

Lecture Notes in Computer Science

2570

Edited by G. Goos, J. Hartmanis, and J. van Leeuwen

Springer

Berlin

Heidelberg

New York

Barcelona

Hong Kong

London

Milan

Paris

Tokyo

Michael Jünger
Gerhard Reinelt
Giovanni Rinaldi (Eds.)

Combinatorial Optimization – Eureka, You Shrink!

Papers Dedicated to Jack Edmonds

5th International Workshop
Aussois, France, March 5-9, 2001
Revised Papers



Springer

Series Editors

Gerhard Goos, Karlsruhe University, Germany
Juris Hartmanis, Cornell University, NY, USA
Jan van Leeuwen, Utrecht University, The Netherlands

Volume Editors

Michael Jünger
Institut für Informatik
Universität zu Köln
Pohligstr. 1, 50969 Köln, Germany
E-mail: mjuenger@informatik.uni-koeln.de

Gerhard Reinelt
Institut für Informatik
Universität Heidelberg
Im Neuenheimer Feld 368, 69120 Heidelberg, Germany
E-mail: gerhard.reinelt@informatik.uni-heidelberg.de

Giovanni Rinaldi
Istituto di Analisi dei Sistemi ed Informatica "Antonio Ruberti"
CNR
viale Manzoni 30, 00185 Rome, Italy
E-mail: rinaldi@iasi.rm.cnr.it

Cataloging-in-Publication Data applied for

A catalog record for this book is available from the Library of Congress.

Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data is available in the Internet at <<http://dnb.ddb.de>>.

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

ISSN 0302-9743

ISBN 3-540-00580-3 Springer-Verlag 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-Verlag. Violations are liable for prosecution under the German Copyright Law.

Springer-Verlag Berlin Heidelberg New York
a member of BertelsmannSpringer Science+Business Media GmbH

<http://www.springer.de>

© Springer-Verlag Berlin Heidelberg 2003
Printed in Germany

Typesetting: Camera-ready by author, data conversion by PTP-Berlin, Stefan Sossna e. K.
Printed on acid-free paper SPIN: 10872263 06/3142 5 4 3 2 1 0

Preface

A legend says that Jack Edmonds shouted “Eureka – you shrink!” when he found a good characterization for matching (and the matching algorithm) in 1963, the day before his talk at a summer workshop at RAND Corporation with celebrities like George Dantzig, Ralph Gomory, and Alan Hoffman in the audience. During Aussois 2001, Jack confirmed: “Eureka – you shrink!” is really true, except that instead of ‘Eureka’ it maybe was some less dignified word.”

Aussois 2001 was the fifth in an annual series of workshops on combinatorial optimization that are alternately organized by Thomas Liebling, Denis Naddef, and Laurence Wolsey – the initiators of this series – in even years and the editors of this book in odd years (except 1997).

We decided to dedicate Aussois 2001 to Jack Edmonds in appreciation of his groundbreaking work that laid the foundations of much of what combinatorial optimizers have done in the last 35 years. Luckily, Jack is a regular participant of the Aussois workshops and, as ever, he cares a lot for young combinatorial optimizers who traditionally play a major rôle in the Aussois series.

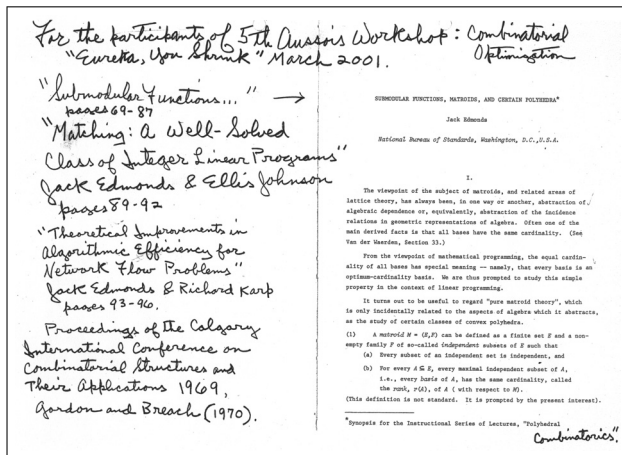


Fig. 1. Handout for the Aussois 2001 participants

Highlights of Aussois 2001 included a special session entitled “Eureka – you shrink!” in honor of Jack and a special lecture by Jack on “Submodular Functions, Matroids, and Certain Polyhedra” that closed the workshop.

