integer linear formulation of such problems is strengthened using valid inequalities derived from solving Reformulation-Linearization relaxation called partial DRL* relaxation. The proposed PDRL* relaxation features block-decomposable structure which are exploited to improve computational efficiency. We present computational results obtained with the rank 2 PDRL*, showing that the proposed mixed integer linear formulation gives rise to significant reduction factors (typically more than 1000) in the size of the branch and bound trees on instances of robust minimum cut problem with weight constraints.

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9:55-11:10 : ***IS : Topics in networks and graphs***
Chairman : Gerd Reneilt
Organizer : Michael Juenger, Gerd Reneilt
. ***César 5***

Submodular Formulations for Range Assignment Problems. *Frank Baumann and Christoph Buchheim.*
We devise two new integer programming models for range assignment problems arising in wireless network design. Building on an arbitrary set of feasible network topologies, e.g., all spanning trees, we explicitly model the power consumption at a given node as a weighted maximum over edge variables. We show that the standard ILP model is an extended formulation of the new

models.
We observe that the objective functions in the compact models are submodular. This enables us to derive complete polyhedral descriptions in the unconstrained case where all topologies are allowed. These results give rise to tight relaxations even in the constrained case. We can show experimentally that the compact formulations compare favorably to the standard approach.

Model reconstruction for discrete deterministic systems. *Luis M Torres and Annegret K Wagler.*
In a previous paper we proposed a compact model for encoding the dynamic behavior of certain discrete deterministic systems based on extending the widely accepted framework of Petri nets. Here, the problem of reconstructing such a model from experimental data obtained by observation of dynamic processes in the system is addressed. This is equivalent to inferring a valid orientation of a certain transition conflict graph. For a special class of systems where the corresponding valid orientations are acyclic, we present a lower bound on the number of experiments required for model reconstruction and show that it is not possible to devise a solution strategy that achieves this bound for every instance.

An Improved Interior-Point Cutting-Plane Method for Binary Quadratic Optimization. *Alexander Engau, Miguel Anjos and Anthony Vannelli.*
We describe an improved technique for handling large numbers of cutting planes when using an interior-point method for the solution of linear or semidefinite relaxations in binary quadratic optimization. The approach does not require solving successive relaxations to optimality but chooses cuts at intermediate iterates based on indicators of inequality violation and feasibility of their slacks, which are initialized using a recently proposed warmstart technique without any additional correction steps. Computational tests on instances of max-cut suggest that this new scheme is superior to solving only the final relaxation with all relevant cuts known in advance.

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9:55-11:10 : ***IS : Edge-colorings, scheduling***
Chairman : András Sebő
Organizer : András Sebő
. ***César 6***

Balanced list edge-colourings of bipartite graphs. *Tamás Fleiner and András Frank.*
Galvin solved the Dinitz conjecture by proving that bipartite graphs are Δ-edge-choosable. Using an improvement of Galvin's method, we deduce list edge-colouring properties of G from any colouring of the edges of bipartite graph G. In particular, it follows from the existence of bipartite balanced edge-colourings that balanced list edge-colourings exist as well. While the key to Galvin's proof is the stable marriage theorem of Gale and Shapley, our result is based on the well-known "many-to-many" version of the stable matching theorem.

Separation Algorithms for Single-Machine Scheduling with Precedence Constraints. *A. Ridha Mahjoub and S. Thomas McCormick.*
In a 1991 paper M. Queyranne and Y. Wang proposed three classes of valid inequalities for the classic problem of scheduling a single machine with precedence constraints. These constraints are called "parallel constraints", "series constraints", and "Z constraints". It has been understood for a long time how to separate parallel constraints using submodular function minimization, or even just min cut, but separating series constraints has remained open since that time.
We give a fast, practical separation algorithm for series constraints. It is based on parametric min cut algorithms. We also investigate separation of "Z constraints."

Column generation method for an agent scheduling problem. *Balázs Dezső, Alpár Jüttner and Péter Kovács.*
This paper discusses a real life problem of daily schedule planning for customer visiting agents. An optimization scheme using a combination of column generation and rounding techniques is proposed for solving this problem. In order to realize an efficient implementation, a polynomial time algorithm is presented for the column generation sub-problem. Some technical implementation issues are also discussed and finally, experimental results are shown on real-life problem instances. An implementation of the presented solution is currently in production use by one of the leading contact center service providers of Hungary.

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9:55-11:10 : ***Telecommunication 1***
Chairman : Abdel Lisser
. ***César 7***

An Exact Site Availability Approach to Modeling the D-FAP. *Andréa Carneiro Linhares, Philippe Michelon and Dominique Feillet.*
The Dynamic Frequency Assignment Problem (D-FAP) was studied in the context of military exercises, where a wireless network is progressively extended to ensure communication between troops. Therefore new antennas and new links between antennas are dynamically established. To avoid interferences, every new link between two sites (physical location of antennas) requires the (permanent) assignment of a pair of frequencies, one for each direction of communication. A greedy online strategy, which defines exactly the site availability is proposed. Availability is a metrics that measures a site's capability to hold several supplementary links

without causing interference of communication. An asynchronous and a synchronous exact strategy are evaluated and compared. Numerical simulations are conducted on realistic scenarios provided by CELAR (CEntre d'ELectronique de l'ARmement).

Solving Replica Placement and Request Distribution in Content Distribution Networks. *Tiago Neves, Lúcia Drummond, Luiz Ochi, Célio Albuquerque and Eduardo Uchoa.*
A Content Distribution Network (CDN) is an overlay network where servers replicate contents and distribute client's requests with the aim at reducing delay, server load and network congestion, hence improving the quality of service perceived by end clients. Because of server constraints and costs involved in the replication process, it is not reasonable to replicate the contents over the entire set of servers. In this work, exact and heuristic approaches are proposed to solve a dynamic and online problem that appears in CDN management, called the Replica Placement and Request Distribution Problem. The overall objective is to find the best servers to keep the replicas and to handle requests so that the traffic cost in the network is minimized without violating server and QoS constraints.

Cross line and column generation for the cut covering problem in wireless networks. *Christelle Caillouet, Stéphane Pérennes and Hervé Rivano.*
In this paper, we address the problem of bandwidth allocation and routing in wireless networks. A rst model of this problem is known as the Round Weighting Problem (RWP) in which a weight is assigned to the set of rounds, i.e. a set of pairwise non-interfering links. We present a new formulation that forgets about the routing and concentrate on the capacity available on the network cuts. We use the maximum fow/minimum cut theorem known in graph theory to develop the Cut Covering Problem (CCP) and prove that it computes equivalent optimal round weights than RWP. We develop a primal/dual algorithm combining line and column generation to deal with the exponential number of variables and constraints of CCP.

11:15-12:30 : ***Polyhedral combinatorics 3***
Chairman : Francisco Barahona
. ***César 2***

The stable set polytope of claw-free graphs with large stability number. *A. Galluccio, C. Gentile and P. Ventura.*
In this paper we give an explicit description of the stable set polytope of a claw-free graph obtained by repeated applications of the strip composition of fuzzy linear interval strips, fuzzy XX-strips, and fuzzy antihat strips. Using a decomposition theorem of Chudnovsky and Seymour, this allows us to describe the stable set polytope of all facet defining claw-free graphs with stability number greater than 3.

Algorithms and formulations for the minimum cut separator problem. *Walid Ben-Ameur and Mohamed Didi Biha.*
Given $G = (V, E)$ an undirected graph and two specified nonadjacent nodes a and b of V, a cut separator is a subset $F = \delta(C) \subseteq E$ such that $a, b \in V \setminus C$ and a and b belong to different connected components of the graph induced by $V \setminus C$. Given a nonnegative cost vector $c \in \mathbb{R}_+^{|E|}$, the optimal cut separator problem is to find a cut separator of minimum cost. This new problem is closely related to the vertex separator problem. In this paper, we give a polynomial time algorithm for this problem. We also present four equivalent linear formulations, and we show their tightness. Using these results we obtain an explicit short polyhedral description of the dominant of the cut separator polytope.

On the p-median polytope of fork-free graphs. *Mourad Baïou, Francisco Barahona and Jose Correa.*
We study a prize collecting version of the uncapacitated facility location problem and of the p-median problem. We say that the uncapacitated facility location polytope has the intersection property, if adding the extra equation that fixes the number of opened facilities does not create any fractional extreme point. We show that this property holds if and only if the graph has no fork. A fork is a particular subgraph. We give a complete description of the polytope for this class of graphs.

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11:15-12:30 : ***IS : Computational integer programming***
Chairman : Michael Juenger
Organizer : Michael Juenger, Gerd Reneilt
. ***César 3***

On the knapsack closure of 0-1 Integer Linear Programs. *Matteo Fischetti and Andrea Lodi.*
Many inequalities for Mixed-Integer Linear Programs (MILPs) or pure Integer Linear Programs (ILPs) are derived from the Gomory corner relaxation, where all the nonbinding constraints at an optimal LP vertex are relaxed. Computational results show that the corner relaxation gives a good approximation of the integer hull for problems with general-integer variables, but the approximation is less satisfactory for problems with 0-1 variables only. A possible explanation is that, for 0-1 ILPs, even the non-binding variable bound constraints play an important role, hence their relaxation produces weaker bounds.
In this note we address a relaxation for 0-1 ILPs that explicitly takes all variable bound constraints into account. More specifically, we introduce the concept of knapsack closure as a tightening of the classical Chvatal-Gomory (CG) closure. A MILP model for the

corresponding separation problem is also introduced.

Column Generation based Primal Heuristics. *Cédric Joncour, Sophie Michel, Ruslan Sadykov, Dimitri Sverdlov and François Vanderbeck.*
In the past decade, significant progress has been achieved in developing generic primal heuristics that made their way into commercial mixed integer programming (MIP) solver. Extensions to the context of a column generation solution approach are not straightforward. The Dantzig-Wolfe decomposition principle can indeed be exploited in greedy, local search, rounding or truncated exact methods. The price coordination mechanism can bring a global view that may be lacking in some "myopic" approaches based on a compact formulation. However, the dynamic generation of variables requires specific adaptation of heuristic paradigms. The column generation literature reports many application specific studies where primal heuristics are a key to success. There remains to extract generic methods that could be seen as black-box primal heuristics for use across applications. In this paper we review generic classes of column generation based primal heuristics. We then focus on a so-called "diving" method in which we introduce diversification based on Limited Discrepancy Search. While being a general purpose approach, the implementation of our heuristic illustrates the technicalities specific to column generation. The method is numerically tested on variants of the cutting stock and vehicle routing problems.

The Stochastic Guaranteed Service Model with Recourse for Multi-Echelon Warehouse Management. *Jörg Rambau and Konrad Schade.*
The Guaranteed Service Model computes optimal order-points in multi-echelon inventory control under the assumptions that delivery times can be guaranteed and the demand is bounded. Our new Stochastic Guaranteed Service Model with Recourse covers also scenarios that violate these assumptions. Simulation experiments on real-world data of a large german car manufacturer show the potential of the approach.

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11:15-12:30 : ***Knapsack problems***
Chairman : Gérard Plateau
. ***César 4***

Large-scale multi-period precedence constrained knapsack problem: A mining application. *Eduardo Moreno, Daniel Espinoza and Marcos Goycoolea.*
We study an extension of the precedence constrained knapsack problem where the knapsack can be filled in multiple periods. This problem is known in mining industry as the open-pit mine scheduling problem. We present an algorithm to solve the LP relaxation of this problem on very large instances and an LP-based heuristic to obtain feasible solutions. Computational experiments show that we can solve real mining instances with millions of items in minutes, obtaining solutions within 6% of optimality.

Sensitivity Analysis to Perturbations of the Weight of a Subset of Items: The Single Knapsack Case Study. *Mhand Hifi and Hedi Mhalla.*
In this paper, we study the sensitivity of the optimum of the single knapsack problem (KP) and the knapsack sharing problem (KSP) to perturbations of the weight of a subset of items. We try to establish lower and upper bounds limits when a dynamic programming is applied. First, we show how to stabilize an optimal solution of KP, by considering two cases. A first case in which all perturbations are negative or nonnegative. A second case -that is a general case- for which a set of the perturbed items is divided into two disjoints subsets: a subset containing the items with nonnegative perturbations and another subset composed of items with negative perturbations. Second and last, we show how we can adapt the results established for KP to the KSP.

A new Lagrangian based Branch-and-bound algorithm for the 0-1 Knapsack Problem. *Alexandre Cunha, Laura Bahiense, Abilio Lucena and Cid de Souza.*
In this paper, we present a new Branch-and-bound algorithm that uses Gomory and cover cuts to reinforce Lagrangian dual bounds for solving 0-1 Knapsack Problems. Our preliminary computational results indicate the algorithm works well for instances with knapsack capacities as large as 10^{16}. For them, the proposed method seems to be a reasonable choice, since the number of states in Dynamic Programming based algorithms may be too large and Linear Programming cutting plane approaches may run into numerical problems. We also discuss how we plan to turn the method competitive with other approaches in the literature for general classes of instances.

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11:15-12:30 : ***Computational molecular biology***
Chairman : Eduardo Uchoa
. ***César 5***

The biclique k-clustering problem in bipartite graphs and its application in bioinformatics. *Alexandre Freire, Carlos Ferreira, Vicente Acuña and Eduardo Moreno.*
In this paper we study the biclique k-clustering problem (BkCP) in bipartite graphs, a generalization of the maximum edge biclique problem which has several applications in biological data analysis. We present an application of the BkCP in bioinformatics, and introduce two integer linear formulations for the problem. Finally, we discuss the approximability of the problem and show computational experiments with random ge-

nerated instances and also with instances that come the application.

Pancake Flipping with Two Spatulas. *Sharmin Mahfuza, Rukhsana Yeasmin, Masud Hasan, Atif Rahman and M Sohel Rahman.*
In this paper, we give approximation algorithms for several variations of the pancake flipping problem, which is also well known as the problem of sorting by prefix reversals. We consider the variations in the sorting process by adding prefix transpositions, prefix transreversals etc. along with the prefix reversals.

A branch-and-cut approach to the repetition-free longest common subsequence problem. *Christian Tjandraatmadja and Carlos E. Ferreira.*
We present a branch-and-cut approach to solve the following problem. Given two sequences x and y over a finite alphabet, find a repetition-free longest common subsequence of x and y. Implementation details of an efficient separation routine and several heuristics are described. We can solve medium size instances of the problem to optimality.

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11 :15-12 :30 : ***IS : Approximation algorithms connected with matroids and submodular functions***
Chairman : Jon Lee
Organizer : Jon Lee
. ***César 6***

Fractional matroid matching. *Dion Gijswijt and Gyula Pap.*
The matroid matching problem is the following : Given a set of (disjoint) pairs from a matroid, find a maximum number of pairs whose union is independent. For general matroids, this problem is not polytime solvable, but for linearly represented matroids, a polytime algorithm was given by Lovász. It is an open problem whether weighted linear matroid matching is polytime solvable and no polyhedral description is known. In this talk we describe the fractional matroid matching polytope introduced by Vande Vate, a 1/2-integer relaxation that is exact in the special case of matroid intersection. We explain an efficient algorithm for maximum weight fractional matroid matching, extending the algorithm of Chang et al. for the unweighted case. As an application, we obtain a 2/3-approximation for weighted linear matroid matching.

