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Edmund Burke
Michael Trick (Eds.)

Practice and Theory of Automated Timetabling V

5th International Conference, PATAT 2004
Pittsburgh, PA, USA, August 2004
Revised Selected Papers

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Preface

This volume contains a selection of papers from the 5th International Conference on the Practice and Theory of Automated Timetabling (PATAT 2004) held in Pittsburgh, USA, August 18–20, 2004. Indeed, as we write this preface, in the Summer of 2005, we note that we are about one month away from the tenth anniversary of the very first PATAT conference in Edinburgh. Since those very early days, the conference series has gone from strength to strength and this volume represents the latest in a series of five rigorously refereed volumes which showcase a broad spectrum of ground-breaking timetabling research across a very wide range of timetabling problems and applications.

Timetabling is an area that unites a number of disparate fields and which cuts across a number of diverse academic disciplines. While the most obvious instances of timetabling occur in educational institutions, timetabling also appears in sports applications, transportation planning, project scheduling, and many other fields. Viewing timetabling as a unifying theme enables researchers from these various areas to learn from each other and to extend their own research and practice in new and innovative ways. This volume continues the trend of the conference series to extend the definition of timetabling beyond its educational roots. In this volume, seven of the 19 papers involve domains other than education. Of course, educational timetabling remains at the core of timetabling research, and the papers in this volume represent the full range of this area including exam timetabling, room scheduling, and class rostering.

There are a number of particularly interesting aspects to the research presented in this volume. First, the variety of techniques being used to address these problems is striking. In this book, there are papers exploring optimization, constraint programming, evolutionary algorithms, tabu search, fuzzy approaches, and many other exact and heuristic methodologies. In many ways, timetabling is an ideal testbed for algorithmic approaches. The strength of timetabling in this regard revolves around a number of characteristics. First, timetabling problems are difficult, even for small instances. It is not necessary to have 10,000 students and 1,000 courses to lead to hard instances: even problems one-hundredth the size can be difficult. But it is exactly problems of that size that are of practical interest. Problems of practical interest are neither too large to be possibly solved, nor too small to be trivial. They are "just right": challenging, but possible. Furthermore, there are a lot of data available, and much of those data are available to academics. Finally, there are a number of different problem types available, allowing for a rich field of problems to be addressed. Taken together, these characteristics make timetabling an ideal domain for research on algorithms, and this volume demonstrates this richness through the variety of novel timetabling approaches that are explored and discussed.

Second, it is important to note how grounded in practice these papers are. Most of the papers begin with a real-world problem to solve. It is this interplay between real practice and theory that gives timetabling its richness. These papers are generally not about theoretical issues but are based on the need to create real timetables. This gives an immediacy to this work that is uncommon in much research.

The downside of this real-world aspect is a lack of standardization, leading to many papers solving only slightly different problems. The third interesting aspect of this volume is a growing interest in standardizing problem definitions and creating robust, flexible definitions of general timetabling problems. This trend is most obvious in the "General Issues" papers, but occurs in many other papers in the volume. While grounding the work in practice, there is a growing interest in generalizations.

Overall, we think this volume shows timetabling as a broad, important field with a rich set of practical models, and a robust and growing set of solution approaches. We thank the authors for their contributions, and are confident in the continuing success of the PATAT conference series.

Conference Series

The Meeting in Pittsburgh was the fifth in the PATAT series of international conferences. The first four conferences were held in Edinburgh (1995), Toronto (1997), Constance (2000), and Gent (2002). Selected papers from these four conferences appeared in the Springer *Lecture Notes in Computer Science* series. The full references are:

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

Edmund Burke and Michael Carter (Eds.): Practice and Theory of Automated Timetabling, 2nd International Conference, Toronto, Canada, September 1997, Selected Papers, Lecture Notes in Computer Science, Vol. 1408, Springer, 1998.

Edmund Burke and Wilhelm Erben (Eds.): Practice and Theory of Automated Timetabling, 3rd International Conference, Konstanz, Germany, August 2000, Selected Papers, Lecture Notes in Computer Science, Vol. 2079, Springer, 2001.

Edmund Burke and Patrick De Causmaecker (Eds.): Practice and Theory of Automated Timetabling, 4th International Conference, Gent, Belgium, August 2002, Selected Papers, Lecture Notes in Computer Science, Vol. 2740, Springer, 2003.

The sixth conference will be held in Brno, Czech Republic, August/September 2006. See http://www.asap.cs.nott.ac.uk/patat/patat-index.shtml for information on the conference series.

Acknowledgements

We are very grateful to a large number of people for the success of the Pittsburgh conference and for their efforts in helping to put together this volume. We would like to acknowledge the financial support from the Tepper School of Business, Carnegie Mellon; the Carnegie Bosch Institute, Carnegie Mellon; and the Aladdin Center, Carnegie Mellon. Their generosity helped to give the conference the special atmosphere that made it such a memorable occasion. A particular thank you also goes to Cathy Burstein, who was invaluable in handling the local organization and registration, and the program could not have occurred without her efforts.