In this book, we give an account of the “Eureka – you shrink!” session as well as reprints of three hardly accessible papers that Jack gave as a handout to the Aussois 2001 participants and that were originally published in the *Proceedings of the Calgary International Conference on Combinatorial Structures and Their Applications 1969*, Gordon and Breach (1970) – newly typeset by the editors and reprinted by permission.

We are happy that 13 speakers of Aussois 2001 agreed to dedicate revisions of the papers they presented during the workshop to Jack Edmonds. Their contributions have made this book possible.

As organizers and editors we would like to thank Jack Edmonds, the authors, Miguel Anjos for transcribing Bill Pulleyblank’s speech, and, in particular, Bill Pulleyblank for support that went well beyond the contribution you will find in the “Eureka – you shrink!” chapter!

When Jack gave an interview for the Kitchener-Waterloo Record of May 30, 1985, on the occasion of the award of the John von Neumann Theory Prize to him a month earlier, he said: “I hit it lucky by putting a poetic title on a paper that was mathematically a hit,” referring to his seminal paper entitled “Paths, Trees, and Flowers.” With the help of Matthias Elf, we found an artist whose proposal for a cover illustration immediately convinced all three of us: People who know Jack’s work will have the right association without reading the words. A special “Thank You!” to Thorsten Felden who contributed his own homage à Jack!

January 2003

Cologne
Heidelberg
Rome

Michael Jünger
Gerhard Reinelt
Giovanni Rinaldi

Participants

Aardal, Karen (University of Utrecht)
Ahr, Dino (University of Heidelberg)
Amaldi, Edoardo (Politecnico di Milano)
Békési, Jozsef (University of Szeged)
Bixby, Robert E. (Rice University, Houston)
Buchheim, Christoph (University of Cologne)
Cameron, Kathie (Wilfried Laurier University, Waterloo)
Caprara, Alberto (University of Bologna)
Edmonds, Jack (University of Waterloo)
Elf, Matthias (University of Cologne)
Euler, Reinhardt (University of Brest)
Evans, Lisa (Georgia Institute of Technology, Atlanta)
Farias, Ismael de (University at Buffalo)
Feremans, Corinne (University of Brussels)
Fischetti, Matteo (University of Padova)
Fleischer, Lisa (Columbia University, New York)
Fortz, Bernard (University of Brussels)
Galambos, Gábor (University of Szeged)
Gruber, Gerald (Carinthia Tech Institute, Villach)
Hemmecke, Raymond (University of Duisburg)
Johnson, Ellis (Georgia Institute of Technology, Atlanta)
Jünger, Michael (University of Cologne)
Kaibel, Volker (University of Technology, Berlin)
Labbé, Martine (University of Brussels)
Lemaréchal, Claude (INRIA Rhône-Alpes)
Letchford, Adam (Lancaster University)
Liers, Frauke (University of Cologne)
Lodi, Andrea (University of Bologna)
Lübbecke, Marco (University of Braunschweig)
Luzzi, Ivan (University of Padova)
Maffioli, Francesco (Politecnico di Milano)
Martin, Alexander (University of Technology, Darmstadt)
Maurras, Jean François (Université de la Méditerranée, Marseille)
Meurdesoif, Philippe (INRIA Rhône-Alpes)