The positive circuits of oriented matroids with the packing property or idealness. *Kenji Kashiwabara and Tadashi Sakuma.*
The class of clutters of the positive circuits of oriented matroids is an important class which generalizes both the dicut clutters and the dicycle clutters of directed graphs, together. In this article, we will show that the clutter of the positive circuits of an oriented matroid whose co-rank is at most 4 has the packing property if and only if it has none of the six minimally non-packing minors J_3, C_3^2, C_5^3, Q_6, $Q_6 \otimes 1$ and $Q_6 \otimes \{1, 2\}$. By using this, we will also prove that the clutter of the positive circuits of an oriented matroid whose co-rank is at most 4 is ideal if and only if it has none of the three minimally non-packing minors J_3, C_3^2, and C_5^3.

Local Search and Linear-Programming Relaxations for Matroid Matching in Graphs and Hypergraphs. *Jon Lee, Maxim Sviridenko and Jan Vondrak.*
We consider the classical matroid matching problem. Unweighted matroid matching for linear matroids was solved by Lovasz, and the problem is known to be intractable for general matroids. We present a PTAS for unweighted matroid matching for general matroids. In contrast, we show that natural LP relaxations that have been studied have an $\Omega(n)$ integrality gap and moreover, $\Omega(n)$ rounds of the Sherali-Adams hierarchy are necessary to bring the gap down to a constant.
More generally, for any fixed $k \geq 2$ and $\epsilon > 0$, we obtain a $(k/2 + \epsilon)$-approximation for matroid matching in k-uniform hypergraphs, also known as the matroid k-parity problem. As a consequence, we obtain a $(k/2 + \epsilon)$-approximation for the problem of finding the maximum-cardinality set in the intersection of k matroids. We also design a 3/2-approximation for the weighted version of a known special case of matroid matching, the matchoid problem.

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11:15-12:30 : ***Graphs and combinatorial optimization 2***
Chairman : S. Thomas McCormick
. ***César 7***

A Combined Parallel Lagrangian Decomposition and Cutting-Plane Generation for Maximum Stable Set Problems. *Manoel Campêlo and Ricardo C. Corrêa .*
We propose an integer programming formulation for the problem of finding the maximum k-partite induced sub-graph of a graph G based on representatives of stable sets. We investigate upper bounds provided by the solution, via a parallel sub-gradient algorithm, of a Lagrangian decomposition that breaks up this formulation into maximum weighted stable set problems for sub-graphs of G. Some computational experiments were carried out with an effective multi-threaded parallel implementation in a multi-core system, and their results are presented.

Lower Bounds for the Minimum Sum Coloring Problem. *Aziz Moukrim, Kaoutar Sghiouer, Corinne Lucet and Yu Li.*
In this paper we present our study of the minimum sum

coloring problem (MSCP). We propose a general lower bound for MSCP based on extraction of specific graph classes. Also, we propose a lower bound using some decomposition into cliques. The experimental results show that our approach improves the results for most literature instances.

Coloring Toeplitz graphs. *Ugo Pietropaoli and Sara Nicoloso.*
Let n, $a_1, a_2, \ldots, a_k$ be distinct positive integers. A finite Toeplitz graph $T_n(a_1, a_2, \ldots, a_k) = (V, E)$ is a graph where $V = \{v_0, v_1, ..., v_{n-1}\}$ and $E = \{(v_i, v_j),$ for $|i - j|$ in $\{a_1, a_2, \ldots, a_k\}\}$. If $V = N$, we get an infinite Toeplitz graph. In this paper we first give a complete characterization for bipartite finite and infinite Toeplitz graphs. We then focus on (finite/infinite) Toeplitz graphs with $k \leq 3$, and provide a characterization of their chromatic number.

12:30-14:00 : *Lunch*

14:00-15:00. ***Plenary session : Applications of combinatorial optimization in statics (rigidity of frameworks).***
András Recski
Chairman : Gérard Cornuéjols
. ***Amphi César***
Rigidity of frameworks, composed of rigid rods and rotatable joints, is an important question in civil engineering and, at the same time, a rich area for the applications of combinatorics.
In the first part of the talk
- we introduce the necessary concepts (rigidity and infinitesimal rigidity of the frameworks, the classical results of Maxwell etc),
- present results in the planar case, like Laman's theorem on the characterization of generic rigidity in the plane, the algorithm of Lovász and Yemini for checking this condition,
- briefly review the analogous results and open questions for tensegrity frameworks (where not only rigid rods but cables and struts are also permitted).

Then we concentrate on a special case: how to make a square grid rigid in the plane (or a cubic grid rigid in the space) by using diagonal bars. Here we shall see that seemingly innocent engineering questions can lead to very interesting (and sometimes quite deep) results in graph theory.
The lecture does not require any preliminary knowledge in engineering. Some basic concepts in graph theory are needed only.

15:05-16:45 : ***Network design 2***
Chairman : Eric Gourdin
. ***César 2***

Finding min-degree constrained spanning trees faster with a Branch-and-cut algorithm. *Leonardo Martinez and Alexandre Cunha.*
In this paper, two formulations for the Min-degree Constrained Minimum Spanning Tree Problem, one based on undirected Subtour Elimination Constraints and the other on Directed Cutset inequalities, are discussed. The quality of the Linear Programming bounds provided by them is addressed and a Branch-and-cut algorithm based on the strongest is investigated. Our computational experiments indicate that the method compares favorably with other exact and heuristic approaches in the literature, in terms of solution quality and execution times. Several new optimality certificates and new best upper bounds are provided here.

The Location-Dispatching Problem : polyedral results and Content Delivery Network Design. *Philippe Chretienne, Pierre Fouilhoux, Eric Gourdin and Jean-Mathieu Segura.*
Let $G = (V, A)$ be a directed graph and F be a set of items. The Location-Dispatching Problem consists of determining subsets $L_i \subseteq F$, $i \in V$, minimizing the sum of two costs: an installation cost associated with nodes i of V such that $L_i \neq \emptyset$ and, for every nodes of V, a cost for accessing each item of F. We formulate this problem as an integer linear program and propose a facial study of the associated polytope. We describe valid inequalities and give sufficient conditions for these inequalities to be facet defining. Using this, we devise a branch-and-cut algorithm and report some preliminary experimental results. This algorithm has been used to solve Content Delivery Network instances in order to optimize a Video On Demand (VoD) system.

Networks with unicyclic connected components and without short cycles. *Walid Ben-Ameur, Makhlouf Hadji and Adam Ouorou.*
This paper focuses on the design of networks with unicyclic connected components. The size of each cycle should not be less than a given number. A polyhedral study is proposed. Many facets and valid inequalities are derived. Some of them can be exactly separated in polynomial time. Then the network design problem is solved by a cutting plane algorithm based on these inequalities and using a compact formulation issued from the transversality of the bicircular matroid.

Steiner Networks with unicyclic connected components . *Walid Ben-Ameur and Makhlouf Hadji.*
This paper focuses on the design of minimum cost networks satisfying two technical constraints. First, the connected components should be unicyclic. Second, some given special nodes must belong to cycles. This problem is a generalization of the perfect binary 2-

matching problem. It turns out that the problem is easy to solve since it can be seen as a b-matching in an appropriate extended graph. We also present a partial description of the convex hull of the incidence vectors of these Steiner networks. Polynomial time separation algorithms are described. One of them is a generalization of the Padberg-Rao algorithm to separate blossom inequalities.

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15:05-16:45 : ***IS : Inverse combinatorial optimization***
Chairman : Rainer E. Burkard
Organizer : Rainer E. Burkard
. ***César 3***

On Inverse Chromatic Number problems. *Yerim Chung, Jean-François Culus and Marc Demange.*
We study inverse chromatic number problems in permutation graphs and in interval graphs. Given a fixed instance and a fixed integer K, the instance has to be modified as little as possible so that the newly obtained graph can be colored with K colors or less. We show that the inverse (p, k)-colorability problem (defined similarly) in permutation graphs is polynomially solvable for fixed p and k. We then propose a polynomial-time algorithm for solving inverse chromatic number problem in interval graphs where all intervals have length 1 or 2. We also show that the latter problem is NP-hard if there is a constant number of different interval lengths.

The 1-Median Problem in Rd with the Chebyshev-Norm and its Inverse Problem. *Johannes Hatzl.*
In this paper, we consider the 1-median problem in Rd with the Chebyshev-norm. We give an optimality criterion for this problem which enables us to solve the following inverse location problem in polynomial time: Given n points $P_1, \ldots, P_n$ with non-negative weights wi and a point P_0 the task is to find new non-negative weights $\tilde{w}_i$ such that P_0 is a 1-median with respect to the new weights and $||w - \tilde{w}||_1$ is minimized. In fact, this problem reduces to a balancing flow problem for which an optimal solution can be obtained in polynomial time.

The inverse 1-median problem on a tree and on a path . *Mohammadreza Galavii.*
This article considers the inverse 1-median problem on a tree and on a path. The aim is to change the vertex weights at minimum total cost with respect to given modification bounds such that a prespecified vertex becomes 1-median. The inverse 1-median problem on trees with nonnegative weights can be formulated as a relaxation knapsack problem and therefore the problem is solvable in O(n)-time. For a path with pos/neg weights the 1-median lies on one of the vertices with positive weights or lies on one of the end points. This property leads us to solve the inverse 1-median problem on a path with negative weights (the weight of endpoints are arbitrary) in linear time.

Inverse center location problems. *Rainer Burkard and Behrooz Alizadeh.*
We investigate the inverse 1-center location problem on trees and outline combinatorial algorithms with time complexity $O(n^2)$ in case that the topology of the tree does not change. In the uniform cost model an improved running time of $O(n \log n)$ can be obtained. If topology changes occur, the complexity increases by a factor bounded by n. This improves earlier results of Yang and Zhang.

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15:05-16:45 : ***IS : Recent developments in scheduling theory***
Chairman : Ammar Oulamara
Organizer : Ammar Oulamara, Ameur Soukhal
. ***César 4***

A bicriteria flow-shop scheduling problem with two serial batching machines. *Afef Bouzaiene, Najoua Dridi, Mohamed Ali Aloulou and Daniel Vanderpooten.*
We consider a bicriteria two-machine flow-shop serial-batch problem where the batches have limited size. The first criterion is the number of batches to be minimized. This criterion reflects situations where processing of any batch induces a fixed cost, which leads to a total cost proportional to the number of batches. The second criterion is the makespan. We provide a dynamic programming algorithm in the case where the jobs processing times on the first machine are constant. We also establish a dominance relation allowing us to derive an alternative algorithm with better complexity when the batch size is equal to two.

Polynomial Lower Bounds for the Two-Machine Flowshop Problem with Sequence-Independent Setup Times . *Anis Gharbi, Talel Ladhari, Mohamed Kais Msakni and Mehdi Serairi.*
In this paper, we address the problem of two-machine flowshop scheduling problem with sequence independent setup times to minimize the total completion time. We propose five new polynomial lower bounds. Computational results based on randomly generated data show that our proposed lower bounds consistently outperform those of the literature.

Scheduling flexible flowshops with unit-time operations and minimum time delays. *Djamal Rebaine.*
In this paper, we consider the flexible flowshop problem with unit-time operations and minimum time delays. We present two simple heuristic algorithms to

solve this problem along with their worst-case analyses.

New scheduling problems coming from grid computing. *Alexandre Lissy and Patrick Martineau.*
In this article, we exposes how the availability of an increasing computational power affects scheduling problems that are used around grid computing to use this power. We first present how is currently handled the scheduling problems, and the so-called "next-generation" clusters that will have different needs. Starting from those, we extract "real-life" issues that will affect the scheduling and its resolutions and we will exposes how it affects scheduling and assignment problems. Then, we will conclude with some emerging ways to increase scheduling performances.

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15:05-16:45 : ***IS : Oiks and games***
Chairman : Jack Edmonds
Organizer : Jack Edmonds
. ***César 5***

On Finding Another Room-Partitioning of the Vertices. *Jack Edmonds and Laura Sanitá.*
Let T be a triangulated surface given by the list of vertex-triples of its triangles, called rooms. A room-partitioning of T is a subset R of the rooms such that each vertex of T is in exactly one room in R. We prove that if T has a room-partitioning R, then there is another room-partitioning of T which is different from R. The proof is a simple algorithm which walks from room to room, which however we show to be exponential by constructing a sequence of (planar) instances, where the algorithm walks from room to room an exponential number of times relative to the number of rooms in the instance. We unify the above theorem with Nash's theorem stating that a 2-person game has an equilibrium, by proving a combinatorially simple common generalization.

Euler Complexes (Oiks). *Jack Edmonds.*
We present a class of instances of the existence of a second object of a specifed type, in fact, of an even number of objects of a specifed type, which generalizes the existence of an equilibrium for bimatrix games. The proof is an abstract generalization of the Lemke-Howson algorithm for finding an equilibrium of a bimatrix game. Versions of this note, with various examples, were presented at a Dagstuhl conference in 2007, the Dubrovnik ECCO XXI conference in 2008, the Paris TGGT conference in 2008, and the Bonn conference, "Recent trends in Combinatorial Optimization", proceedings : Springer, 2009. The version here is meant to be updated convenience for the session on Oiks, ISCO, 2010.

Sperner Oiks. *Jack Edmonds, Stephane Gaubert and Vladimir Gurvich.*
The idea of "Lemke pivoting in a family of oiks (Euler complexes)" generalizes, and abstracts to pure combinatorics, the Lemke-Howson exchange algorithm for finding a Nash equilibrium in bimatrix games, as well as the classical algorithm for finding the properly colored room in Sperner's Lemma. Given a "room-partitioning", this algorithm finds another (distinct) room-partitioning by traversing the exchange graph. In this paper we show that each family of k oiks $O = \{O(1), \ldots, O(k)\}$ can be reduced to a pair of oiks $O' = \{O(1) + \ldots + O(k), O(0)\}$ (one of which, $O(0)$, is a Sperner oik) such that the exchange graphs for O and O' are isomorphic. Numerous applications of Sperner's Lemma in combinatorial topology are well known.

Scarf Oiks. *Jack Edmonds, Stephane Gaubert and Vladimir Gurvich.*
We formulate the famous Scarf Lemma in terms of oiks. This lemma has two fundamental applications in game and graph theory. In 1967, Scarf derived from it core-solvability of balanced cooperative games. Recently, it was shown that kernel-solvability of perfect graphs also results from this lemma. We show that Scarf's combinatorially defined oiks are in fact realized by polytopes, and that Scarf's algorithm for proving the Scarf Lemma is an instance of the Lemke-Howson algorithm for finding an equilibrium of a bimatrix game. We give a sequence of inputs of two equal d-dimensional Scarf oiks on $2d$ vertices, found by computer, such that the pivoting path of the algorithm grows exponentially with d.

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15:05-16:45 : ***IS : Mathematical programming reformulations and applications***
Chairman : Leo Liberti
Organizer : Leo Liberti
. ***César 6***

Valid Inequalities and Convex Hulls for Multilinear Functions. *Andrew J. Miller, Mahdi Namazifar and Pietro Belotti.*
We study the convex hull descriptions of the bounded, nonconvex set defined by constraining one bounded variable to be a product of n other product variables. We seek to derive strong valid linear inequalities for this set this is motivated by the fact that many exact solvers for nonconvex problems use polyhedral relaxations so as to compute a lower bound via linear programming solvers.
We present a class of linear inequalities that, together with the well-known McCormick inequalities, defines the convex hull of the bounded product of two variables (i.e., $n = 2$). This class of inequalities, which we call lifted tangent inequalities, is uncountably infinite, which is not surprising given that the convex hull of the bounded binliear set is not a polyhedron. Moreover, this class of inequalities generalizes directly to the

case in which $n > 2$, allowing us to define strengthened relaxations for these higher dimensional sets as well.