The papers that appear in this volume were carefully and thoroughly refereed. Many thanks go to the members of the Programme Committee who spent a significant amount of time ensuring the quality of the conference program itself and, particularly, of the selected papers that appear in this volume. Their hard work plays a major role in ensuring the success and high standards that have come to characterize the conference. We are also grateful to the staff at Springer for their help and encouragement and to Jan van Leeuwen, who, as an editor of the *Lecture Notes in Computer Science* series, has always given us valuable support and advice since the very beginning of the conference series back in 1995.

We would like to offer a very special thank you to Piers Maddox, our copy editor. The very high formatting and typesetting standards of this volume are entirely due to him. Special thanks should also go to Emma-Jayne Dann for all her hard work in supporting the administration that underpinned the editorial process for this book.

We are, of course, also very grateful to the authors and delegates at the conference who contributed so much towards making it such an enjoyable event. Finally, we would like to thank all the people on the Steering Committee for their hard work in organizing the entire series of PATAT conferences.

We are looking forward to the next conference and to seeing you in Brno in the Summer of 2006.

July 2005

Edmund Burke
Michael Trick

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General Issues

Learning User Preferences in Distributed Calendar Scheduling

Jean Oh and Stephen F. Smith

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Abstract. Within the field of software agents, there has been increasing interest in automating the process of calendar scheduling in recent years. Calendar (or meeting) scheduling is an example of a timetabling domain that is most naturally formulated and solved as a continuous, distributed problem. Fundamentally, it involves reconciliation of a given user's scheduling preferences with those of others that the user needs to meet with, and hence techniques for eliciting and reasoning about a user's preferences are crucial to finding good solutions. In this paper, we present work aimed at learning a user's time preference for scheduling a meeting. We adopt a passive machine learning approach that observes the user engaging in a series of meeting scheduling episodes with other meeting participants and infers the user's true preference model from accumulated data. After describing our basic modeling assumptions and approach to learning user preferences, we report the results obtained in an initial set of proof of principle experiments. In these experiments, we use a set of automated CMRADAR calendar scheduling agents to simulate meeting scheduling among a set of users, and use information generated during these interactions as training data for each user's learner. The learned model of a given user is then evaluated with respect to how well it satisfies that user's true preference model on a separate set of meeting scheduling tasks. The results show that each learned model is statistically indistinguishable from the true model in their performance with strong confidence, and that the learned model is also significantly better than a random choice model.

1 Introduction

One vision of research in the field of intelligent software agents is the realization of personal computer assistants. A personal computer assistant is a software agent that is integrated into a user's computing environment and pro-actively accomplishes various tasks in support of high-level user goals. Like a human assistant, such a personal computer assistant would do such things as process email, schedule meetings, service information requests, organize events, and so on; autonomously interacting with other personal computer assistants as necessary to carry out a given task and in each case recognizing if and when it is

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appropriate to engage the user in the process. One fundamental aspect of a personal computer assistant is that it is enduring and self-improving. It is expected to persist indefinitely, and learn over time to make decisions that better reflect user constraints and preferences.

Toward this goal of creating personal computer assistants, there has been increasing interest in automating the process of scheduling meetings and managing user calendars. Calendar scheduling can be seen as a kind of timetabling problem—the objective is to assign time slots to meetings in such a way that the constraints and preferences of meeting requests and prospective attendees are best satisfied. However, the problem of calendar scheduling differs from typical timetabling problems in a couple of important respects:

- *Continuous, dynamic problem.* Calendar scheduling is an ongoing endeavor. At any point in time, there are some number of meetings booked, and new requests are serviced continuously in an incremental manner. It is generally desirable to maintain stability in assignments over time, although invariably it will be necessary to bump previously scheduled meetings, and the busier individuals are, the more frequently such tradeoffs will need to be considered.
- *Distributed decision-making.* Although one can consider centralized approaches to the calendar scheduling problem, this requires all individuals involved to share their calendars and this is not a realistic assumption in many circumstances. In these cases, protocols for negotiating time slots that are mutually acceptable to prospective attendees must be devised. Note that in some situations it may be necessary to settle on a subset of attendees, and/or coordinate with additional resource brokers (e.g., room booking agents).

Like other timetabling domains, calendar scheduling preferences will vary from user to user, and one strong prerequisite of any calendar scheduling solution is an ability to incorporate user-specific preferences. Preferences can range from simple static time of day (or day of week) preferences, to more complex dynamic preferences (such as scheduling meetings back-to-back or retaining free time in proximity to important deadlines), to preferences of which meeting(s) to bump in over-constrained situations. Typical timetabling solutions require users to directly specify their preferences as input to the problem solving process. However, the fact that calendar scheduling is an ongoing, continuous process suggests the possibility of automatically acquiring this knowledge over time through observation of meeting scheduling episodes.

Our recent research in the calendar scheduling domain has led to development of CMRADAR, a distributed calendar scheduling system [9]. Each CMRADAR scheduling agent accepts requests for meetings from its user, and interacts autonomously with the CMRADAR agents of other users to determine and confirm a mutually agreeable meeting time. If the action of scheduling a given meeting pre-empts a previously scheduled meeting, then affected CMRADAR agents coordinate to reschedule the bumped meeting. CMRADAR meeting scheduling protocols support a range of negotiation strategies, allowing the amount of information exchanged (e.g., number of options, preference values) and the assumptions made about organizational structure to be varied. Scheduling options