Möhring, Rolf H. (University of Technology, Berlin)
Monaci, Michele (University of Bologna)
Mutzel, Petra (University of Technology, Vienna)
Naddef, Denis (ENSIMAG, Montbonnot Saint Martin)
Nemhauser, George (Georgia Institute of Technology, Atlanta)
Nguyen, Viet Hung (Université de la Méditerranée, Marseille)
Ortega, Francois (CORE, Louvain-la-Neuve)
Oswald, Marcus (University of Heidelberg)
Percan, Merijam (University of Cologne)
Perregard, Michael (Carnegie Mellon University, Pittsburgh)
Pulleyblank, William (IBM Yorktown Heights)
Reinelt, Gerhard (University of Heidelberg)
Remshagen, Anja (University of Texas at Dallas)
Rendl, Franz (University of Klagenfurt)
Richard, Jean Philippe (Georgia Institute of Technology, Atlanta)
Riis, Morton (University of Aarhus)
Rinaldi, Giovanni (IASI-CNR Rome)
Rote, Günter (Free University of Berlin)
Salazar-González, Juan-José (University of La Laguna, Tenerife)
Schultz, Rüdiger (University of Duisburg)
Skutella, Martin (University of Technology, Berlin)
Spille, Bianca (EPFL-DMA Lausanne)
Stork, Frederik (University of Technology, Berlin)
Toth, Paolo (University of Bologna)
Uetz, Marc (University of Technology, Berlin)
Vandenbusse, Dieter (Georgia Institute of Technology, Atlanta)
Verweij, Bram (Georgia Institute of Technology, Atlanta)
Weismantel, Robert (University of Magdeburg)
Wenger, Klaus (University of Heidelberg)
Woeginger, Gerhard (University of Twente)
Wolsey, Laurence (CORE, Louvain-la-Neuve)
Zimmermann, Uwe (University of Technology, Braunschweig)

Table of Contents

“Eureka – You Skrink!”

“Eureka – You Shrink!”	1
<i>Surprise Session for Jack Edmonds</i>	
Submodular Functions, Matroids, and Certain Polyhedra.....	11
<i>Jack Edmonds (National Bureau of Standards, Washington)</i>	
Matching: A Well-Solved Class of Integer Linear Programs	27
<i>Jack Edmonds (National Bureau of Standards, Washington), Ellis L. Johnson (I.B.M. Research Center, Yorktown Heights)</i>	
Theoretical Improvements in Algorithmic Efficiency for Network Flow Problems	31
<i>Jack Edmonds (National Bureau of Standards, Washington), Richard M. Karp (University of California, Berkeley)</i>	
Connected Matchings.....	34
<i>Kathie Cameron (Wilfried Laurier University, Waterloo)</i>	
Hajós’ Construction and Polytopes	39
<i>Reinhardt Euler (Université de Brest)</i>	
Algorithmic Characterization of Bipartite b -Matching and Matroid Intersection.....	48
<i>Robert T. Firla (University of Magdeburg), Bianca Spille (EPFL-DMA, Lausanne), Robert Weismantel (University of Magdeburg)</i>	
Solving Real-World ATSP Instances by Branch-and-Cut	64
<i>Matteo Fischetti (University of Padova), Andrea Lodi (University of Bologna), Paolo Toth (University of Bologna)</i>	
The Bundle Method for Hard Combinatorial Optimization Problems	78
<i>Gerald Gruber (Carinthia Tech Institute, Villach), Franz Rendl (University of Klagenfurt)</i>	
The One-Commodity Pickup-and-Delivery Travelling Salesman Problem .	89
<i>Hipólito Hernández-Pérez, Juan-José Salazar-González (University of La Laguna, Tenerife)</i>	
Reconstructing a Simple Polytope from Its Graph	105
<i>Volker Kaibel (University of Technology, Berlin)</i>	

An Augment-and-Branch-and-Cut Framework for Mixed 0-1 Programming	119
<i>Adam N. Letchford (Lancaster University), Andrea Lodi (University of Bologna)</i>	
A Procedure of Facet Composition for the Symmetric Traveling Salesman Polytope	134
<i>Jean François Maurras, Viet Hung Nguyen (Université de Marseille)</i>	
Constructing New Facets of the Consecutive Ones Polytope	147
<i>Marcus Oswald, Gerhard Reinelt (University of Heidelberg)</i>	
A Simplex-Based Algorithm for 0-1 Mixed Integer Programming	158
<i>Jean-Philippe P. Richard (Georgia Institute of Technology, Atlanta), Ismael R. de Farias (CORE, Louvain-la-Neuve), George L. Nemhauser (Georgia Institute of Technology, Atlanta)</i>	
Mixed-Integer Value Functions in Stochastic Programming	171
<i>Rüdiger Schultz (University of Duisburg)</i>	
Exact Algorithms for NP-Hard Problems: A Survey	185
<i>Gerhard J. Woeginger (University of Twente, Enschede)</i>	
Author Index	209