Mathematical programming based debugging. *Leo Liberti, Stéphane Le Roux, Jeremy Leconte and Fabrizio Marinelli.*
Verifying that a piece of software has no bugs means proving that it has certain desired properties, such as an array index not taking values outside certain bounds. Abstract interpretation is used in the static analysis of code to establish the inclusion-wise smallest set of values (numerical invariant) that the program variables can attain during program execution. Such sets can be used to detect run-time errors without actually running the program. We present a mathematical program that determines guaranteed smallest interval invariants of computer programs with integer affine arithmetics and compare our results to existing techniques.

Formulation symmetries in circle packing . *Alberto Costa, Leo Liberti and Pierre Hansen.*
The performance of Branch-and-Bound algorithms is severely impaired by the presence of symmetric optima in a given problem. We describe a method for the automatic detection of formulation symmetries in MINLP instances. A software implementation of this method is used to conjecture the group structure of the problem symmetries of packing equal circles in a square. We provide a proof of the conjecture and compare the performance of spatial Branch-and-Bound on the original problem with the performance on a reformulation that cuts away symmetric optima.

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15:05-16:45 : ***Cutting plane algorithms***
Chairman : Andrea Lodi
. ***César 7***

A Branch-and-Cut Algorithm for the Latent Class Logit Assortment Problem. *Isabel Méndez-Díaz, Juan Jose Miranda Bront, Gustavo Vulcano and Paula Zabala.*
We study the product assortment problem of a retail operation that faces a stream of customers heterogeneous with respect to preferences. Upon arrival, each customer checks the offer set displayed by the firm, and either chooses one of those products according to a multinomial-logit (MNL) criterion or quits without purchasing. The firm's goal is to maximize the expected revenue extracted from each customer.
The general version of the logit assortment problem is known to be NP-Hard. In this paper, we analyze uncapacitated and capacitated (i.e., with a limited number of products to display) versions of it, and propose a branch-and-cut algorithm that is computationally feasible and leads to high-quality solutions.

Primal-dual simplex method for shooting. *Sangho Shim, Ellis Johnson and Wenwei Cao.*
Gomory (1969) solved the cyclic group problem by a dynamic programming algorithm. We discuss its complexity and introduce a (fractional) cutting plane algorithm as an alternative algorithm. Each cutting plane is generated by solving a shooting linear programming problem. We implement primal-dual simplex method to solve the shooting linear programming problem. A computational result is given on a Wong-Coppersmith digraph.

Cutting-planes for weakly-coupled 0/1 second order cone programs. *Sarah Drewes and Sebastian Pokutta.*
We will analyze mixed 0/1 second order cone programs where the fractional and binary variables are solely coupled via the conic constraints. For this special type of mixed-integer second order cone programs we devise a cutting-plane framework based on the generalized Bender's cut. We show that the resulting cuts are very effective as symmetric solutions are automatically cut off as well and each equivalence class of 0/1 solutions is visited at most once. We also present computational results showing the effectiveness of our method and sketch an application in optimal pooling of securities.

Lower Bounds for the Minimum Linear Arrangement of a Graph. *Alberto Caprara, Adam Letchford and Juan José Salazar.*
Minimum Linear Arrangement is a classical basic combinatorial optimization problem from the 1960s, which turns out to be extremely challenging in practice. In particular, for most of its benchmark instances, even the order of magnitude of the optimal solution value is unknown, as testified by the surveys on the problem that contain tables in which the best known solution value often has one more digit than the best known lower bound value. In this paper, we propose a linear-programming based approach to compute lower bounds on the optimum. This allows us, for the first time, to show that the best known solutions are indeed not far from optimal for most of the benchmark instances.

16:45-17:15 : *Coffee Break*

17:15-18:55 : ***IS : Telecommunication network design***
Chairman : Walid Ben-Ameur
Organizer : Michal Pioro
. ***César 2***

Optimal routing for minimizing the maximal link congestion. *Olivier Klopfenstein and Hassan Hijazi.*
A lot of attention has been devoted to flow routing in

networks by the past. Usually, each commodity to be routed is characterized by a single deterministic traffic value. However, many real-life application contexts require to consider stochastic flows. This is the case, for instance, in telecommunication networks. The current paper revisits usual network routing and dimensioning models, in considering that traffic amounts to be routed are random variables. This leads naturally to probabilistic constraints. Some mathematical properties of the stochastic models introduced are described. A special focus is made on the relations between these stochastic models and usual deterministic approaches.

Failure disjoint paths. *Mateusz Zotkiewicz, Walid Ben-Ameur and Michal Pioro.*
Given a weighted directed graph where some arcs can fail while others are reliable, we aim to compute a shortest pair of failure-disjoint paths. If a reliable arc is used by both paths, its cost is counted only once. We present a polynomial time algorithm to solve the problem.

Polynomial traffic demand polytope partitioning . *Walid Ben-Ameur and Mateusz Zotkiewicz.*
We consider the problem of partitioning of a traffic demand polytope using a hyperplane. The polytope is divided into parts, and different routing schemes are applied while dealing with traffic matrices from different parts of the polytope. Different demands cannot share resources, and reservation vectors on opposite sides of the hyperplane have to be identical. We provide a polynomial time algorithm solving the presented problem when a traffic demand polytope is defined as a convex hull of a known set of traffic demand matrices.

Load Balancing Optimization of Capacitated Networks with Path Protection. *Amaro de Sousa, Dorabella Santos, Pedro Matos and Joaquim Madeira.*
This article deals with the routing of a given set of traffic flows over a telecommunications network with given link capacities. The aim is to optimize the network load balancing. We address the case where each traffic flow is supported by two edge disjoint routing paths, a mechanism known as path protection, which guarantees full traffic protection of single link failures. We describe an exact solving method based on mathematical programming and propose a meta-heuristic algorithm. Then, we define a set of case studies arising in the context of metropolitan Ethernet networks. Finally, we present the computational results of both methods and compare them in terms of solutions optimality versus runtime.

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17:15-18:55 : ***IS : Progress in scheduling***
Chairman : Anis Gharbi
Organizer : Anis Gharbi
. ***César 3***

An exact method for the bi-objective one-machine problem with maximum lateness and unit family setup cost objectives . *Christian Artigues, Nicolas Jozefowiez and Mohamed-Ali Aloulou.*
This paper deals with an NP-hard bi-objective one-machine problem with ready times involving maximum lateness and unit family setup cost objectives. Considering separately both objectives, the maximum lateness one-machine problem is also NP-hard but efficiently solved by Carlier's algorithm while the unit family setup cost one machine-problem with two families can be solved in polynomial timeby Darte's algorithm, even when precedence constraints are considered. Under the epsilon-constraint framework we propose a branch-and-bound method to minimize the first objective with a given upper bound on the second.

Minimizing total completion time on a batching machine with job processing time compatibilities. *Adrien Bellanger, Ammar Oulamara and Mikail Kovalyov.*
The problem of scheduling n jobs on an unbounded batching machine to minimize the total completion time is studied. The machine can process any number of jobs simultaneously in a batch, subject to an additional constraint that, in the same batch, the job processing times are compatible. There are given normal job processing times. An actual job processing time can exceed its normal value up to a certain percent. This percent is the same for all jobs. Thus, there are processing time intervals for the jobs. The job processing times are compatible if the corresponding processing time intervals intersect. The processing time of a batch is given by the longest processing time of the tasks in the batch and it correspnds to the left endpoint of the intersection of the job processing time intervals in this batch. For the total completion time a dynamic programming algorithm is provided.

Exact Method for Robotic Cell Problem. *Mohamed Kharbeche, Jacques Carlier, Mohamed Haouari and Aziz Moukrim.*
This study investigates an exact method for the Robotic Cell Problem. We present an exact branch and bound algorithm which is the first exact procedure specifically designed for this strongly NP-hard problem. In this paper, we propose a new mathematical formulation and we describe a new lower bound for the RCP. In addition, we propose a genetic algorithm. We report that the branch and bound algorithm is more effective than the proposed mathematical formulation which can solve small sized problem. Also, computational study provides evidence that the genetic algorithm delivers reasonably good solutions while requiring significantly

shorter CPU times for large problems.

Extending the Single Machine-Based Relaxation Scheme for the Job Shop Scheduling Problem. *Anis Gharbi and Mohamed Labidi.*
The contribution of this paper to the job shop related literature is twofold. First, we provide an efficient way of solving the job shop scheduling problem with release dates, delivery times and delayed precedence constraints. It is shown that the latter problem is equivalent to a classical job shop with precedence constraints. Second, an effective extension of the standard single machine-based relaxation scheme is derived. Preliminary computational results conducted on a set of benchmark instances show that effective multiple machine-based lower bounds can be computed within reasonable CPU time.

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17:15-18:55 : ***IS : Extended formulations in combinatorial optimization***
Chairman : Volker Kaibel
Organizer : Volker Kaibel
. ***César 4***

Symmetry matters for the sizes of extended formulations. *Kanstantsin Pashkovich, Volker Kaibel and D. O. Theis.*
Yannakakis (J. Comput. System Sci., 1991) proved that no symmetric extended formulation for the matching polytope of the complete graph K_n with nnodes has a number of variables and constraints that is bounded subexponentially in n. Here, symmetric means that the formulation remains invariant under all permutations of the nodes of K_n. It was also conjectured inthe paper mentioned above that "asymmetry does not help much," but no corresponding result for general extended formulations has been found so far. In this paper we show that for the polytopes associated with the matchings in K_n with $log(n)$ (rounded down) edges there are non-symmetric extended formulations of polynomial size, while nevertheless no symmetric extended formulation of polynomial size exists. We furthermore prove similarstatements for the polytopes associated with cycles of length $log(n)$ (rounded down). Thus, with respect to the question for smallest possible extended formulations, in general symmetry requirements may matter a lot.

The stable set polytope of the composition of strips. *Gianpaolo Oriolo, Yuri Faenza and Gautier Stauffer.*
Composition of strips was introduced by Chudnovsky and Seymour as a key tool for decomposing claw-free graphs. In a recent paper Oriolo, Pietropaoli and Stauffer have revealed how one can use the structure of this composition to solve the stable set problem for composed graphs in polynomial time by reduction to matching. In this talk we are now going to reveal the nice polyhedral counterpart, i.e. how one can use the structure of thiscomposition to describe the stable set polytope of composed graphs from the matching one and, more importantly, how one can use it to separate over the stable set polytope in polynomial time. We will then apply those general results back to where they originated from : stable set in claw-free graphs, to show that the stable set polytope can be reduced to understanding the polytope in very basic structures (for most of which it is already known). In particular for a general claw-free graph G, we show an integral extended formulation for $STAB(G)$ and a procedure to separate in polynomial time over $STAB(G)$ moreover, we provide a complete characterization of $STAB(G)$ when G is any claw-free graph with stability number at least 4 having neither homogeneous pairs nor 1-joins. We believe that the missing bricks towards the characterization of the stable set polytope of claw-free graphs are more technical than fundamentals in particular, we have a characterization for most of the building bricks of the Chudnovsky-Seymour decomposition result and we are therefore very confident it is only a question of time before we solve the remaining case.

Finding Gale Strings. *Marta Casetti, Julian Merschen and Bernhard von Stengel.*
The problem 2-NASH of finding a Nash equilibrium of a bimatrix game belongs to the complexity class PPAD. This class comprises computational problems that are known to have a solution by means of a path-following argument. For bimatrix games, this argument is provided by the Lemke-Howson algorithm. It has been shown that this algorithm is worst-case exponential with the help of dual cyclic polytopes, where the algorithm can be expressed combinatorially via labeled bitstrings defined by the 'Gale evenness condition' that characterize the vertices of these polytopes. We define the combinatorial problem ANOTHER COMPLETELY LABELED GALE STRING whose solutions define the Nash equilibria of games defined by cyclic polytopes, including games where the Lemke-Howson algorithm takes exponential time. If this problem was PPAD-complete, this would imply that 2-NASH is PPAD-complete, in a much simpler way than the currently known proofs, including the original proof by Chen and Deng. However, we show that ANOTHER COMPLETELY LABELED GALE STRING is solvable in polynomial time by a simple reduction to PERFECT MATCHING in graphs, making it unlikely to be PPAD-complete. Although this result is negative, we hope that it stimulates research into combinatorially defined problems that are PPAD-complete and imply this property for 2-NASH.

Polyhedral branching systems. *Volker Kaibel and A. Andreas Loos.*
We introduce the framework of polyhedral branching systems that can be used in order to construct extended formulations for polyhedra by combiningextended

formulations for other polyhedra. The framework, for instance, simultaneously generalizes extended formulations like the well-known ones(see Balas) for the convex hulls of unions of polyhedra (disjunctiveprogramming) and like those obtained from dynamic programming algorithmsfor combinatorial optimization problems (due to Martin, Rardin, and Campbell). Using the framework, we construct extended formulations for full orbitopes (the convex hulls of all 0/1-matrices with lexicographically sorted columns), we show at the examples of two special matching problems, how polyhedral branching systems can be exploited in order to construct formulations for certain nested combinatorial problems, and we indicate how one can build extended formulations for stable set polytopes using the framework of polyhedral branching systems.

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17:15-18:55 : ***IS : Graphs and combinatorial optimization problems 1***
Chairman : Arnaud Pêcher
Organizer : Arnaud Pêcher
. ***César 5***

Balancedness of some subclasses of circular-arc graphs . *Flavia Bonomo, Guillermo Alfredo Durán, Martín Darío Safe and Annegret K. Wagler.*
A graph is balanced if its clique-vertex incidence matrix is balanced, i.e., it does not contain a square submatrix of odd order with exactly two ones per row and per column. Interval graphs, obtained as intersection graphs of intervals of a line, are well-known examples of balanced graphs. A circular-arc graph is the intersection graph of a family of arcs on a circle. Circular-arc graphs generalize interval graphs, but are not balanced in general. In this work we characterize balanced graphs by minimal forbidden induced subgraphs restricted to graphs that belong to some classes of circular-arc graphs.

Total chromatic number of {square,unichord}-free graphs. *Raphael Machado and Celina de Figueiredo.*
We determine a surprising class for which edge-colouring is NP-complete but whose graphs are all Type 1. The class of unichord-free graphs was recently studied by Trotignon and Vušković in the context vertex-colouring. Machado, Figueiredo and Vušković established the NP-completeness of edge-colouring unichord-free graphs. For the subclass of {square,unichord}-free graphs, an interesting complexity dicothomy holds : if the maximum degree is 3, the edge-colouring is NP-complete, otherwise, the problem is polynomial. Subsequently, Machado and Figueiredo settled the validity of the Total-Colouring Conjecture for square,unichord-free graphs by proving that non-complete {square,unichord}-free graphs of maximum degree at least4 are Type 1. In the present work, we prove that non-complete {square,unichord}-free graphs of maximum degree 3 are Type 1, establishing the polynomiality of total-colouring restricted to {square,unichord}-free graphs.

Complexity dichotomy on degree-constrained VLSI layouts with unit-length edges. *Vinícius G. P. de Sá, Celina M. H. de Figueiredo, Guilherme D. da Fonseca and Raphael S. Machado.*
Deciding whether an arbitrary graph admits a VLSI layout with unit-length edges is NP-complete, even when restricted to binary trees. However, for certain graphs, the problem is polynomial or even trivial. A natural step, outstanding thus far, was to provide a broader classification of graphs that make for polynomial or NP-complete instances. We provide such a classification based on the set of vertex degrees in the input graphs, yielding a comprehensive dichotomy on the complexity of the problem, with and without the restriction to trees.

