

Edmund Burke Michael Carter (Eds.)

Practice and Theory of Automated Timetabling II

Second International Conference, PATAT'97
Toronto, Canada, August 20-22, 1997
Selected Papers



Springer

Series Editors

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

Volume Editors

Edmund Burke
University of Nottingham, Department of Computer Science
University Park, Nottingham NG7 2RD, UK
E-mail: ekb@cs.nott.ac.uk

Michael Carter
University of Toronto
Department of Mechanical and Industrial Engineering
5 King's College Road, Toronto, Ontario, Canada M5S 3G8
E-mail: carter@mie.utoronto.ca

Cataloging-in-Publication data applied for

Die Deutsche Bibliothek - CIP-Einheitsaufnahme

Practice and theory of automated timetabling II : second international conference ; selected papers / PATAT '97, Toronto, Canada, August 20 - 22, 1997 / Edmund Burke ; Michael Carter (ed.). - Berlin ; Heidelberg ; New York ; Barcelona ; Budapest ; Hong Kong ; London ; Milan ; Paris ; Singapore ; Tokyo : Springer, 1998 (Lecture notes in computer science ; 1408) ISBN 3-540-64979-4

CR Subject Classification (1991): I.2.2, I.2.8, H.4.1-2, J.1, K.3, F.2, G.2

ISSN 0302-9743

ISBN 3-540-64979-4 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 1998
Printed in Germany

Typesetting: Camera-ready by author
SPIN 10637176 06/3142 - 5 4 3 2 1 0 Printed on acid-free paper

Preface

This volume contains the selected papers from the second international conference on the Practice And Theory of Automated Timetabling (PATAT'97) held in Toronto, August 20-22, 1997.

The Concise Oxford Dictionary (seventh edition) defines a "time table" as a "scheme of school work, etc., table showing times of public transportation". Most dictionaries do not include "timetabling" as a word. "Timetabling" can be defined as the process of assigning specific times to a set of activities. It occurs in a wide variety of organisations, institutions and everyday situations. Everybody has come into contact with a timetable at one time or another in their lives. Common examples occur in universities and schools (determine what time each exam will be held or what time each course will take place); in transportation (determine what time a train/bus/aeroplane will depart/arrive for each station/airport) and in sports (determine the time and date of each match/event to be played). Timetabling is also required for conferences (determine the times for each session), for interview planning (determine which dates each party will be available for interviews) and for employee management (designing each employee's work timetable).

The term timetabling and the term scheduling are sometimes used interchangeably. People will talk about timetabling a set of exams or scheduling a set of exams. Anthony Wren* surveyed the use of the terms scheduling, timetabling and rostering, and found a great deal of variety. He decided to define timetabling as a special case of scheduling:

"Timetabling is the allocation, subject to constraints, of given resources to objects being placed in space-time, in such a way as to satisfy as nearly as possible a set of desirable objectives."

For example, examinations and courses must be scheduled so that no person should be expected to be in two places at once! In addition, there may be space constraints on the size of rooms available at any time, and special facilities required. There may also be a number of features that are desirable but not absolutely critical in all cases such as attempting to reduce the number of times a student has to take two exams consecutively (without a break). Indeed the problem varies from situation to situation. Some educational institutions will place more weight on constraints like these than other institutions do.

People have been constructing timetables for hundreds of years, and yet we know surprisingly little about efficient techniques for performing this class of tasks. Even today, the majority of timetabling functions are carried out manually. In some cases, it is done by someone who, through years of experience, has developed an intuitive sense of how the pieces should fit together. However,

* See A. Wren, "Scheduling Timetabling and Rostering - A special Relationship", in Burke and Ross (eds.), "The Practice and Theory of Automated Timetabling", Lecture Notes in Computer Science, Vol. 1153, 1996, pages 46-76.

more often than not, timetabling is left to relative amateurs who spend days and weeks trying to devise a reasonable solution. Yet, research papers on automated timetabling have consistently appeared over the last forty years or so and in many situations, computerised methods have been used to assist in the problem solution. However, it is clear that there is still much work to be done on the automation of this important class of problems. Indeed, in the last few years, the level of research interest in this fascinating area has increased dramatically. The establishment of the series of international conferences on the Practice and Theory of Automated Timetabling (PATAT) and the great success of the first two conferences in the series have reflected this increase of interest in the area. Another indicator is the establishment of the EURO (Association of European Operational Research Societies) Working group on Automated TimeTabling (WATT). See <http://www.cs.rdg.ac.uk/cs/research/pedal/watt/index.html> for further details.

