



Preface: The fourth International Symposium on Combinatorial Optimization (ISCO) 2016

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This special issue of *Journal of Combinatorial Optimization* is dedicated to the fourth International Symposium on Combinatorial Optimization (ISCO 2016), which took place in Vietri Sul Mare, Italy, on May 16–18, 2016. ISCO 2016 was preceded by the Spring School on “Extended Formulations for Combinatorial Optimization” given by Samuel Fiorini and Volker Kaibel. This edition of ISCO was the fourth of a series of biennial conferences on combinatorial optimization with its first venue held in Hammamet, Tunisia in March 2010. ISCO is intended to be a forum for the exchange of recent scientific developments and for the discussion of new trends. The scope of the conference includes all aspects of combinatorial optimization ranging from mathematical foundations and theory of algorithms to computational studies and practical applications. Detailed information about ISCO 2016 is available in <http://www.isco2016.it/>.

In the past years, combinatorial optimization has undergone rapid developments, major advances being obtained in different areas such as computational complexity, approximation algorithms, cutting plane methods, and stochastic and robust optimization. Combinatorial optimization problems arise in different domains of production, telecommunication, economy, and the likes. Various exact, heuristic, and metaheuristic approaches have been devised for analysing and solving hard combinatorial optimization problems. Moreover, great development has been seen in graph theory and combinatorics, which are central tools in combinatorial optimization. In this issue, several combinatorial optimization problems and resolution techniques as well as structural aspects of graphs and combinatorics are considered.

- Base polyhedra and the linking property, by Tamàs Király.

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Here it is proved that an integer polyhedron in the hyperplane $\sum_{j=1, \dots, n} x_j = \beta$ is a base polyhedron if and only if it has the linking property, which implies that an integer polyhedron has the strong linking property if and only if it is a generalized polymatroid.

- On a general framework for network representability in discrete optimization, by Yuni Iwamasa.

In this paper, the author shows a complete characterization of network representable functions on $\{0,1\}^n$ in a general framework for the network representability of functions together with its implications to bi-submodular functions and k -submodular functions.

- A compact representation for minimizers of k -submodular functions, by Hiroshi Hirai and Taihei Oki.

A complete characterization of the class of a poset with inconsistent pairs (PIP) arising from k -submodular functions is given. Some algorithms to construct the elementary PIP of minimizers of a class of k -submodular functions are also discussed.

- An Algorithm for finding a representation of a subtree distance, by Kazutoshi Ando and Koki Sato.

In this paper, the authors give an $O(n^3)$ time algorithm for finding a representation of a given subtree distance. Using this, they also give an $O(n^3)$ time algorithm for deciding whether a given mapping is a subtree distance.

- Lot sizing with storage losses under demand uncertainty, by Stefano Coniglio, Arie M.C.A. Koster and Nils Spiekermann.

Here lot sizing with storages losses and demand uncertainty is modeled as a two-stage robust optimization problem. Computational experiments on heat production indicate that the two-stage approach with second-stage production and storage variables is preferable to having first-stage production variables. A hybrid stochastic-robust approach is also investigated yielding the overall best performance.

- ILP Formulations of the degree-constrained minimum spanning hierarchy problem, by M. Merabet, M. Molnar and S. Durand.

In this paper, a hierarchy is interpreted as a homomorphism of a tree in a graph. An integer linear programming formulation for finding a degree-constrained minimum spanning hierarchy is discussed. Moreover A computational comparison of the degree-constrained minimum spanning tree problem to the new problem type shows a cost improvement when using the more general structure.

- Uniqueness of equilibria in atomic splittable polymatroid congestion games, by Tobias Harks and Veerle Timmermans.

The authors investigate here uniqueness of Nash equilibria in atomic splittable congestion games and derive a uniqueness result based on polymatroid theory.

- Sum-of-Squares rank upper bounds for matching problems, by Adam Kurpisz, Samuli Leppänen and Monaldo Mastrolilli.

In this paper the authors provide upper bounds for the rank of the sum-of-squares hierarchy for matching problems. In particular, they show that when the problem formulation is strengthened by incorporating the objective function in the constraints, the hierarchy requires at most $k/2$ ($(k+1)/2$) levels to refute the existence of a perfect matching in an odd clique of size $2k+1$, if k is even (odd).

- Robust trading mechanisms over $0/1$ polytopes, by Mustafa Pinar.