The computational complexity of the Edge-Perfect Graph and the Totally Balanced Packing Game recognition problems. *Valeria Leoni, María Patricia Dobson and Graciela Nasini.*
Edge-perfect graphs were recently introduced by Escalante et al. An edge-subgraph of a given graph is an induced subgraph obtained by deletion of the endpoints of a subset of edges. A graph is edge-perfect if the stability and the edge covering numbers coincide for every edge-subgraph.
In this work we prove that the recognition of edge-perfect graphs is an *NP*-hard problem. As a by-product, we derive the *NP*-completeness of two related problems in graphs.
From the NP-hardness of the edge-perfection recognition problem we answer the open question on the recognition of totally balanced packing game defining matrices —raised by Deng et al. in 2000—, obtaining that this problem is NP-hard in contrast with the polynomiality for the covering case due to van Velzen (2005).

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17:15-18:55 : ***Packing problems 1***
Chairman : Alain Quilliot
. ***César 6***

Consecutive ones matrices for multi-dimensional orthogonal packing problems. *Arnaud Pêcher and Cédric Joncour.*
The multi-dimensional orthogonal packing problem (OPP) is a well studied optimization problem. Given a set of items with rectangular shapes, the problem is to decide whether there is a non-overlapping packing of these items in a rectangular bin. Rotation of items is not allowed.
Fekete and Schepers introduced a tuple of interval

graphs as data structures to store a feasible packing, and gave a very efficient algorithm. In this paper, we propose a new algorithm using consecutive one matrices as data structures, due to Fulkerson and Gross's characterization of interval graphs. Computational results are reported, which show its effectiveness.

A Computational Study of Lower Bounds for the Two Dimensional Bin Packing Problem. *Mehdi Serairi and Mohamed Haouari.*
We survey lower bounds for the variant of the two-dimensional bin packing problem where items cannot be rotated. We prove that the dominance relation claimed by Carlier et al. between their lower bounds and those of Boschetti and Mingozzi is not valid. We analyze the performance of lower bounds from the literature and we provide the results of a computational study.

A Linear Programming Approach for the Three-Dimensional Bin-Packing Problems. *Mhand Hifi, Imed Kacem, Stéphane Negre and Lei Wu.*
In this paper we consider the three-dimensional single bin-size bin packing problem (3D-SBSBPP). Such a problem is a well-known NP-hard problem which consists in packing a set of items in a minimal number of bins. First, we introduce a mixed-integer linear model of 3D-SBSBPP (MILP1). Some special valid inequalities will be presented in order to improve the relaxed lower bound (LB) of MILP1. An upper bound (U B) can be calculated by solving a sequence of single bin filling problems. At last, we test our LB and U B over 9 groups of instances described by Martello et al. The obtained results show that our method provides better results over 50% instances. Furthermore, the proposed model can be easily integrated in other the practical issues.

Prospective Network flow models and algorithms for Bin Packing Problems. *Alain Quilliot and Hélène Toussaint.*
In this paper, we aim at making appear the way Flow and Multi-commodity Flow Theory may be used in order to deal with combinatorial geometry problems like the 2D-Bin Packing problem. In order to do it, we introduce a notion of no circuit double flow, we state a Reformulation Theorem which associates some multi-commodity flow model with a given Bin-Packing problem, and we provide an algorithm whose purpose is to study the way one may deal with the no circuit constraint which is at the core of our multi-commodity flow model.

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17:15-18:55 : ***Approximation algorithms***
Chairman : Vangelis Paschos
.
César 7

1-local 7/5-competitive Algorithm for Multicoloring Hexagonal Graphs. *Rafal Witkowski and Janez Zerovnik.*
Hexagonal graphs are graphs induced on subsets of vertices of triangular lattice. They arise naturally in studies of cellular networks. We present a 1-local 7/5-competitive distributed algorithm for multicoloring a hexagonal graph, thereby improving the previous 1-local 17/12-competitive algorithm.

Approximability of the Multiple Stack TSP. *Sophie Toulouse.*
STSP seeks for a pair of pickup and delivery tours in two distinct networks, where the two tours are related by LIFO contraints. We address here the problem approximability. We notably establish that asymmetric MaxSTSP and MinSTSP12 are APX, and propose a heuristic that yields to a 1/2, 3/4 and 3/2 standard approximation for respectively Max2STSP, Max2STSP12 and Min2STSP12.

Approximation of the Clustered Set Covering Problem. *Laurent Alfandari and Jérôme Monnot.*
We define a **NP**-hard clustered variant of the Set Covering Problem where subsets are partitioned into K clusters and a fixed cost is paid for selecting at least one subset in a given cluster. This variant can reformulate as a master problem various multi-commodity flow problems in transportation planning. We show that the problem is approximable within ratio $(1+\epsilon)(e/e-1)H(q)$, where q is the maximum number of elements covered by a cluster and $H(q) = \sum_{i=1}^{q} \frac{1}{i}$.

Approximation by moderately exponential algorithms. *Vangelis Th. Paschos.*
We present a trade-off between polynomial approximation and exact computation. We show how using ideas from both fields one can design approximation algorithms for several combinatorial problems achieving ratios that cannot be achieved in polynomial time (unless a very unlikely complexity conjecture is confirmed) with worst-case complexity much lower (though super-polynomial) than that of an exact computation. We then show how such ratios can be achieved for maximum independent set, minimum vertex cover and minimum set cover.

Thursday, March 25

8:00-9:40 : ***IS : Engineering applications of combinatorial optimization***
Chairman : Andras Recski
Organizer : Andras Recski
. ***César 2***

Piece Selection Algorithm for Layered Video Streaming in P2P Networks. *Tibor Szkaliczki, Michael Eberhard, Hermann Hellwagner and László Szobonya.*
This paper introduces the piece selection problem that arises when streaming layered video content over peer-to-peer networks. The piece selection algorithm decides periodically which pieces to request from other peers (network nodes) for download. The main goal of the piece selection algorithm is to provide the best possible quality for the available bandwidth.
Our recommended solution approaches are related to the typical problems and solutions in the knapsack problem.

Query-based Information Gathering in Intelligent Transportation Systems. *Peter Laborczi, Balazs Mezny, Attila Torok and Zoltan Ruzsa.*
One of the roles of Intelligent Transportation Systems (ITS) is to collect and disseminate certain information from different locations of the road network. This information can be related to traffic safety (e.g. dangerous situations on the road), to traffic efficiency (e.g. current experienced travel times), or to other information (e.g. parking possibilities) the drivers are interested in. The communication network used for dissemination can be either distributed or centralized or a combination of them. In this paper we focus on optimizing the positions where vehicles along their routes should send query messages in order to collect information about traffic jams. This problem is formulated and solved as an Integer Linear Programming problem. Finally, the numerical results are presented and analyzed.

Additive Approximation for Layer Minimization of Manhattan Switchbox Routing. *Dávid Szeszlér.*
Switchbox routing is one of the many problems arising in the field of VLSI routing. It requires interconnecting given sets of terminals that are placed on the boundaries of a rectangular circuit board using a 3-dimensional grid in a vertex-disjoint way.
An important special case is the Manhattan Switchbox Routing problem. Here minimizing the number of layers of a routing (that is, the height of the grid) is known to be NP-hard. In this paper we provide a linear time algorithm that solves any such problem on a number of layers that is greater by at most 5 than the optimum.

A Survey on Algorithms for the Maximum Internal Spanning Tree and Related Problems. *Gabor Salamon.*
Given an undirected connected graph G we consider the problem of finding a spanning tree of G with a maximum number of internal (at-least-2 degree) vertices. This problem, called the Maximum Internal Spanning Tree problem, is obviously NP-hard since it generalizes the Hamiltonian Path problem. In this paper we aim at giving a survey on recent results about the Maximum Internal Spanning Tree problem including different approaches such as exact exponential algorithms, fixed parameter tractability, and approximation algorithms. We also consider the problem of finding a large at-most-q-leaf subtree of the input graph for some fixed q.

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8:00-9:40 : ***Metaheuristics 1***
Chairman : Said Hanafi
. ***César 3***

Cooperative model-based metaheuristics. *Leonid Hulianytskyi and Sergii Sirenko.*
The paper presents a methodology for the construction of cooperative model-based metaheuristics for combinatorial optimization problems. Its distinctive feature is two-level structure. The lower level constitutes of independent model-based algorithms called basic. The higher (guiding) level perform search in the problem models space using individual models provided by basic algorithms. The guiding procedure also implement search experience exchange between basic algorithms. As basic algorithms one can take copies of the algorithms that belong either to the same or to the different model-based methods. Cooperative metaheuristic on the basis of ant colony optimization was developed for study of the approach. Results of computational experiment show the efficacy of the suggested cooperation scheme. Presented framework can serve as a basis for hyper-heuristics development.

A Variable Neighborhood Search and its Application to a Ring Star Problem Generalization. *Majid Salari, Zahra Naji-Azimi and Paolo Toth.*
We address the Capacitated m-Ring-Star Problem (CmRSP) in which the goal is to find m rings (simple cycles) visiting a central depot, a subset of customers and a subset of potential (Steiner) nodes, while customers not belonging to any ring must be "allocated" to a visited (customer or Steiner) node. Moreover, the rings must be node-disjoint and the number of customers allocated or visited in a ring cannot be greater than a capacity Q. The objective is to minimize the total visiting and allocation costs. The problem is a generalization of the Traveling Salesman Problem, hence it is NP-hard. We present a new heuristic approach

based on a Variable Neighborhood Search (VNS), and incorporating an Integer Linear Programming (ILP) based improvement procedure. A comparison of the proposed VNS method with existing algorithms for CmRSP, clearly shows the effectiveness of the proposed approach.

Hybrid Variable Neighbourhood Decomposition Search for 0-1 Mixed Integer Programming Problem. *Said Hanafi, Jasmina Lazic, Nenad Mladenovic, Christophe Wilbaut and Igor Crevits.*
In this paper we propose new hybrid heuristics for the 0-1 mixed integer programming problem, based on the variable neighbourhood decomposition search principle and on exploiting information obtained from a series of relaxations. In the case of a maximization problem, we add iteratively pseudo-cuts to the problem in order to produce a sequence of lower and upper bounds of the problem, so that integrality gap is reduced. We validate our approaches on the well-known 0-1 multidimensional knapsack problem, in which the general-purpose CPLEX MIP solver is used as a black box for solving subproblems generated during the search process. The results obtained with these methods are comparable with the current state-of-the-art heuristics on a set of large scale instances.

Variable Neighbourhood Pump Heuristic for 0-1 Mixed Integer Programming Feasibility . *Said Hanafi, Jasmina Lazic and Nenad Mladenovic.*
In this paper we propose a new method for finding initial feasible solutions of Mixed integer programs. We call it Variable neighborhood pump, since it combines ideas of Variable neighborhood branching and Feasibility pump heuristics. The proposed heuristic was tested on an established set of 83 benchmark problems proven to be difficult to solve to feasibility. The results are compared with those of IBM ILOG CPLEX 11.1, which already includes standard feasibility pump as a primal heuristic. With our approach we managed to obtain better initial objective function values than CPLEX on 63 test instances, within similar average computational time.

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8:00-9:40 : ***Applications of combinatorial optimization 1***
Chairman : Naceur Azaiez
. ***César 4***

A Heuristic for an Earth Observing Satellite Constellation Scheduling Problem with Download Considerations. *Pei Wang and Gerhard Reinelt.*
This paper presents a priority-based conflict-avoided heuristic for the earth observing satellite constellation scheduling problem considering image downloads. A mathematical formulation for this oversubscribed vehicle routing and scheduling problem with time windows is defined. A priority-based conflict-avoided heuristic is provided, and the download scheduling mechanism is also studied. Finally the lower bound provided by the heuristic is compared with a lower bound obtained by a FIFO heuristic and an upper bound provided by ILOG CP.

Optimization for the test of on-chip memories. *Yann Kieffer and Lilia Zaourar.*
The insertion of electronic non-functional components to increase the testability of on-chip memories after production induces a multi-objective optimization problem. We give a model for this problem, and propose a three-step implemented methodology to solve it, without reducing the problem to the mono-objective optimization setting.

Matching with sizes (or scheduling with processing set restrictions). *Peter Biro and Eric McDermid.*
Matching problems on bipartite graphs where the entities on one side may have different sizes are intimately related to scheduling problems with processing set restrictions. We survey the close relationship between these two problems, and give new approximation algorithms for the (NP-hard) variations of the problems in which the sizes of the jobs are restricted. Specifically, we give an approximation algorithm with an additive error of one when the sizes of the jobs are either 1 or 2, and generalise this to an approximation algorithm with an additive error of $2^k - 1$ for the case where each job has a size taken from the set $\{1, 2, 4, \ldots, 2^k\}$ (for any constant integer k). We show that the above two problems become polynomial time solvable if the processing sets are nested.

Minimizing Expected Attacking Cost in Networks. *Anis Gharbi, Mohamed Naceur Azaiez and Mohamed Kharbeche.*
A branch-and-bound algorithm is devised to determine the optimal attack strategy to disconnect a network where the objective is to minimize the expected attacking cost. The attacker cannot launch an attack if its cost is beyond his available budget or its probability of success falls below a threshold level. The proposed branch-and-bound algorithm includes, among other features, a dynamic programming-based lower bound as well as a preprocessing algorithm which aims at identifying unattackable links and removing irrelevant ones. Extensive use of the min-cut algorithm is made to derive valid upper bounds and to perform feasibility tests. Preliminary numerical implementation shows potential to provide exact solutions for medium-sized networks within reasonable time.

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8:00-9:40 : ***IS : Network design 1***
Chairman : Valeria Leggieri
Organizer : Chefi Triki, Valeria Leggieri
. ***César 5***

An Exact Algorithm for the Steiner Tree Problem with Delays. *Valeria Leggieri, Mohamed Haouari and Chefi Triki.*
The Steiner Tree Problem with Delays (STPD) is a variant of the well-known Steiner Tree Problem in which the delay on each path between a source node and a terminal node is limited by a given maximum value. We propose a Branch-and-Cut algorithm for solving this problem using a formulation based on lifted Miller-Tucker-Zemlin subtour elimination constraints. The effectiveness of the proposed algorithm is assessed through computational experiments carried out on dense benchmark instances.

An exact algorithm for the minimum power multicasting problem in wireless sensor networks. *Roberto Montemanni and Valeria Leggieri.*
The Minimum Power Multicast Problem arises in wireless sensor networks and consists in assigning a transmission power to each node of a network in such a way that it is minimized the total power consumption requested for maintaining a source node connected to a set of destination nodes. We propose an exact algorithm based on column generation and branch and price for the solution of the problem.

Some Valid Inequalities fo the Probabilistic Minimum Power Multicasting Problem. *Janos Barta, Valeria Leggieri, Roberto Montemanni, Paolo Nobili and Chefi Triki.*
In this paper we describe some results on the linear integer programming formulation of the Probabilistic Minimum Power Multicast (PMPM) problem for wireless networks. The PMPM problem consists in optimally assigning transmission powers to the nodes of a given network in order to establish a multihop connection between a source node and a set of destination nodes. The nodes are subject to failure with some probability, however the assignment should be made so that the reliability of the connection is above a given threshold level. This model reflects the necessity of taking into account the uncertainty of hosts' availability in a telecommunication network.

Strength of Three MIP Formulations for the Prize Collecting Steiner Tree Problem with a Quota Constraint . *Mohamed Haouari, Safa Bhar and Hanif D. Sherali.*
This paper investigates the quota version of the Prize Collecting Steiner Tree Problem (PCSTP) on a graph which is a generalization of the well-known Steiner tree problem. For this challenging network design problem that arises in telecommunication settings, we present three MIP formulations: (a) the first one is a very compact Miller-Tucker-Zemlin (MTZ-) based formulation, (b) the second one is derived through the lifting the MTZ constraints, and (c) the third one is based on the RLT technique. We report the results of extensive computational experiments on large PCSTP instances, having up to 2500 nodes using a general-purpose MIP solver.

