

*Commenced Publication in 1973*

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

## Editorial Board

David Hutchison

*Lancaster University, UK*

Takeo Kanade

*Carnegie Mellon University, Pittsburgh, PA, USA*

Josef Kittler

*University of Surrey, Guildford, UK*

Jon M. Kleinberg

*Cornell University, Ithaca, NY, USA*

Friedemann Mattern

*ETH Zurich, Switzerland*

John C. Mitchell

*Stanford University, CA, USA*

Moni Naor

*Weizmann Institute of Science, Rehovot, Israel*

Oscar Nierstrasz

*University of Bern, Switzerland*

C. Pandu Rangan

*Indian Institute of Technology, Madras, India*

Bernhard Steffen

*University of Dortmund, Germany*

Madhu Sudan

*Massachusetts Institute of Technology, MA, USA*

Demetri Terzopoulos

*University of California, Los Angeles, CA, USA*

Doug Tygar

*University of California, Berkeley, CA, USA*

Moshe Y. Vardi

*Rice University, Houston, TX, USA*

Gerhard Weikum

*Max-Planck Institute of Computer Science, Saarbruecken, Germany*

Matteo Fischetti David P. Williamson (Eds.)

# Integer Programming and Combinatorial Optimization

12th International IPCO Conference  
Ithaca, NY, USA, June 25-27, 2007  
Proceedings

## Volume Editors

Matteo Fischetti  
University of Padova  
DEI, Dipartimento di Ingegneria dell'Informazione  
via Gradenigo, 6/A, 35131 Padova, Italy  
E-mail: [matteo.fischetti@unipd.it](mailto:matteo.fischetti@unipd.it)

David P. Williamson  
Cornell University  
School of Operations Research and Information Engineering  
Rhodes 236, Ithaca, NY 14853, USA  
E-mail: [dpw@orie.cornell.edu](mailto:dpw@orie.cornell.edu)

Library of Congress Control Number: 2007928347

CR Subject Classification (1998): G.1.6, G.2.1, F.2.2, I.3.5

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

ISSN	0302-9743
ISBN-10	3-540-72791-4 Springer Berlin Heidelberg New York
ISBN-13	978-3-540-72791-0 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

Springer is a part of Springer Science+Business Media

[springer.com](http://springer.com)

© Springer-Verlag Berlin Heidelberg 2007  
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India  
Printed on acid-free paper      SPIN: 12069569      06/3180      5 4 3 2 1 0

# Preface

This volume contains the papers selected for presentation at IPCO XII, the 12th Conference on Integer Programming and Combinatorial Optimization, held June 25–27, 2007, in Ithaca, New York, USA. Since its inception in 1990, the IPCO conference series has become an important forum for researchers and practitioners working on various aspects of integer programming and combinatorial optimization. The aim of the conference is to present recent developments in theory, computation, and applications in these areas.

IPCO is sponsored by the Mathematical Programming Society, and is held in those years in which no International Symposium on Mathematical Programming takes place. The previous Symposium was held in 2006 in Rio de Janeiro, Brazil, and the previous two IPCOs were held in 2004 and 2005 in New York, USA and Berlin, Germany, respectively.

There were over 120 submissions to the conference. During its meeting in early January of 2007, the Program Committee carefully selected 36 papers for presentation in non-parallel sessions at the conference. Because of the limited number of time slots for presentations, many excellent submissions could not be accepted.

During the selection process, the extended abstracts were refereed according to the standards of refereed conferences. As a result, this volume contains papers describing high-quality research efforts. The page limit for contributions to these proceedings was set to 15. We expect full versions of these papers to appear in scientific journals in the near future.

We gratefully acknowledge IBM Research, ILOG, and the Office of Naval Research for their sponsorship of IPCO 2007. We are grateful for the use of EasyChair ([www.easychair.org](http://www.easychair.org)), which greatly simplified the process of collecting submissions, reviewing papers, and assembling this proceedings volume. We thank Phoebe Sengers and the Culturally Embedded Computing Group at Cornell, whose server was used to host the IPCO 2007 Web site. We thank the members of the Program Committee and the many subreferees who spent untold hours examining all of the submissions. And finally, we especially thank the many authors for submitting their work to the conference.

March 2007

Matteo Fischetti  
David P. Williamson

# Conference Organization

## Program Committee

Dimitris Bertsimas (MIT)  
Dan Bienstock (Columbia)  
Alberto Caprara (Bologna)  
Bill Cook (Georgia Tech)  
G rard Cornu jols (CMU)  
Matteo Fischetti, Chair (Padova)

Bertrand Guenin (Waterloo)  
Christoph Helmberg (TU Chemnitz)  
Tibor Jord n (ELTE Budapest)  
Tom McCormick (UBC)  
David P. Williamson (Cornell)  
Gerhard Woeginger (Eindhoven)

## Local Organization

David P. Williamson (Cornell)

## Conference Sponsors



# IBM Research

# Table of Contents

## Session 1

Inequalities from Two Rows of a Simplex Tableau . . . . .	1
<i>Kent Andersen, Quentin Louveaux, Robert Weismantel, and Laurence A. Wolsey</i>	
Cuts for Conic Mixed-Integer Programming . . . . .	16
<i>Alper Atamtürk and Vishnu Narayanan</i>	
Sequential-Merge Facets for Two-Dimensional Group Problems . . . . .	30
<i>Santanu S. Dey and Jean-Philippe P. Richard</i>	

