

Academic Timetabling: Linking Research and Practice

Barry McCollum^{1,3}, Paul McMullan^{1,3}, Edmund Burke^{2,3}, Graham Kendall^{2,3}, Adrian Gough⁴,
Adrian Jones⁴

¹School of Electronics, Electrical Engineering and Computer Science

Queen's University,

Belfast,

University Road,

N. Ireland,

BT7 1NN

b.mccollum@qub.ac.uk

²School of Computer Science

University of Nottingham

Jubilee Campus,

Nottingham,

United Kingdom,

NG8 1BB

³EventMAP Ltd

SARC Building,

Queen's University,

Belfast,

N. Ireland

BT95AH

⁴Corbett Engineering Ltd (trading as CELCAT)

21-23 Mercia Business Village,

Torwood Close,

Coventry,

United Kingdom,

CV4 8HX

The timetabling of courses and examinations is a challenging problem faced by many institutions across the world on an ongoing basis. The difficulty arises from a combination of factors e.g. variation within institutional requirements, the range of constraints that have to be captured in the model, political considerations within the institution, software and associated support etc. Recently, the subject of an international competition (ITC2007), many aspects of the overall problem model have been reported along with the effectiveness of the application of particular search methodologies and techniques (McCollum 2008). Building on this important work, further effort is required in bridging the gap which currently exists between research and

practice in this difficult problem area (McCollum 2007a). The work reported here approaches this central theme by combining research and practice in the planned provision of an overall solution. One of the main issues relating to institutional timetabling lies in the provision of software which is able to provide both effective decision support and intelligent automation. Commercial, or in-house, software based timetabling systems often suffer from drawbacks such as inadequate optimization techniques, poor user interfaces and the inability to provide sufficient feedback to the user in helping to focus on good quality solutions. Although the use of software is only part of the required overall solution in providing effective institutional timetabling, these issues often exasperate the difficulties associated with the overall implementation process.

CELCAT® and EventMAP Limited have recently joined forces in the creation of a software aided solution. The new product will draw on the strengths of both companies. CELCAT's *Timetabler*, which will be underpinned by the Optime Scheduling Engine™, aims to provide institutions with a powerful, intuitive user friendly environment for creating and improving efficient institutional timetables. We believe that this partnership will significantly add to the user experience of utilising automation within the timetable creation and management process. In addition to the user perspective, in developing this solution, the companies will jointly address the acknowledged gap which currently exists between research and practice in timetabling research. Moreover, this partnership will allow large scale implementation details on how institutions deal with timetabling issues to be directly fed back to the research community.

Specifically the resultant solution offered by the partnership will integrate leading edge optimisation algorithms within a large management information system capable of managing and directing the user in how best to make use of resources within their institution. CELCAT® *Timetabler* has been developed over the last 20 years. Its strengths are its flexibility and easy to use graphical interface, as is indicated by its large and loyal user base. The integration of leading edge research based automation will enhance the current product offering to both existing and potential new customers. The use of the Optime Scheduling Engine™ allows the user to make both macro and micro decisions on how the academic timetable should be constructed (McCollum 2003) while making best use of their teaching space (McCollum 2007b) as well as delivering flexibility to students and staff alike. This includes feedback mechanisms in terms of (i) solution quality measurement (including the application of "what-if" scenario building), and (ii) decision support for semi-automatic use. Initially it is envisaged there will be three aspects to the integration of this component based solution.

Firstly, during an initial phase, a methodology will be developed to help understand the needs and aspirations of the institution in terms of already established and newly proposed procedures. This will establish what, and where, the data sources are, how constraints should be modeled and how they should interact, how the quality of any solution will be measured and an indication of high level heuristics which should be implemented, e.g. centralised space usage strategies. In essence, this will build the Institutional Model (McCollum 2007a) in relation to requirements and priorities. It is envisaged a generic problem model will be developed and added to as implementations proceed.