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8:00-9:40 : ***Applications of combinatorial optimization 2***
Chairman : Mustapha Bouhtou
. ***César 6***

A 0/1 Integer Programming Model for the Office Space Allocation Problem. *Ozgur Ulker and Dario Landa-Silva.*
We propose a 0/1 integer programming model to tackle the office space allocation (OSA) problem which refers to assigning room space to a set of entities (people, machines, roles, etc.), with the goal of optimising the space utilisation while satisfying a set of additional requirements. In the proposed approach, these requirements can be modelled as constraints (hard constraints) or as objectives (soft constraints). Then, we conduct some experiments on benchmark instances and observe that setting certain constraints as hard (actual constraints) or soft (objectives) has a significant impact on the computational difficulty on this combinatorial optimisation problem.

The minimax problem solving of physical fields sources allocation in specified positions. *Svetlana Yaremchuk, Roman Burda and Oleg Morgalyuk.*
The problem of allocating physical field sources in specified positions is considered in this research paper. To solve this problem the P-algorithm is developed. The conditions when the developed algorithm reaches the global minimum are defined. Also the combined algorithm is developed consisting of the P-algorithm and the method of slump vector. By applying the combined algorithm the point of local or global minimum can be found.

Structural Analysis for Differential-Algebraic Systems : Complexity, formulation and facets.. *Mathieu Lacroix, A. Ridha Mahjoub and Sébastien Martin.*
In this paper we consider the structural analysis problem for differential-algebraic systems with conditional equations. This consists, given a conditional differential algebraic system, in verifying if the system is well-constrained for every state and if not in finding a state for which the system is bad-constrained. We first show that the problem reduces to the perfect matching free subgraph problem in a bipartite graph. We then show the NP-completeness of this problem and give a formulation as an integer linear program. We also discuss the

polytope of the solutions of this problem and propose a Branch-and-Cut algorithm.

Submodularity and Randomized rounding techniques applied to Optimal Experimental Design. *Mustapha Bouhtou, Stéphane Gaubert and Guillaume Sagnol.*
We review recent results obtained by the authors on the approximability of a family of combinatorial problems arising in optimal experimental design. We first recall a result based on submodularity, which states that the greedy approach always gives a design within 1-1/e of the optimal solution. Then, we present a new result on the design found by rounding the solution of the continuous relaxed problem, an approach which has been applied by several authors : When the goal is to select n out of s experiments, the D-optimal design may be rounded to a design for which the dimension of the observable subspace is within n/s of the optimum.

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8:00-9:40 : ***Traveling salesman problem***
Chairman : Paula Zabala
. ***César 7***

Discrete optimization methods to determine trajectories for Dubins' vehicles. *André César Medeiros and Sebastián Urrutia.*
Dubins' vehicles describe a twice differentiable curve of bounded curvature. In this work we present an algorithm for the Traveling Salesman Problem for Dubins' vehicles. In our approach, we propose using a version of the Traveling Salesman Problem that minimizes both distance and direction change angles to determine the tour specifying the order in which the points should be visited. In order to calculate the point-to-point Dubins' path we rely on a result by Dubins, and apply a shortest path algorithm on a discretized search space. Results indicate that the new algorithm obtains better solutions than the ones found in the literature in similar computation times.

Approximating the asymmetric profitable tour. *Viet Hung Nguyen and Thi Thu Thuy Nguyen.*
We study the version of the asymmetric prize collecting traveling salesman problem, where the objective is to find a directed tour that visits a subset of vertices such that the length of the tour plus the sum of penalties associated with vertices not in the tour is as small as possible. In (Amico), the authors defined it as the *Profitable Tour Problem* (PTP). We present an $(1 + \log(n))$-approximation algorithm for the asymmetric PTP with n is the vertex number. The algorithm that is based on Frieze et al.'s heuristic for the asymmetric traveling salesman problem as well as a method to round fractional solutions of a linear programming relaxation to integers (feasible solution for the original problem), represents a directed version of the Bienstock et al.'s algorithm for the symmetric PTP.

An integer programming approach for the time-dependent TSP. *Juan Jose Miranda Bront, Isabel Méndez-Díaz and Paula Zabala.*
The Time-Dependent Travelling Salesman Problem (TDTSP) is a generalization of the traditional TSP where the travel cost between two cities depends on the moment of the day the arc is travelled. In this paper, we focus on the case where the travel time between two cities depends not only on the distance between them, but also on the position of the arc in the tour. We consider the formulations proposed in Picard and Queryanne and Vander Wiel and Sahinidis, analyze the relation-ship between them and derive some valid inequalities and facets. Computational results are also presented for a Branch and Cut algorithm (B&C)that uses these inequalities, which showed to be very effective.

Hop-indexed Circuit-based formulations for the Travelling Salesman Problem. *Maria Teresa Godinho, Luís Gouveia and Pierre Pesneau.*
We discuss a new Hop-indexed Circuit-based formulation for the TSP. We show that the new formulation enhanced with some valid inequalities dominates the previous best (compact) formulations from the literature and that it produces very tight linear bounds (with emphasis on the so-called cumulative TSP).

9:40-9:55 : *Coffee Break*

9:55-10:55. ***Plenary session : Cutting planes: A convex analysis perspective.***
Gérard Cornuéjols
Chairman : Laurence A. Wolsey
. ***Amphi César***
This talk will be based on joint work with Borozan, Basu, Conforti and Zambelli. We extend a theorem of Lovasz characterizing maximal lattice-free convex sets. This result has implications in integer programming. In particular we show a one-to-one correspondance between these sets and minimal inequalities.

11:00-12:15 : ***IS : Polyhedral combinatorics 2***
Chairman : Pierre Bonami
Organizer : Annegret K. Wagler
. ***César 2***

The set covering problem on circulant matrices: polynomial instances and the relation with the dominating set problem on webs. *Silvia M. Bianchi, Graciela Nasini and Paola Tolomei.*
The dominating set polyhedron of a web graph W_n^k

is the set covering polyhedron of a circulant matrix C_n^{2k+1}. In a previous work we generalize the results by Argiroffo and Bianchi on valid inequalities associated with every circulant minor of a circulant matrix and we conjecture that, for any k, the minor inequalities together with the boolean facets and the rank constraint are enough to describe the set covering polyhedron of C_n^k. In this work we prove that the conjecture is true for the family of C_{sk+r}^k with $s = 2, 3$ and $0 \leq r \leq s-1$ and give a polynomial separation algorithm for inequalities involved in the description. Thus, we prove the polynomiality of the set covering problem on these families. As a consequence we obtain the polynomiality of the minimum weight dominating set problem on webs of the form W_n^t, when $n = 2st + s + r$ with $s = 2, 3$ and $0 \leq r \leq s - 1$.

A comparison between lift-and-project indices and imperfection ratio on web graphs. *Mariana Escalante, Silvia Bianchi and Maria Susana Montelar..*
In this paper we study the lift-and-project polyhedral operators defined by Lovasz and Schrijver and by Balas, Ceria and Cornuejols on the clique relaxation of the stable set polytope of webs. We prove they have the same perfomance when starting from the clique relaxation of the family of webs $W_{s(k+1)+k}^k$. Considering the lift-and-project strength of facets for the stable set polytope on webs defined by Bianchi et al., we obtain that the facets of maximum strength for the family $W_{s(k+1)+k}^k$ are also the facets of maximum strength according to Goemans' measure. This last result is obtained by means of the imperfection index and imperfection ratio defined by Aguilera et al. and by Gerke and Mc Diarmid.

Clique and chromatic number of circular-perfect graphs. *Arnaud Pêcher and Annegret Wagler.*
A main result of combinatorial optimization is that clique and chromatic number of a perfect graph are computable in polynomial time (Groetschel, Lovasz and Schrijver 1981). Circular-perfect graphs form a well-studied superclass of perfect graphs. We extend the above result for perfect graphs by showing that clique and chromatic number of a circular-perfect graph are computable in polynomial time as well. The results strongly rely upon Lovasz's Theta function.

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11:00-12:15 : ***Resource constrained scheduling***
Chairman : Christian Artigues
. ***César 3***

A heuristic approach to project staffing. *Matthias Walter and Jürgen Zimmermann.*
In this paper we consider a company with a matrix organization where employees are members of departments and project teams at the same time, i.e. the employees have to accomplish operational work within their department apart from project work. The employees have different skills while projects require some of these skills. It is the aim to minimize the number of assignments of employees to projects. For this staffing problem we present a minimum cost network flow model. We prove that the problem is NP-hard and provide a heuristic solution approach.

IP-Based Energetic Reasoning for the Resource Constrained Project Scheduling Problem. *Anis Kooli, Mohamed Haouari, Lotfi Hidri and Emmanuel Néron.*
In this paper, we consider the Resource Constrained Project Scheduling Problem (RCPSP). New feasibility tests for the energetic reasoning are introduced based on new integer programming (IP) formulations. Experimental results are presented based on PSPLIB instances.

Lagrangian relaxation-based lower bound for resource-constrained modulo scheduling. *Maria Ayala, Christian Artigues and Bernat Gacias.*
In this work we propose a Lagrangian relaxation of a time indexed integer programming formulation to compute a lower bound for the resource-constrained modulo scheduling problem (RCMSP). Solving the RCMSP consists in finding a 1-periodic schedule minimizing the period subject to both temporal and resource constraints. This work is ins pired by Möhring et al, 2003 results for the (non cyclic) resource constrained project scheduling problem, where each subproblem solved within the subgradient optimization is equivalent to a minimum cut problem. Experimental results, presented on instruction scheduling instances from the STMicroelectronics ST200 VLIW processor family, underline the interest of the proposed method.

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11:00-12:15 : ***Metaheuristics 2***
Chairman : Ibrahim Osman
. ***César 4***

A Differential Evolution Algorithm for the Winner Determination Problem in Combinatorial Auctions. *Dalila Boughaci.*
In this paper, a differential evolution algorithm (DE) is studied for the optimal winner determination problem (WDP) in combinatorial auctions. Experiments on various benchmark problems are performed to show and compare the effectiveness of our approach. The comparisons between DE and hybrid simulated annealing (SAGII), genetic algorithms (GA) and memetic algorithms(MA) show that the DE provides competitive results and finds good quality solutions.

An efficient metaheuristic to improve accessibility by rural road network planning. *Pablo Maya, Kenneth Sorensen and Peter Goos.*

In this paper we consider the problem of allocating resources to upgrade a rural road network in order to improve the accessibility of as many people as possible to the main cities or regional center where the economic and social infrastructure is usually located. We propose a solution approach based on the GRASP and VNS Metaheuristic. The efficiency of our approach is demonstrated on a set of random small and medium size instances and on a large instance that has been built based on a real road network.

An Iterated Local Search for Solving A Location-Routing Problem. *Houda Derbel, Bassem Jarboui, Said Hanafi and Habib Chabchoub.*
This paper focuses on a location routing problem with multiple capacitated depots. We seek for better location and routing decisions simultaneously which is a challenging problem. We develop an iterative local search to deal with this problem. The fundamental feature is to improve the solution successively by intensifying the solution space with the local search. A computational study is provided to compare our approach with the tabu search heuristic.

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11:00-12:15 : ***IS : Matchings and paths***
Chairman : Kathie Cameron
Organizer : András Sebő
. ***César 5***

Hypergraph Extensions of the Erdős-Gallai Theorem. *Gyula Y. Katona, Ervin Győri and Nathan Lemons.*
The Erdős-Gallai Theorem gives the maximum number of edges in a graph without a path of length k. We extend this result for Berge paths in r-uniform hypergraphs. We also find the extremal hypergraphs avoiding t-tight paths of a given length and consider this extremal problem for other definitions of paths in hypergraphs.

On stable matchings and flows. *Tamás Fleiner.*
We describe a flow model that generalizes ordinary network flows the same way as stable matchings generalize the bipartite matching problem. We prove that there always exists a stable flow and generalize the lattice structure of stable marriages to stable flows.

An Excluded Minor Characterization of Seymour Graphs. *Alexander A. Ageev, András Sebő, Zoltán Szigeti.*
A graph G is said to be a *Seymour graph* if for any edge set F there exist $|F|$ pairwise disjoint cuts each containing exactly one element of F, provided for every circuit C of G the necessary condition $|C \cap F| \leq |C \setminus F|$ is satisfied. Seymour graphs behave well with respect to some integer programs including multiflow problems, or more generally odd cut packings, and are closely related to matching theory.
A first coNP characterization of Seymour graphs has been shown by Ageev, Kostochka and Szigeti, the recognition problem has been solved in a particular case by Gerards, and the related cut packing problem has been solved in the corresponding special cases. In this article *we show a new, minor-producing operation that keeps this property, and prove excluded minor characterizations of Seymour graphs : the operation is the contraction of full stars, or of odd circuits.* This sharpens the previous results, providing at the same time a simpler and self-contained algorithmic proof of the existing characterizations as well, still using methods of matching theory and its generalizations.
Dualizing the planar special case, Seymour graphs are becoming those for which the cut condition is sufficient for the existence of disjoint paths for any set of demand pairs. Either the disjoint paths or a forbidden minor can be found in polynomial time.

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11:00-12:15 : ***Multiobjective combinatorial optimization***
Chairman : Foued Ben Abdelaziz
. ***César 6***

On a particular case of the multi-criteria unconstrained optimization problem. *Luis Paquete and Jochen Gorski.*
We consider the three-criteria unconstrained optimization problem with two binary criteria coefficients, which is a special case of the multi-criteria unconstrained optimization problem. We propose a polynomial-time greedy algorithm to find the non-dominated set. Moreover, we show that the efficient set is connected with respect to a combinatorial notion of neighborhood. This is the first positive and non-trivial result of connectedness in multi-criteria combinatorial optimization.

Time dependent multiobjective best path for multimodal urban routing. *Tristram Gräbener, Alain Berro and Yves Duthen.*
While the fastest path problem has been widely studied with excellent results, little research has been done on the time dependent multiobjective best paths. Applied to multimodal urban routing, this approach offers multiple suggestions adapted to variety of user preferences. We propose a simple model with intersting properties that allows to use traditional algorithms with little modifications. The experimental computation time are acceptable for a real world application.

Exact And Metaheuristic Methods For Generating Maximal Efficient Faces In Multiobjective Linear Programming. *Saoussen Krichen, Hela Masri and Adel Guitouni.*
In this paper, we propose a new method for generating

the effcient set in multi-objective linear programming problems (MOLPs). An exact tree-based method is proposed to generate all the pareto set, by adopting a bottom-up approach. This method is suitable for small and medium sized problems. For large scaled problems, we develop a tabu search based metaheuristic combined with a dichotomic exploration of the efficient set. This approximative method generates potentially maximal efficient faces. The two methods are empirically compared. Experimental results show that the tree-based method ensures finding the entire efficient set in a reasonable CPU time. Furthermore, the dichotomic tabu search method has a significant advantage for solving large scaled instances of MOLPs. The metaheuristic method features good compromise between CPU time and the size of the generated efficient set.

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11:00-12:15 : ***Telecommunication 2***
Chairman : Olivier Klopfenstein
. ***César 7***

A post-optimization method to route scheduled lightpath demands with multiplicity. *Lucile Belgacem, Irène Charon and Olivier Hudry.*
We consider a NP-hard problem related to the routing and wavelength assignment (RWA) problem in optical networks, dealing with scheduled lightpath demands (SLDs) with multiplicity. A SLD is a connection demand between two nodes of the network, during a certain time. Each SLD requires a given number of wavelengths (its multiplicity). Given a set of SLDs, we want to assign a lightpath (i.e. a routing path and the necessary wavelengths) to each SLD, so that the total number of required wavelengths is minimized. To solve the problem, we design a post-optimization method allowing to improve the solutions provided by a heuristic. Experimental results show that this post-optimization method is quite efficient to reduce the number of necessary wavelengths.