## Session 2

Triangle-Free Simple 2-Matchings in Subcubic Graphs . . . . .	43
<i>David Hartvigsen and Yanjun Li</i>	
The Smoothed Number of Pareto Optimal Solutions in Bicriteria Integer Optimization . . . . .	53
<i>Rene Beier, Heiko Röglin, and Berthold Vöcking</i>	
Finding a Polytope from Its Graph in Polynomial Time . . . . .	68
<i>Eric J. Friedman</i>	

## Session 3

Orbitopal Fixing . . . . .	74
<i>Volker Kaibel, Matthias Peinhardt, and Marc E. Pfetsch</i>	
New Variants of Lift-and-Project Cut Generation from the LP Tableau: Open Source Implementation and Testing . . . . .	89
<i>Egon Balas and Pierre Bonami</i>	
Orbital Branching . . . . .	104
<i>James Ostrowski, Jeff Linderoth, Fabrizio Rossi, and Stefano Smriglio</i>	

## Session 4

Distinct Triangle Areas in a Planar Point Set . . . . .	119
<i>Adrian Dumitrescu and Csaba D. Tóth</i>	
Scheduling with Precedence Constraints of Low Fractional Dimension . . . . .	130
<i>Christoph Ambühl, Monaldo Mastrolilli, Nikolaus Mutsanas, and Ola Svensson</i>	

Approximation Algorithms for 2-Stage Stochastic Scheduling Problems .....	145
<i>David B. Shmoys and Mauro Sozio</i>	

## Session 5

On Integer Programming and the Branch-Width of the Constraint Matrix .....	158
<i>William H. Cunningham and Jim Geelen</i>	
Matching Problems in Polymatroids Without Double Circuits .....	167
<i>Márton Makai, Gyula Pap, and Jácint Szabó</i>	
Maximizing a Submodular Set Function Subject to a Matroid Constraint .....	182
<i>Gruia Calinescu, Chandra Chekuri, Martin Pál, and Jan Vondrák</i>	

## Session 6

On a Generalization of the Master Cyclic Group Polyhedron .....	197
<i>Sanjeeb Dash, Ricardo Fukasawa, and Oktay Günlük</i>	
A Framework to Derive Multidimensional Superadditive Lifting Functions and Its Applications .....	210
<i>Bo Zeng and Jean-Philippe P. Richard</i>	
On the Exact Separation of Mixed Integer Knapsack Cuts .....	225
<i>Ricardo Fukasawa and Marcos Goycoolea</i>	

## Session 7

A Faster Strongly Polynomial Time Algorithm for Submodular Function Minimization .....	240
<i>James B. Orlin</i>	
On Convex Minimization over Base Polytopes .....	252
<i>Kiyohito Nagano</i>	
Computational Geometric Approach to Submodular Function Minimization for Multiclass Queueing Systems .....	267
<i>Toshinari Itoko and Satoru Iwata</i>	

## Session 8

Generating Multiple Solutions for Mixed Integer Programming Problems .....	280
<i>Emilie Danna, Mary Fenelon, Zonghao Gu, and Roland Wunderling</i>	
A Branch and Bound Algorithm for Max-Cut Based on Combining Semidefinite and Polyhedral Relaxations .....	295
<i>Franz Rendl, Giovanni Rinaldi, and Angelika Wiegele</i>	

DINS, a MIP Improvement Heuristic . . . . .	310
<i>Shubhashis Ghosh</i>	

## Session 9

Mixed-Integer Vertex Covers on Bipartite Graphs . . . . .	324
<i>Michele Conforti, Bert Gerards, and Giacomo Zambelli</i>	
On the MIR Closure of Polyhedra . . . . .	337
<i>Sanjeeb Dash, Oktay Günlük, and Andrea Lodi</i>	
The Intersection of Continuous Mixing Polyhedra and the Continuous Mixing Polyhedron with Flows . . . . .	352
<i>Michele Conforti, Marco Di Summa, and Laurence A. Wolsey</i>	

## Session 10

Simple Explicit Formula for Counting Lattice Points of Polyhedra . . . . .	367
<i>Jean B. Lasserre and Eduardo S. Zeron</i>	
Characterizations of Total Dual Integrality . . . . .	382
<i>Edwin O'Shea and András Sebő</i>	
Sign-Solvable Linear Complementarity Problems . . . . .	397
<i>Naonori Kakimura</i>	

## Session 11

An Integer Programming Approach for Linear Programs with Probabilistic Constraints . . . . .	410
<i>James Luedtke, Shabbir Ahmed, and George Nemhauser</i>	
Infrastructure Leasing Problems . . . . .	424
<i>Barbara M. Anthony and Anupam Gupta</i>	
Robust Combinatorial Optimization with Exponential Scenarios . . . . .	439
<i>Uriel Feige, Kamal Jain, Mohammad Mahdian, and Vahab Mirrokni</i>	

## Session 12

Approximation Algorithms for the Multi-item Capacitated Lot-Sizing Problem Via Flow-Cover Inequalities . . . . .	454
<i>Retsef Levi, Andrea Lodi, and Maxim Sviridenko</i>	
Optimal Efficiency Guarantees for Network Design Mechanisms . . . . .	469
<i>Tim Roughgarden and Mukund Sundararajan</i>	
The Set Connector Problem in Graphs . . . . .	484
<i>Takuro Fukunaga and Hiroshi Nagamochi</i>	

<b>Author Index</b> . . . . .	499
-------------------------------	-----