This volume has been organised into sections based on the primary solution method employed in the papers (Tabu search and simulated annealing, population based methods, constraint based methods and graph theory). Of course, there is some overlap in the categorisations and some papers could happily have fitted into two (or more) sections. We also include a section on surveys, and a section on practical issues. Every effort has been made to ensure that among the papers in the conference (and so in this volume of selected papers), there will be something of interest to both researchers and practitioners. We have, therefore, in addition to research papers, included papers on practical issues that describe some of the more subjective considerations in timetabling from the viewpoint of administrators and practitioners. The main motivation behind this is, not only that the papers will be of interest to practitioners, but also that they should be of interest to researchers in the area and should help them to focus their research on some of the issues that administrators raise.

The Conference Series

The conference in Toronto was the second in a series of international conferences on the Practice And Theory of Automated Timetabling (PATAT). This volume contains the selected papers from that conference.

The first conference was held in Edinburgh in August/September 1995. Selected papers from this also appeared in the Springer Lecture Notes in Computer Science series. The full reference is:

Edmund Burke and Peter Ross (editors), *The Practice and Theory of Automated Timetabling: Selected Papers from the 1st International Conference on the Practice and Theory of Automated Timetabling*, Edinburgh August/September 1995, Lecture Notes in Computer Science, Vol. 1153, Springer 1996.

The third conference in the series will be held in Konstanz, Germany, in August 2000. Future conferences will be held every three years. For further information about the conference series, contact the steering committee (see below) or see <http://www.asap.cs.nott.ac.uk/ASAP/ttg/patat-index.html>

Acknowledgements

The conference in Toronto was a great success. It built on the considerable success of the first conference in the series. Many people worked very hard to make the conference run smoothly and efficiently. The organising committee (members are listed below) worked extremely hard to make it the valuable, enjoyable and interesting event that it turned out to be. We would like to extend our sincere thanks to them. Particular thanks go to Margaret Thompsett. She looked after registration, notification, correspondence, meals and residence, and virtually ran the local arrangements single-handedly. Under her capable guidance, everything went smoothly.

The papers and abstracts were fully refereed for the conference itself. All the papers that were submitted to this "Selected papers" volume had to undergo a second round of very careful and rigorous refereeing. A lot of work (throughout both rounds of refereeing) has gone into the process of selecting those papers which now appear in this book. We are very grateful to the members of the programme committee (listed below) who helped to referee the papers during these two rounds. Thanks must also go to the staff of Springer for their support and encouragement. As editor of the Lecture Notes in Computer Science series, Jan van Leeuwen was particularly helpful throughout this project, as he was with the previous volume. His comments and advice were, once again, invaluable in bringing the book to publication. We are also particularly grateful to Farida Alibhai for the secretarial work she carried out during the first round of refereeing and to Carol Jones for her work during the (early part of the) second round of refereeing. Special thanks also go to Alison Payne for all the secretarial support she has given us towards the end of the second round of refereeing and during the preparation of this volume.

The main contributors to the success of the conference were (once again), without doubt, the delegates, the vendors who presented their software and the authors of submitted papers and presentations. Our thanks go to them for the enthusiasm and support they have given to us and to this event and that (hopefully) they will continue to give to future events. Finally, we would like to thank the steering committee (listed below) for their continuing work in bringing us this and future PATAT conferences. We apologise for any omissions that have been inadvertently made. So many people have helped with this conference and with the series of conferences that it is difficult to remember them all.

April 1998

Edmund Burke
Mike Carter

Second International Conference on the Practice and Theory of Automated Timetabling (PATAT '97) Programme Committee