Routing Concurrent Video Signals over SDH Networks. *Monia Giandomenico, Fabrizio Rossi and Stefano Smriglio.*
Synchronous Digital Hierarchy (SDH) is a standard for data transmission over telecommunication networks which is often used for framing and synchronization at the physical layer. SDH networks can carry large payloads, but, at the same time, accommodate lower speed signals packed into elementary transport units. The price of this flexibility consists of a potential waste of capacity, due to the complexity of simultaneously determining an efficient signal packing and routing. We address the problem of maximizing the number of communication requests of a given set which can be routed so as to fulfill capacity restrictions (on links and encoders/decoders) and additional constraints imposed by the signal packing mechanism. Despite the technological complexity, we show that a flow formulation can still be provided including signal packing. This formulation shows a nice experimental behavior when tested on the video network of one major Italian broadcasting company.

An Adaptive Scheduling Algorithm for Video Transmission over Wireless Packet Networks. *Mohamed Hassan, Taha Landolsi, Khaled Assaleh and Husameldin Mukhtar.*
In this paper, we propose an adaptive and fair-scheduling algorithm for video streaming over wireless links. The algorithm selects the client to be served based on the instantaneous occupancy of the decoder buffers of the wireless clients as well as the *predicted* quality of the channel as seen by these clients in addition to the sensitivity of video frames. We consider a *two-tier* nonlinear channel predictor that helps in the selection process of the clients.

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11:00-12:15 : ***Vehicle routing***
Chairman : Roberto Tadei
. ***César 8***

Tree based heuristics for the preemptive asymmetric stacker crane problem. *Hervé Kerivin, Mathieu Lacroix, Alain Quilliot and Hélène Toussaint.*
In this paper, we deal with the preemptive asymmetric stacker crane problem in an heuristic way. We first present some theoretical results which allow us to turn this problem into a specific tree design problem. We next derive from this new representation simple, efficient greedy and local search heuristics. We conclude by presenting experimental results which aim at both testing the efficiency of our heuristic and at evaluating the impact of the preemption hypothesis.

New Families of Valid Inequalities for the Two-Echelon Vehicle Routing Problem. *Guido Perboli, Roberto Tadei and Francesco Masoero.*
Multi-echelon distribution systems are quite common in supply-chain and logistic management. They are used by public administrations in their transportation and traffic planning strategies as well as by companies to model their distribution systems. In the literature, most studies address issues related to the movement of flows throughout the system from the origins to their final destinations.
In this paper we consider the Two-Echelon Vehicle Routing Problem (2E-CVRP), the two-echelon variant of the well known Capacitated Vehicle Routing Problem, where the delivery from one depot to the customers is managed by routing and consolidating freight through intermediate depots, called satellites. Valid inequalities based on the TSP and CVRP, the network flow formulation, and the connectivity of the transportation system graph are presented.

Extensive computational results on instances with up to 50 customers show an improvement of the best known results between 4% and 15%.

On the Vehicle Routing Problem with lower bound capacities. *Luis Gouveia, Jorge Riera and Juan-José Salazar.*
In this paper we show and discuss a family of inequalities for solving a variant of the classical vehicle routing problem where also a lower bound is considered. The inequalities are related to the projected inequalities from a single commodity flow formulation. Other inequalities are based on rounding procedures. We also show computational experiments proving the utility of the new inequalities.

12:15-13:00 : *Lunch*

Friday, March 26

8:00-9:40 : ***IS : Using metaheuristics for solving combinatorial optimisation problems***
Chairman : Jacques Teghem
Organizer : Taicir Loukil, Jacques Teghem
. ***César 2***

Hybrid meta-heuristics for minimizing the total weighted completion time on uniform parallel machines. *Makram Zaidi, Bassem Jarboui, Imed Kacem and Taicir Loukil.*
In this work, we consider the problem of scheduling a set of independent jobs on a set of uniform parallel machines such that total weighted completion time is minimized. We present a set of metaheuristics to solve this complex problem. Different benchmarks are generated and tested in order to evaluate the efficiency of these techniques.

A genetic algorithms to solve the bicriteria shortest path problem. *Mohamed Cheikh, Taïcir Loukil and Bassem Jarboui.*
This paper considers the Bicriteria Shortest Path Problem (BSP) with the two conflicting objectives, minimizing the cost and the total travel distance. Bicriteria Shortest Path Problems, are often NP-hard problems, since obtaining the set of efficient solutions to a BSP problem is more difficult than solving the corresponding single-objective problem. This paper proposes a Bicriteria Genetic Algorithm approach to solve bicriteria shortest path problem.

A simulated annealing algorithm for the flowshop scheduling problem with time lags constraints minimizing the number of tardy jobs. *Emna Dhouib, Jacques Teghem and Taïcir Loukil.*
In this paper, we consider the permutation flowshop scheduling problem with minimal and maximal time lags to minimize the number of tardy jobs. Time lags are defined as intervals that must exist between every pair of consecutive operations of the job. We develop a simulated annealing algorithm to solve the studied problem. The main aim of the paper is to compare different neighborhood structures to solve instances of large dimension. Computational results are presented to compare the proposed neighborhoods.

Multiple crossover genetic algorithm for the multiobjective traveling salesman problem. *Semya Elaoud, Jacques Teghem and Taicir loukil.*
Many crossover operators have been proposed and adapted to different combinatorial optimization problems. In particular, many permutation based crossovers are well designed for the traveling salesman problem (TSP) which is among the most-studied combinatorial optimization problems. However, there is no evidence that one crossover operator is superior to another operator. This is specially true for multiobjective optimization. The performance of any genetic algorithm generally varies according to the crossover and mutation operators used.

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8:00-9:40 : ***Scheduling 2***
Chairman : Talel Ladhari
. ***César 3***

Scheduling of Lifting Vehicles in Port Container Terminals. *Moussi Riadh, Thierry Galinho and Adnan Yassine.*
The competitiveness of a terminal is mainly reflected by its efficiency of transshipment because of loads paid by a boat which depend on the time of rotation and on number of containers loaded and off-loaded on a terminal. The container terminal is generally exploited with three types of equipments: the quay cranes (QCs), vehicles and automated yard cranes (AYCs).
In this paper, we present a particular type of vehicles which is used at terminal of Normandy. In this terminal, the containers are transported from the marshalling yard to a ship by the lifting vehicle (LV), capable of raising and of depositing a single container at various heights. This study discusses how to dispatch the LVs by using information about pickup and delivery locations. Our goal is to organize the transfer of containers in order to minimize the total travel time of each LV for a given number of containers. In order to resolve this problem we will use a genetic algorithm with three types of cross-over.

Climbing discrepancy search for flowshop and jobshop scheduling with time lags. *Wafa Karoui, Marie-José Huguet, Pierre Lopez and Mohamed Haouari.*
This paper addresses the jobshop and the flowshop scheduling problems with minimum and maximum time lags. To solve this kind of problems, we propose adaptations of Climbing Discrepancy Search (CDS). We study various parameter settings. Computational experiments are provided to evaluate the propositions.

Variable Parameters' Lengths Genetic Algorithm for Minimizing Earliness-Tardiness Penalties of Single Machine Scheduling With a Common Due Date. *Hemmak Allaoua, Ibrahim Osman, Belouadah Hocine and Bouderah Brahim.*
Modern manufacturing philosophy of just-in-time emphasizes that a job should be completed as close as possible to its due date to avoid inventory cost and loss of customers' goodwill. In this paper, the single machine scheduling problem with a common due date, where the objective is to minimize the total earliness and tar-

diness penalties in the schedule of jobs, is considered. A new genetic algorithm inspired by the philosophy of dynamic programming, where the chromosome and the population lengths are varied from one iteration to another, is proposed. The algorithm is tested on a set of benchmark instances from the literature. The algorithm produced excellent results demonstrated by its ability in producing better solutions than those previously reported in the literature. The algorithm can be recommended to similar problems where dynamic property is exhibited.

Production scheduling problems with intermediate inventory and delivery considerations. *Deyun Wang, Olivier Grunder and Abdellah EIMoudni.*
We consider a two-stage scheduling problem in which n identical jobs with given due dates are to be firstly processed on a single machine in batches. Then the jobs are delivered in batches to customers by a capacitated transporter. Delay is not allowed. Two earliness penalties of a job are defined as the cost occurred in the time difference of: (1) its completion date of and delivery date (2) its arrival date to customer and due date. The objective is to find a coordinated schedule of production and transportation such that the sum of setup, earliness penalties and delivery cost is minimized. A branch and bound (BBP) algorithm is proposed for solving this problem and then in order to improve the time efficiency, we proposed another approach-greedy algorithm. Computational results indicate the efficiency of the greedy algorithm.

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8:00-9:40 : ***Graphs and combinatorial optimization 3***
Chairman : Petra Mutzel
. ***César 4***

On the use of similarity metrics for approximate graph matching. *Sègla Kpodjedo, Philippe Galinier and Giuliano Antoniol.*
In this paper, we investigate heuristics for approximate graph matching, in particular its formulation as a Maximum Common Edge Subgraph problem. Our experiments suggest that a small percentage of accurate node matches is sufficient to get near optimal solutions using a simple hill-climbing. The real challenge could then be to somehow drag the search in this zone. For this purpose, we discuss the use of similarity measures. We present and assess the performance of two similarity measures. Very good results were obtained on labeled graphs.

The sandwich line graph. *Denis Cornaz and Philippe Meurdesoif.*
We observe that $\omega(G)+\chi(S(\vec{G})) = n = \omega(S(\vec{G}))+\chi(G)$ for any graph G with n vertices, where $\vec{G}$ is any acyclic orientation of G and where $S(\vec{G})$ is the (complement of the) auxiliary line graph introduced in (Cornaz and Jost, 2008). (Where as usual, ω and χ denote the clique number and the chromatic number.) It follows that, for any graph parameter $\beta(G)$ sandwiched between $\omega(G)$ and $\chi(G)$, then $\Phi_\beta(\vec{G}) := n - \beta(S(\vec{G}))$ is sandwiched between $\omega(G)$ and $\chi(G)$ too. Numerical experiments show that Φ_ϑ is closer to χ than ϑ, where ϑ is Lovász theta function.

An integer programming model for the Minimum Interval Graph Completion Problem. *Isabel Cristina Lopes and José Manuel Valério de Carvalho.*
The minimum interval graph completion problem consists of, given a graph G, finding a supergraph H that is an interval graph, while adding the least number of edges.
We present an integer programming formulation for solving the minimum interval graph completion problem recurring to a characterization of interval graphs that produces a linear ordering of the maximal cliques of the solution graph.

A Mixed Integer Model for the Sparsest Cut problem. *Eric Gourdin.*
In a capacitated graph with a set of commodities, the sparsity of a cut is the ratio between the capacity of the cut and the demand of the commodities separated by the cut. The Sparsest Cut (SC) is often introduced as a weak dual of the Maximum Concurrent Flow problem (MCF). Contrarily to MCF, problem SC is, in general, NP-hard. This problem has been considerably studied, motivating the design of very elaborated approximation algorithms. Somewhat surprisingly, to the best of our knowledge, problem (SC) has not been investigated with exact approaches using Mixed Integer Programming models. In this paper, we propose a formulation arising "naturally" from the dual of (MCF).

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8:00-9:40 : ***Scheduling 1***
Chairman : Bernard Gendron
. ***César 5***

Scheduling on parallel machines considering job-machine dependency constraints. *Mitre Costa Dourado, Rosiane de Freitas Rodrigues and Jayme Luiz Szwarcfiter.*
We consider a multi-purpose machine scheduling problem, where jobs should be executed in some machine belonging to a given subset of the set of machines. The problem is $PMPM|r_j p_j = 1|\sum w_j U_j$, with n independent unit-time jobs, time window constraints, m identical parallel multi-purpose machines, and the minimization of the total weighted number of tardy jobs. The best previous complexity for this problem is $O(n^2 m(n+\log m))$, employing network flow techniques. We develop an algorithm that uses basic concepts of computer science to handle more efficiently successive

nesting of on-time jobs, with $O(n^3)$ overall time complexity.

Polynomial-time algorithms for scheduling problem for coupled-tasks in presence of treatment tasks. *Gilles Simonin, Rodolphe Giroudeau and Jean-Claude König.*
We consider the problem to schedule n coupled-tasks in presence of treatment tasks. This work is motivated by the problem of data acquisition for a torpedo. In such context, we developp a $O(nlog(n))$ polynomial-time algorithm for a large class of coupled-tasks scheduling problem.

Minimizing lateness for precedence graphs with delays on dedicated pipelined processors. *Abir Benabid and Claire Hanen.*
This paper studies the generalization of Zinder-Roper algorithm for the maximum lateness problem to the case of unitary typed tasks systems with constant delays. One of the remarkable feature of this algorithm is that it is based on iterated list scheduling, without any other computation. The performance of the extended algorithm is evaluated through worst-case analysis. If all the tasks have the same type and no delay is considered, then the upper bound obtained coincides with the upper bound for the Zinder-Roper algorithm on identical processors, which is one of the best known for the maximum lateness problem.

Grammar-Based Integer Programming Models for Multi-Activity Shift Scheduling. *Marie-Claude Côté, Bernard Gendron and Louis-Martin Rousseau.*
We present a new implicit formulation for shift scheduling problems, using context-free grammars to model regulation in the composition of shifts. From the grammar, we generate an integer programming (IP) model having a linear programming (LP) relaxation equivalent to that of Dantzig set covering model. When solved by a state-of-the-art IP solver on problem instances with a small number of shifts, our model, the set covering formulation and a typical implicit model from the literature yield comparable solution times. On instances with a large number of shifts, our formulation shows superior performance and can model a wider variety of constraints. In particular, multi-activity cases, which cannot be modeled by existing implicit formulations, can easily be handled with grammars.

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8:00-9:40 : ***Network design 3***
Chairman : Luis Gouveia
. ***César 6***

On Minimum Reload Cost Cycle Cover. *Giulia Galbiati, Stefano Gualandi and Francesco Maffioli.*
We consider the problem of spanning the nodes of a given colored graph $G = (N, A)$ by a set of node-disjoint cycles at minimum reload cost, where a reload cost is paid whenever passing through a node where the two consecutive arcs have different colors. We analyze the complexity of the problem, present some integer programming formulations, and report on preliminary computational results.

Counting the Number of Edge Conver on Common Network Topologies. *Guillermo De Ita, J. Raymundo Marcial-Romero and Héctor A. Montes-Venegas.*
Counting the number of edge covers on graphs, denoted as the #Edge Covers problem, is a #P-complete problem. Knowing the number of edge covers is useful for estimating the relevance of the lines in a communication network, which is an important measure in the reliability analysis of a network. In this paper, we present efficient algorithms for solving the #Edge Covers problem on the most common network topologies, namely, Bus, Stars, Trees and Rings. We show that if the topology of the network G does not contain intersecting cycles (any pair of cycles with common edges), then the number of edge covers can be computed in linear time on the size of G.

Earliest Arrival Flows in Networks with Multiple Sinks. *Melanie Schmidt and Martin Skutella.*
Earliest arrival flows model a central aspect of evacuations: In a dangerous situation, as many individuals as possible should be rescued at any point in time. Unfortunately, given a network with multiple sinks, flows over time satisfying this condition do not always exist. We analyze the special case of flows over time with zero transit times and characterize which networks always allow for earliest arrival flows.