The problem of designing a trade mechanism is considered in this paper. Using duality arguments, the author proposes a linear integer programming formulation for the problem. He also gives a full characterization of the convex hull of all the solutions of this formulation. Moreover, he introduces a further robustness concept, and gives a simple polynomial procedure to solve the associated design problem. Finally, he extends the results to the case where budget balance is relaxed to feasibility.

- Optimization problems with color-induced budget constraints, by Corinna Gottschalk, Hendrik Lüthen, Britta Peis, and Andreas Wierz.

Here the authors investigate extensions of the color-constrained matroid optimization problem, considered by Gabow and Tarjan (1984), to more general problems on poset matroids which take precedence constraints on the ground set into account.

- A compact representation for minimizers of k -submodular functions by Hiroshi Hirai and Taihei Oki.

A complete characterization of the class of a poset with inconsistent pairs (PIP) arising from k -submodular functions is given. Some algorithms to construct the elementary PIP of minimizers of a class of k -submodular functions are also discussed.

- Improved mixed-Integer programming models for the multiprocessor scheduling problem with communication delays, by Sven Mallach.

A mixed-integer programming model is introduced to describe the scheduling problem. Three modeling strategies are introduced, one ordering-based, one assignment-based, and finally a combination of the two. Extensive computations are given to demonstrate the efficiency of these approaches.

- Planning personnel retraining: column generation heuristics, by Oliver G. Czubala Hanyu Gu and Yakov Zinder.

This paper deals with the planning of personnel training. The authors show that the problem is NP-complete and discuss quadratic and linear programming formulations for the problem. Three column generation based algorithms and a neighbourhood search procedure are proposed.

- An exact approach for the balanced k -way partitioning problem with weight constraints and its application to sports team realignment, by Diego Recalde, Daniel Severín, Ramiro Torres and Polo Vaca.

This work is related to a balanced k -way partitioning problem with weight constraints to model the sports team realignment. Two integer programming formulations for the problem are introduced, and validity inequalities for the associated polytopes are identified. Using this together with a tabu search procedure for computing an upper bound, a branch-and-cut for the problem is devised.

- Subset sum problems with digraph constraints, by Laurent Gourvès, Jérôme Monnot and Lydia Tlilane.

The authors introduce and study some optimization problems related to the subset sum problem. Each problem is modelled as a node-weighted digraph problem, and one has to determine a node subset whose total weight does not exceed a given budget. Some additional constraints need to be satisfied. Some complexity and approximation results are discussed.

- The QAP polytope and the graph isomorphism problem, by P. Aurora and S.K. Mehta.

Graph isomorphism is investigated in terms of faces of the QAP polytope. Using an integer linear programming formulation of graph isomorphism, the authors provide a first set of certificates for a pair of graphs to be nonisomorphic. In addition, they introduce new facets of the QAP polytope.

- The weakly connected independent set polytope in corona and join of graphs, by Fatiha Bendali and Jean Mailfert.

In this paper, the authors introduce the weakly connected independent set problem, and discuss some compositions in the associated polytope. It is shown that if a graph is obtained from two graphs by either the corona or the join operation, then a complete description of the polytope can be obtained from the polytopes related to the pieces. Also some algorithmic consequences are discussed.

- The min-up/min-down unit commitment polytope, by Pascale Bendotti, Pierre Fouilhoux and Cécile Rottner.

This paper deals with the min-up/min-down unit commitment problem, which consists in finding.

Minimum-cost production plan on a discrete time horizon for a set of fossil-fuel units for electricity production. A polyhedral study of the problem is provided as well as a branch-and-cut algorithm.

- Approximability and exact resolution of the multidimensional binary vector assignment problem, by Marin Bougeret, Guillaume Duvillié and Rodolphe Giroudeau.

This paper discusses some approximation results for the multidimensional binary vector assignment problem.

- On the m -clique free interval subgraphs polytope: polyhedral analysis and applications, by Mohammed-Albarra Hassan, Imed Kacem, Sébastien Martin and Izzeldin M. Osman.

The m -clique free interval subgraphs polytope is studied. Several facet-defining inequalities for this polytope are introduced. The authors also discuss applications to the open-shop problem with disjunctive constraints. Using the polyhedral results, they propose a branch-and-cut algorithm for this problem.

All the submitted papers have gone through the strict reviewing process of this journal. We would like to thank all the authors who submitted their work to this issue and the reviewers for their excellent work. Moreover, we would like to thank Professor

Ding-Zhu Du, Editor-in-Chief of *Journal of Combinatorial Optimization*, for having accepted the publication of this special issue and the editorial assistants of the journal for their great effort and cooperation.