Edmund Burke (co-chair)	University of Nottingham, UK
Mike Carter (co-chair)	University of Toronto, Canada
Victor Bardadym	International Renaissance Foundation, Ukraine
Jim Blakesley	Purdue University, USA
Patrice Boizumault	Ecole des Mines de Nantes, France
Dave Corne	University of Reading, UK
Andrew Cumming	Napier University, UK
Marco Dorigo	Université Libre de Bruxelles, Belgium
Kath Dowsland	University of Wales Swansea, UK
Wilhelm Erben	Fachhochschule Konstanz – University of Applied Sciences, Germany
Jacques Ferland	University of Montreal, Canada
Alain Hertz	EPFL, Switzerland
Jeffrey H. Kingston	University of Sydney, Australia
Gilbert Laporte	Ecole des Hautes Etudes Commerciales, Montreal, Canada
Vahid Lofti	University of Michigan-Flint, USA
Henri Luchian	AL. I. Cuza University of Iasi, Romania
Amnon Meisels	Ben-Gurion University, Beer-Shava, Israel
Thiruthlall Nepal	ML Sultan Technikon, Durban, South Africa
Ben Paechter	Napier University, UK
Peter Ross	University of Edinburgh, UK
Andrea Schaerf	Università di Roma “La Sapienza”, Italy
Jan Schreuder	University of Twente, The Netherlands
Jonathan M Thompson	University of Edinburgh, UK
Michael Trick	Carnegie Mellon University, USA
Rupert Weare	Cap Gemini plc, UK
Dominique de Werra	EPFL, Switzerland
George White	University of Ottawa, Canada
Jay Yellen	Florida Tech, USA
Masazumi Yoshikawa	NEC Corporation, Kawasaki, Japan

Second International Conference on the Practice and Theory of Automated Timetabling (PATAT '97) Organising Committee

Department of Mechanical and Industrial Engineering
University of Toronto, Canada

Michael Carter	Chair
Cathie Kessler	Registration desk
Maurine Kwok	Finance
Sau Yan Lee	Technical support
Ella Lund-Tompsen	Registration desk
Wendy Smith	Secretarial support
Margaret Tompsett	Everything and anything else

The International Series of Conferences on the Practice And Theory of Automated Timetabling (PATAT) Steering Committee

Edmund Burke (Chair)	University of Nottingham, UK
Ben Paechter (Treasurer)	Napier University, UK
Victor Bardadym	International Renaissance Foundation, Ukraine
Michael Carter	University of Toronto, Canada
Dave Corne	University of Reading, UK
Wilhelm Erben	Fachhochschule Konstanz – University of Applied Sciences, Germany
Jeff Kingston	University of Sydney, Australia
Gilbert Laporte	Ecole des Hautes Etudes Commerciales, Montreal, Canada
Peter Ross	University of Edinburgh, UK
George White	University of Ottawa, Canada
Dominique de Werra	EPFL, Switzerland
Anthony Wren	University of Leeds, UK

Contents

Surveys

Recent Developments in Practical Course Timetabling	3
M.W.Carter and G.Laporte	
Space Allocation: An Analysis of Higher Education Requirements	20
E.K.Burke and D.B.Varley	

Tabu Search and Simulated Annealing

Off-the-Peg or Made-to-Measure? Timetabling and Scheduling with SA and TS	37
K.A. Dowsland	
Generalised Assignment-Type Problems: A Powerful Modeling Scheme	53
J.A. Ferland	
An Examination Scheduling Model to Maximize Students' Study Time	78
B. Bullnheimer	
A Comparison of Annealing Techniques for Academic Course Scheduling ..	92
M.A.S. Elmohamed, P. Coddington and G. Fox	

Evolutionary Computation (Population Based Methods)

Some Observations about GA-based Exam Timetabling	115
P. Ross, E. Hart and D. Corne	
Experiments on Networks of Employee Timetabling Problems	130
A. Meisels and N. Lusternik	
Evolutionary Optimisation of Methodist Preaching Timetables	142
D. Corne and J. Ogden	
Improving a Lecture Timetabling System for University-Wide Use	156
B. Paechter, R.C. Rankin and A. Cumming	

Constraint Based Methods

A Constraint-Based Approach from Examination Timetabling Using Local Repair Techniques	169
P. David	

Generating Complete University Timetables by Combining Tabu Search with Constraint Logic	187
G.M. White and J. Zhang	

Graph Theory

Construction of Basic Match Schedules (BMS) for Sports Competitions by Using Graph Theory	201
A. van Weert and J.A.M. Schreuder	

Practical Issues

A Standard Data Format for Timetabling Instances	213
E.K. Burke, J.H. Kingston and P.A. Pepper	
Academic Scheduling	223
J.F. Blakesley, K.S. Murray, F.H. Wolf and D. Murray	
The Implementation of a Central Timetabling System in a Large British Civic University	237
B. McCollum	
A Brute Force and Heuristics Approach to Tertiary Timetabling	254
T. Nepal, S.W. Melville and M.I. Ally	

Other Timetabling Presentations

A List of Other Conference Presentations	269
--	-----

Author Index	273
---------------------------	-----