Spanning Trees with Node Degree Dependent Costs and Knapsack Reformulations. *Luis Gouveia and Pedro Moura.*
The Degree constrained Minimum Spanning Tree Problem (DMSTP) consists in finding a minimal cost spanning tree such that every node has a degree no greater than a fixed value. We consider a generalization of the DMSTP with a more general objective function that includes modular costs associated to the degree of each node. We show how the problem can be viewed as the intersection of a spanning tree problem and a knapsack problem. We present several linear programming models, based on the previous decompositions, together with some valid inequalities and compare their respective linear programming relaxations using random instances.

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8:00-9:40 : ***Stochastic and robust optimization***
Chairman : Mohamed Ali Aloulou
. ***César 7***

Stochastic Quadratic Knapsack with Recourse. *Abdel Lisser and Rafael Lopez.*
This paper is dedicated to a study of different extensions of the classical knapsack problem to the case when different elements of the problem formulation are subject to a degree of uncertainty described by random variables. This brings the knapsack problem into the realm of stochastic programming. In this paper, we propose a model of two-stage quadratic knapsack with recourse in which we introduce a probability constraint on the capacity of the knapsack on the rst stage. As far as we know, this is the first time such a constraint has been used in a two-stage model. The solution techniques are based on the semidefinite relaxations. This allows for solving large instances, for which exact methods cannot be used.

Stochastic Shortest Path Problem with Delay Excess Penalty. *Stefanie Kosuch and Abdel Lisser.*
We study and solve a particular stochastic version of the Restricted Shortest Path Problem, the Stochastic Shortest Path Problem with Delay Excess Penalty. While arc lengths are kept deterministic, arc delays are assumed to be normally distributed and a penalty per time unit occurs whenever the given delay constraint is not satisfied. The objective is to minimize the sum of path cost and total delay penalty.
We propose to solve this problem using a branch-and-bound structure. Lower bounds on subsets of the search space are obtained by solving the corresponding relaxed problems. This, in turn, is done using an adapted projected stochastic gradient method.

Recourse problem of the 2-stage robust location transportation problem. *Virginie Gabrel, Cécile Murat, Nabila Remli and Mathieu Lacroix.*
In this paper, we are interesting in the recourse problem of the 2-stage robust location transportation problem. We propose a resolution using a mixed-integer formulation with an appropriate tight bound.

Robust Aircraft Routing and Flight Retiming. *Mohamed Ali Aloulou, Mohamed Haouari and Farah Zeghal Mansour.*
In this paper, we propose an integrated model for the robust aircraft routing and flight retiming problem. The model optimizes a slack-based robustness measure that explicitly takes heed of the number of passengers in connection and aircraft as well. We provide empirical evidence of the relevance of the proposed approach using computational experiments that were carried out on real-data, provided by Amadeus, SAS.

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8:00-9:40 : ***Applications of combinatorial optimization 4***
Chairman : Juan José Salazar
. ***César 8***

A Mathematical Model for the Optimization of the Airport Check-In Service Problem. *Giuseppe Bruno and Andrea Genovese.*
This work deals with the proposal of some optimization models for airports check-in services. The aim is to decide the optimal number of check-in gates to open for departing flights, in such a way to balance the operative costs of the service and the passenger waiting time at the terminal. We propose new models for this problem, which presents strong similarities with some well known combinatorial optimization models. We show the complexity of the models and computational results based on a real case study.

On a bi-level formulation to protect uncapacitated p-median systems with facility recovery time and frequent disruptions. *Chaya Losada, Maria Paola Scaparra and Richard L. Church.*
We formulate the problem of protecting against the worst-case loss of an uncapacitated p-median system subject to a number of disruptions when considering recovery issues. The model is a mixed integer bi-level problem with integer variables controlled by both the upper and lower level. To solve it, we apply two exact decomposition methods : a decomposition algorithm based on a special type of valid inequalities and Benders decomposition coupled with variable reduction and some heuristic rules to speed up the resolution of the master problems. Although we compare the performance of the two decomposition approaches, for brevity, we only show here the Benders decomposition.

Experimental Analysis of an Online Trading Algorithm. *Günter Schmidt, Esther Mohr and Mike Kersch.*
Trading decisions in financial markets can be supported by the use of online algorithms. We evaluate the empirical performance of a threat-based online algorithm and compare it to a reservation price algorithm, an average price algorithm and to buy-and-hold. The algorithms are analyzed from a worst case and an empirical case point of view. The effectiveness of the algorithms is analyzed with historical DAX-30 prices for the years 1998 to 2007. The performance of the threat-based algorithm found in the simulation runs dominates all other investigated algorithms. We also compare its performance to results from worst case analysis and conduct a t-test.

Expressing Polynomials as the Permanent of low rank Square Matrices. *Mumtaz Ahmad.*
It is known that the problem of computing the permanent of a given matrix is #P hard. However, Alexander I. Barvinok has proven that if we fix the rank of the matrix then its permanent can be computed in strongly polynomial time. Barvinok's algorithm computes the permanent of square matrices of fixed rank by constructing polynomials. We study the problem of expressing polynomials as the permanent of low rank square ma-

trices and vice versa. We prove that the permanent of a square matrix with rank 1 is a monomial and the permanent of a square matrix (with integer entries) that has not full rank, is a polynomial with even coefficients. We also prove that, for a polynomial $f \in k[x]$, there exist a square matrix of rank 2, whose permanent is the polynomial f . Our results contribute in computing the permanent of a square matrix efficiently.

9:40-10:10 : *Coffee Break*

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10 :10-11 :10. ***Plenary session : An Optimization Value Chain Framework for Managing and Measuring the Relative Efficiency Performance of People, Organizations, and Systems.***
Ibrahim Osman
Chairman : Paolo Toth
. ***Salle Hannibal***
In the present digital era of knowledge economy and the existing combinatorial conflict of interests among stakeholders involved in the decision making process at various organizations, the role of academics becomes very important in the provisions of appropriate strategic management tools to aid decision makers to choose and implement the best informed decisions. In this keynote address, we shall propose an optimization value chain framework which integrates efficiently external and internal stakeholders' values to remove conflicts and to align them towards a common set of goals and objectives with shared values. The optimization framework would minimize the stakeholder's costs and risks and maximize its benefits and opportunities to derive the relatively tradeoff values. In this way, it measures the relative performance efficiency of each alternative (or decision making option), establishes the "best practice" efficient benchmarks among all decision making options, and provides projections guideline on how to improve the target level of each inefficient alternative. The framework is illustrated on four case studies : the relative efficiency of Lebanese banks the performance appraisal of Intensive care nurses the performance of meta-heuristics for the vehicle routing problems and the performance of e-Government services.

11:15-12:30 : ***Computational complexity***
Chairman : Brahim Hnich
. ***César 2***

md-MST is NP-hard for $d \geq 4$**.** *Ana Maria de Almeida, Pedro Martins and Maurício Souza.*
The recently introduced combinatorial problem, tMin-Degree Constrained Minimum Spanning Tree (md-MST), can be stated as : given an undirected graph $G = (V, E)$ and a function $d : V \rightarrow N$ find a minimum cost spanning tree T of G, where each node i of T either has a minimum given degree $d(i)$. We will prove that this new problem is NP-hard in general.

Covering oriented points in the plane with orthogonal polygons is NP-complete. *Cem Evrendilek, Genç Burkay and Brahim Hnich.*
We address the problem of covering points with orthogonal polygons. Specifically, given a set of n grid-points in the plane each designated in advance with either a horizontal or vertical reading, we investigate the existence of an orthogonal polygon covering these n points in such a way that each edge of the polygon covers exactly one point and each point is covered by exactly one edge with the additional requirement that the reading associated with each point dictates whether the edge covering it is to be horizontal or vertical. We show that this problem is NP-omplete.

The k-limited packing and k-tuple domination problems in strongly chordal, P_4**-tidy and split graphs.** *M. Patricia Dobson, Valeria Leoni and Graciela Nasini.*
The notion of 2-packing in a graph was recently generalized to k-limited packing. For a given non negative integer k, a subset B of vertices is a k-limited packing if there is at most k elements of B in the closed neighborhood of every vertex. On the other side, a k-tuple domination set in a graph is a subset of vertices D such that every vertex has at least k elements of D in its closed neighborhood. In this work we first reveal a strong relationship between these notions.
From a result due to Liao et al. (2002), we obtain the polynomiality of the k-limited packing problem for strongly chordal graphs. We also prove that, in coincidence with dominating case, the k-limited packing problem is NP-complete for split graphs. Finally, we prove that both problems are polynomial for the non-perfect class of P_4-tidy graphs, including the perfect classes of P_4-sparse graphs and cographs.

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11:15-12:30 : ***Metaheuristics 3***
Chairman : Saoussen Krichen
. ***César 3***

Exposing Metaheuristics as Web Services in Distribuyed Systems using Open CF. *Melquíades Pérez Pérez, Francisco Almeida Rodríguez, Vicente J. Blanco Pérez, José Marcos Moreno Vega and Adrián Santos Marrero.*
Web Services (WS) have emerged as an industry standard attracting the attention of the scientific community as technological alternative for implementing computational portals. Using the OpenCF computational framework, we develop the p-hub Web Service Portal (p-HubWSP) to provide a platform with capabilities for the efficient execution of metaheuristics for p-hub

problems through the Internet. The technology used eases the implementation of a web-accessed computing system. The p-HubWSP portal greatly eases the access and use of sequential and parallel codes and platforms.

A genetic algorithm for the bi-objective multi-depot vehicle routing problem. *Saoussen Krichen, Asma Ben Bouyahia and Fouad Ben Abdelaziz.*
In this paper, we address a bi-objective multi-depot vehicle routing problem. Besides of minimizing the total traveled distance, this paper proposes to integrate the state of the route as an important factor that aects the solution. Thus, the second objective to be minimized is the total quantity of products deteriorated during transportation. We state the mathematical model and develop a multiobjective genetic algorithm (MOGA) that optimizes the two objectives concurrently to approximate the set of ecient solutions. The proposed approach is also tried on a large test-bed to show that it generates tiny gaps from the ecient frontier.

A particle swarm optimization approach for the bi-objective load balancing problem. *Saoussen Krichen and Nadia Dahmani.*
We propose in this paper a two level loading problem that consists on packing items into containers, then stowing these containers in an aircraft while maximizing both of the total weight and the priority of the loaded cargo. At the same time the center of gravity should be within a reasonable distance from the balance ideal position. We state the mathematical formulation of the problem. The minimization of the number of containers is tackled using a multi-objective placement heuristic and the loading process performs a discrete multi-objective particle swarm optimization approach. An experimental investigation is performed on various test instances to illustrate the effectiveness of our algorithm in solving the bi-objective loading problem.

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11:15-12:30 : ***Polyhedral combinatorics 4***
Chairman : Paolo Nobili
. ***César 4***

On the Convex Hull of Huffman Trees. *Thanh Hai Nguyen, Jean-François Maurras and Viet Hung Nguyen.*
A well-known kind of binary tree in information theory is Huffman tree. Given any linear objective function f, Huffman has given an algorithm allowing to find an optimal Huffman tree minimizing f.
In this paper, we associate to each Huffman point of n nodes, a point in $\mathbb{Q}_n$ called Huffman point whose components are the length of the path from the root of the tree to each leaf. In this paper, we study the Huffmanhedron, PH_n, which is the convex hull of the Huffman points in $\mathbb{Q}_n$. In particular, we present a family of facet-defining inequalities for PH_n whose coefficients form a Fibonacci sequence.
We describe several lifting and composition methods which allow to derive new facet-defining inequalities from existing ones. Finally, we show that these methods together with the Fibonacci family of facet-defining inequalities characterize all facets of non-negative coefficients for PH_n containing a deepest Huffman point, i.e. a permutation of the Huffman point $(n-1, n-1, n-2, ..., 3, 2, 1)$.

On cardinality constrained polymatroids. *Rüdiger Stephan and Ingo Spiegelberg.*
Given a polymatroid $P(f, S)$ defined by an integer submodular function f on some set S and an increasing finite sequence c of natural numbers, the cardinality constrained polymatroid is the convex hull of the integer points x of $P(f, S)$ whose sum of all entries is a member of c. We give a complete linear description for this polytope. Moreover, we characterize some facets of the cardinality constrained version of $P(f, S)$ and briefly investigate the separation problem for this polytope. We close with a conjecture about a complete linear description of the intersection of two cardinality constrained polymatroids defined on the same ground set.

Rank of random half-integral polytopes. *Gábor Braun and Sebastian Pokutta.*
We will show that random half-integral polytopes contain certain sets F_k with high probability, the sets of k-tuples with entries in $\{0, \frac{1}{2}, 1\}$, and exactly one entry equal to $\frac{1}{2}$. We precisely determine the threshold number k for which the phase transition occurs. Using these random polytopes we show that establishing integer-infeasibility takes $\Omega(\log n / \log\log n)$ rounds of (almost) any cutting-plane procedure with high probability whenever the number of vertices is $\theta(3^n)$. As a corollary, a relationship between the number of vertices and the rank of the polytope with respect to (almost) any cutting-plane procedure follows.

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11:15-12:30 : ***IS : VRP and applications***
Chairman : Emmanuel Néron
Organizer : Nora Touati
. ***César 5***

A Branch-and-Price Algorithm for Capacitated Arc Routing Problem with Flexible Time Windows. *H. Murat Afsar.*
In this paper we study Capacitated Arc Routing Problem with Flexible Time Windows where violating a time windows implies some extra cost. We propose a branch-and-price algorithm due to the Dantzig-Wolfe decomposition. The subproblem is a non-elementary capacitated shortest path problem. Experimental results are presented on the instances up to 20 nodes and 31 edges.

Search for the best compromise solution on multiobjective shortest path problem. *Gaël Sauvanet and Emmanuel Néron.*
This paper deals with the multiobjective shortest path problem in the context of routing for cycling. Many studies focus on the computation of the entire set of Pareto paths. Here we focus on the determination of a well-balanced trade-off path between the objectives. We recall the original Best Compromise A* method and then we present two improvements in order to speed up the search of the best compromise solution. Finally we present various numerical tests on real-life instances, that prove the efficiency of the improved methods.

An improving dynamic programming algorithm to solve the shortest path problem with time windows. *Nora Touati Moungla, Lucas Létocart and Anass Nagih.*
An efficient use of dynamic programming requires a substantial reduction of the number of labels. We propose in this paper an efficient way of reducing the number of labels saved and dominance computing time. Our approach is validated by experiments on shortest path problem with time windows instances.

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11:15-12:30 : ***Facility location***
Chairman : François Vanderbeck
. ***César 6***

Modelling the Hop Constrained Connected Facility Location Problem on Layered Graphs. *Ivana Ljubic and Stefan Gollowitzer.*
Gouveia, Simonetti and Uchoa (Math. Prog. 2010) show how to model the Hop Constrained Minimum Spanning tree problem as Steiner tree problem on a layered graph. Following their ideas, we provide three possibilities to model the Hop Constrained (HC) Connected Facility Location problem (ConFL) as ConFL on layered graphs. We show that on all three layered graphs the respective LP relaxations of two cut based models are of the same quality. In our computational study we compare a compact hop indexed tree model against the two cut based models on the simplest layered graph. We provide results for instances with up to 1300 nodes and 115000 arcs.

A Continuous Strategy to Solve a Class of Discrete Optimization Problems. *Roberto Nascimento, Edson Figueiredo and Rúbia Santos.*
In this work we develop a method to solve a class of discrete optimization problems. This class covers linear, quadratic, convex, and discrete geometric programming problems. The methodology consists in inserting additional geometric constraints where any viable solution is also discrete. Moreover, we also adopt a methodology for solution of signomial geometric programming problems and solve the problem. We present some examples of facility location problems and the results obtained.

A computational study for the p-median problem. *Sourour Elloumi and Agnès Plateau.*
Given a set of clients and a set of potential sites for facilities, the p-median problem consists of opening a set of p sites and assigning each client to the closest open facility to it. A newformulation of this problem was proposed that takes benefit from identicalvalues in the distance matrix. This formulation, when directly used in a mixed integer linear programming software, was proved to perform better than other known formulations, on a large number of instances. Here, we propose to improve the performances of the new formulation by taking benefit from its structure in the solution of its LP-relaxation. Rows and columns are gradually added to the linear program until a condition on the optimal values of the variables is reached. A computational comparison is carried out on many classes of instances.

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11:15-12:30 : ***IS : Quadratic programming and applications***
Chairman : Sourour Elloumi
Organizer : Sourour Elloumi
. ***César 7***

A roof linearization algorithm to obtain a tight upper bound for integer nonseparable quadratic programming. *Dominique Quadri and Eric Soutif.*
We study in this paper a general case of integer quadratic multi-knapsack problem ($QMKP$) where the objective function is non separable. An upper bound method is proposed for ($QMKP$) which is computed via two steps. The first stage aims to rewrite ($QMKP$) into an equivalent mixed integer quadratic program ($QP_{x,y}$) where the objective function is separable, using Gauss decomposition of the quadratic terms matrix. We then suggest an original technique, we call roof linearization, to linearize ($QP_{x,y}$) so as to obtain a mixed linear program which optimal value provides an upper bound for ($QP_{x,y}$) and consequently for ($QMKP$). Preliminary computational experiments are conducted so as to assess that the proposed algorithm provides a tight upper bound in fast CPU times. Our method is compared with the LP-relaxation of ($QMKP$) and the LP-relaxation of ($QP_{x,y}$).

Numerical Study of Semidefinite Bounds for the k-cluster Problem. *Frédéric Roupin and Jérôme Malick.*
This paper deals with semidefinite bounds for the k-cluster problem, a classical NP-hard problem in combinatorial optimization. We present numerical experiments to compare the standard semidefinite bound with the new semidefinite bound of [malick-roupin-2009], re-

garding the trade-off between tightness and computing time. We show that the formulation of the semidefinite bounds has an impact on the efficiency of the numerical solvers, and that the choice of the solver depends on what we expect to get: good accuracy, cheap computational time, or a balance of both. We argue that the new semidefinite bound of [malick-roupin-2009] may be a good choice as a bounding procedure in a branch-and-bound algorithm.

A quadratic programming problem arising from the p-version for obstacle problems. *Matthias Maischak, Andreas Krebs and Ernst Stephan.*
We present a quadratic programming problem arising from the p-version for a finite element method with an obstacle condition prescribed in Gauss-Lobatto points. We show convergence of the approximate solution to the exact solution in the energy norm. We show an a-priori error estimate and derive an a-posteriori error estimate based on bubble functions which is used in an adaptive p-version. Numerical examples show the superiority of the p-version compared with the h-version.

12:30-14:00 : *Lunch*

14:00-15:00. ***Plenary session : Matrix relaxations for optimization problems on graphs.***
Franz Rendl
Chairman : Nelson Maculan
. ***Salle Hannibal***
Semidefinite programs (SDP) have turned out to be a strong modeling tool in combinatorial optimization. In this talk, matrix relaxations of NP-hard graph optimization problems will be discussed.
Special focus is given to SDP relaxations, which are usually tractable, and to relaxations based on the cone of completely positive matrices. It is intractable to optimize over this cone, but relaxations based on it often provide exact formulations of the underlying integer problem. We show some recent developments related to max-k-cut, coloring, linear ordering and some other graph optimization problems. The resulting SDP are typically of sizes, not accessible by interior point methods. We therefore also discuss some very recent algorithmic developments to solve these relaxations and present computational results.

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15:05-16:45 : ***Metaheuristics 4***
Chairman : Jouhaina Chaouachi
. ***César 2***

Heuristic Algorithms Based Local Search For Operating Theatre Planning. *Mejdi Souki and Abdelwaheb Rebai.*
In this paper, we propose a variable neighborhood search (VNS) and an iterated local search (ILS) to solve the operating theatre planning. The latter consists in assigning from the waiting list the interventions on the patients in the surgeon time block of the same medical specialty while taking into account the availability of hospital beds and the surgeon time blocks. Finally, computational experiment is presented to analyze the performance of the algorithms.

2-opt local search based greedy algorithm for the mixed vehicle routing problem. *Moncef Bourguiba and Abdelwaheb Rebai.*
The mixed vehicul routing problem (M VRPMB) has several applications in the real life, in this work we adopt two heuristics to solve a specific cas of pickup and delivery problem (M VRPMB). In the construction phase, the approach is to assign two customers scattered in two different vehicles to reduce the total distance traveled, while the phase of improvement, we chose a fairly simple and treats all permutations, this approach takes into consideration not only possible changes in the load but also on the number of tours and the total distance traveled.

Tabu search for the sum coloring problem. *Hend Bouziri and Mouna Jouini.*
The sum coloring problem has many applications in practice, especially in scheduling. It is a variant of the vertex coloring problem where the objective is to minimize the sum of colors used in coloring the vertices. In this paper we use tabu search to solve the sum coloring problem. Experiments are performed on instances extracted from the second DIMACS challenge. Results shows significative improvements on existing chromatic sum bounds.

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15:05-16:45 : ***Scheduling 3***
Chairman : Lotfi Hidri
. ***César 3***

FH2(P2, P2) hybrid flow shop scheduling with recirculation of jobs. *Nadjat Meziani and Mourad Boudhar.*
This work consists to study two scheduling problems to minimize the makespan. The first is the hybrid flow shop on two stages with only one machine on each stage and recirculation of jobs. This problem is polynomial. The second one is the hybrid flow shop on two stages such as each one contains two identical parallel machines and every job recirculates a finite number of times. This problem is NP-hard in general. linear mathematical formulation and heuristics are also presented with numerical experimentations.

Integrative cooperative approach for solving permutation flowshop scheduling problem with sequence dependent family setup times. *Bouabda Radhouan, Bassem Jarboui, Mansour Eddaly and Abdelwaheb Rebai.*
This paper addresses the permutation flowline manufacturing cell with sequence dependent family setup times problem with the objective to minimize the makespan criterion. We develop a cooperative approach including a genetic algorithm and a branch and bound procedure. The latter is probabilistically integrated in the genetic algorithm in order to enhance the current solution. Moreover, the application of the branch and bound algorithm is based upon the decomposition of the problem into subproblems. The performance of the proposed method is tested by numerical experiments on a large number of representative problems.

Heuristics for minimizing the makespan in a flow shop with blocking. *Soulef Khalfallah and Seddik Kraim.*
The impact of the NEH heuristic on permutation flow shop research is considerable. For the flow shop with blocking problem, other heuristics such as the McCormic profile fitting (PF) heuristic and the Ronconi Min_Max (MM) heuristic are more promising, especially when used to initiate the NEH heuristic. Our study presents an extention of the MM heuristic called MM_Alternated and a new heuristic called Best_Pos which replaces step 2 and 3 of the NEH. The proposed heuiristic gives good results compared to other metaheuristics and in a short time.

Taking into account of flexibility in dynamic planning : A case study. *Ridha Erromdhani, Mansour Eddaly and Abdelwaheb Rebaï.*
In this paper we address to the planning problem in the agroalimentary domain. In such industry, several specific constraints should be taken into account for planning task such as the constraints of interdependencies between the products and variable production modes. Furthermore, we present the relationship between two large fields as the production hierarchical planning and the flexibility. Especially, we show that the flexibility planning should be made a priori and then integrated in the hierarchical planning process. Indeed, we have established a mathematical model according to different production levels. While taking into account real capacities of the shop and the interdependencies between the products, the results of our formulation are satisfactory in terms of quality of solution and time requirements. It's shown that our model is able to reach all optimal solutions for all treated models and for all system levels.

. ***César 4***

The Bidding Method for NP-Hard Problems. *Fouad Chedid.*
We propose a general method, named the Bidding Method, for developing approximation algorithms for NP-Hard problems. In particular, we show how to use our method to derive a number of classical solutions for Bin Packing.

On Packing Splittable Items With Cardinality Constraints. *Fouad Chedid.*
This paper studies a memory allocation problem that can be abstracted as a variation of Bin Packing where items are of different types and the weight of each item can be greater than 1, which is the size of a bin. Furthermore, in this problem, items may be split arbitrarily, but each bin may contain at most k types of items, for any fixed integer $k \geq 2$. This problem was recently introduced by Epstein and van Stee following another recent work by Chung *et al.* who gave a 3/2-approximation for $k = 2$ and an optimal algorithm for $k = 2$, if the total weight is at least as large as the number of types. Epstein and van Stee showed that a straightforward generalization of NEXT FIT gives a $(2 - 1/k)$-approximation for any $k \geq 2$. In this paper, we show that the absolute approximation ratio of NEXT FIT for any $k \geq 2$ is 3/2, if the total weight is at least as large as half the number of types.

A two stage method for the cardinality constrained bin packing problem with conflicts : An application for batch annealing in the steel industry. *Abdelghani Bouras.*
In this paper we investigate the problem of batch annealing, modeled as the one-dimensional k-item bin-packing problem with conflicts. The cardinality constrained bin-packing problems, or k-item bin-packing problem, requires that at most k items are allowed in one bin. We solve this problem from steel industry to optimality using a two-stage method. A first stage consists of a heuristic to build feasible pattern (bin), while the second stage is a binary linear program we solve efficiently using GAMS.

MPQ-trees for orthogonal packing problem. *Cédric Joncour, Arnaud Pêcher and Petru Valicov.*
In this paper we present an exact algorithm for solving bi-dimensional Orthogonal Packing Problem. It is based on the Fekete and Schepers' characerization of the problem using interval graphs. Our contribution consists in the use of MPQ-trees - combinatorial structures introduced by Korte and Möhring to encode interval graphs. It allowed us to enumerate potential solutions avoiding some symmetry problems. We give the running times of our implementation of the algorithm to show its competitiveness.

15:05-16:45 : ***Packing problems 2***
Chairman : José Manuel Valerio de Carvalho

15:05-16:45 : ***Survivable networks***
Chairman : A. Ridha Mahjoub
. ***César 5***

Minimum Cost $\leq k$ Edges Connected Subgraph Problems. *Firdovsi Sharifov and Hakan Kutucu.*
The minimum-cost network design problem is considered in the case where an optimum network remains connected, after deleting any $\leq k$ edges which form a matching in the optimum network. For the case $k = 1$, we develop heuristic algorithms to compute a lower and a upper bounds for optimal value of objective function. These algorithms are used in the branch and bound methods to nd a solution to the considered problem. We also present computational results.

Strong Lower Bounds for a Survivable Network Design Problem. *Markus Leitner and Günther R. Raidl.*
We consider a generalization of the Price Collecting Steiner Tree Problem on a graph with special redundancy requirements on a subset of the customer nodes suitable to model a real world problem occurring in the extension of fiber optic communication networks. We strengthen an existing connection-based mixed integer programming formulation involving exponentially many variables using a recent result with respect to the orientability of two-node connected graphs. The linear programming relaxation of this model is then solved by means of column generation. We show that our new model is theoretically stronger than a previously described one and present promising preliminary computational results.

Design of Multilayer Survivable Optical Networks. *Sylvie Borne, Virginie Gabrel, A. Ridha Mahjoub, Raouia Taktak.*
With the explosive growth of traffic data, telecommunication networks have evolved toward a multilayer architecture with high-speed routers interconnected by intelligent optical core networks. This architecture must be sufficiently survivable so that network services can be restored in the event of a catastrophic failure.
In this paper, we consider the following survivable IP-over-optical network design problem. Given a set of traffic demands and two node-disjoint paths routing each demand in the IP layer, the problem is to find for each demand two node-disjoint paths in the optical layer going through the optical switches corresponding to the routers visited in the paths of the IP layer and respecting the same order.
We give two integer programming formulations for the problem. The first one uses the cut constraints and the second is a path-based formulation. We discuss the pricing problem for the latter and present some preliminary computational results. We also discuss the polyhedron associated with the cut formulation.

Design of optical WDM netwoks. *Amal Benhamiche, A. Ridha Mahjoub, Nancy Perrot.*
In this paper we consider the traffic Grooming, Routing and Wavelength Assignment problem in optical WDM mesh networks. This is a network design problem which consists in grooming the demands in lightpaths, assigning a wavelength to each lightpath and routing the traffic on these with minimum cost. We first give an Integer Linear Programming formulation for the problem. Then we discuss some pre-processing procedure and propose a fast heuristic which shows to be very efficient for solving large real instances of. We finally provide an illustrative application of the proposed heuristic for a real backhaul network instance.

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15:05-16:45 : ***Applications of combinatorial optimization 3***
Chairman : Olivier Hudry
. ***César 6***

Speculative data prefetching for branching structures in dataflow programms. *Sergiu Carpov, Renaud Sirdey, Jacques Carlier and Dritan Nace.*
This paper deals, to some extent, with the problem of speculative data prefetching for dataflow programming models, such models providing a suitable approach to the effective programming of a newly emerging generation of massively multicore microprocessors for the embedded market. In particular, we focus on finding optimum prefetch strategies for a simple n-way dataflow branching structure with respect to several objective functions. Two objectives are considered : the mathematical expectation of the execution time and the worst-case execution time. Also, two different strategies are investigated : a fractional strategy, whereby the unknowns are proportions of data to prefetch for each branch, and, an all-or-nothing strategy, whereby an optimum branch prefetching order is to be found. We demonstrate that these problems can be dealt with in polynomial time and exhibit practical algorithms, grounded in known OR techniques, for doing so.

Automatic Selection of Beam Orientations in Intensity-Modulated Radiation Therapy. *Ahmad-Saher Azizi-Sultan.*
Finding an optimal set of beam orientations in intensity-modulated radiation therapy (IMRT) planning is an important, but unfortunately, large-scale NP-hard optimization problem with impractical excessive time complexity. Selecting appropriate beam directions in IMRT is still a time-consuming manual trial-and-error search procedure that depends on intuition and empirical knowledge. This work utilizes the methods of beam's eye view and observer's view, which are recognized for beam orientations in conventional conformal radiation therapy, to present an automatic algorithm that works in clinically practical time and

aims at determining a suitable set of beam orientations for IMRT.

A simulated annealing for reconstructing hv-convexe binary matrices. *Fethi Jarray and Ghassen Tlig.*
We consider a variant of the NP-hard problem of reconstructing hv-convex binary matrices from two projections. This sub problem is reformulated as integer programming problem and approximated by a simulated annealing approach.

Combinatorial Optimization of Capacity and Flow Assignment Problem for Unicast and Anycast Connections with Linear and Convex Objective Functions - Exact and Heuristic algorithms. *Jakub Gladysz and Krzysztof Walkowiak.*
In this work we focus on Capacity and Flow Assignment (CFA) problem for simultaneous unicast and anycast flows. Anycast flow is a new technique to deliver packets in computer networks, in which user can download or send packets to any one of several possible servers offering a particular service or application. In our work we consider two models of CFA problem. In the first model as the criterion we assume the total average delay function with the budget constraint. This problem can be solved by using the branch-and-bound method. In the second model as the objective we use the linear function of cost. To obtain optimal solution we intend to use CPLEX linear programming package. The considered problems are NP-complete - with a growing network structure, finding an optimal solution may be difficult in sensible time. Therefore, to solve larger problem instances we propose new heuristic algorithms that can be applied. To our best knowledge this is the first paper that addresses CFA problem for simultaneously unicast and anycast flows to minimize convex (total average delay) objective function for modular links.

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