Secondly, the development of an intuitive interface between the Optime Scheduling Engine™ and CELCAT® *Timetabler* software will be developed. The aim is to ensure that data, constraints and flexibility measures are effectively represented and shared between both of the current software solutions, with the aim of producing an effective timetable solution. A number of scheduling algorithms will be made available incorporating recent leading edge research, e.g. use of Extended Great Deluge which incorporates intelligent local search heuristics, optimized to the minimum practical time to reach a solution (McMullan 2007). Reinforcement Learning (Lou 2007), Neural Network (Corr 2006) and fuzzy based construction techniques (Asmuni 2008) will be investigated. In addition, hyperheuristic based techniques (Burke 2007a) will be investigated with the aim of adaptively selecting algorithms to be used based on the problem model presented.

Thirdly, the development of an intelligent interface allowing intuitive modeling of constraints and understanding of solution quality, e.g. Fuzzy techniques (Asmuni 2007), Multi-objective techniques (Burke 2008), adaptive construction algorithms (Yellen 2007, Burke 2007b) and innovative user interface methodologies (Yellen 2008). Multi-Objective evaluation strategies (McCollum 2007) will be evaluated in relation to the most appropriate visual representation in aiding the user to choose the 'best' solution. It is envisaged this work will build on the approach introduced in (Ahmadi 2002).

At the conference, progress on the integration will be outlined within the overall aim of bridging the identified gap between leading edge research technique and practical implementations. It is expected that this relationship between academia and industry will be highly productive in setting the research and commercial agenda for the timetabling community in the future.

- Ahmadi (2002), S. Ahmadi, R. Barone, E.K. Burke, P. Cheng, P. Cowling, B. McCollum, Integrating human abilities and automated systems for timetabling: a competition using STARK and HuSSH Representations.(PATAT 2002). Proceedings of the Conference on the Practice and Theory of Automated Timetabling (PATAT 2002), Gent, Belgium, 21-23 August 2002, ISBN 90-806096-1-7, pages265-273.
- Asmuni (2008), H. Asmuni, E.K. Burke, J. Garibaldi, B. McCollum, A. Parkes, An Investigation of Fuzzy Multiple Heuristic Orderings in the Construction of University Examination Timetables, Accepted for publication to Computers and Operations Research, doi:10.1016/j.physletb.2003.10.071.
- Asmuni (2007), H. Asmuni, E.K. Burke, J. Garibaldi, B. McCollum, A Novel Fuzzy Approach to Evaluate the Quality of Examination Timetabling (2007), Practice and Theory of Automated Timetabling VI (eds. E.K.Burke and H.Rudova), Lecture Notes in Computer Science Volume 3867, Springer 2007, pp 327-346.
- Burke (2008), E.K. Burke, B. McCollum, P. McMullan, A. Parkes, Multi-Objective Aspects of the Examination Timetabling Competition Track, Accepted for presentation at the Practice and Theory of Automated Timetabling VII, 2008.
- Burke (2007a), Burke, E.K., McCollum, B., Meisels, A., Petrovic, S. and Qu, R., A Graph-Based Hyper Heuristic for Educational Timetabling Problems, European Journal of Operational Research, Volume 176, Issue 1, 1 January 2007, pages 177-192.
- Burke (2007b), E. K. Burke, G. Kendall, B. McCollum, P. McMullan, Constructive versus Improvement Heuristics: An Investigation of Examination Timetabling, 3rd Multidisciplinary International Scheduling Conference: Theory and Applications, 28-31 August 2007.
- Lou (2007), Z. Luo, D. Bell, and B. McCollum, Skill Combination in Reinforcement Learning, 8th International Conference on Intelligent Data Engineering and Automated Learning (IDEAL'07), Birmingham, UK, 2007, LNCS 4881, pp. 87–96, 2007.
- McCollum (2008), B. McCollum, A. Schaerf, B. Paechter, P. McMullan, R. Lewis, A. Parkes, L. Di Gaspero, R.Qu, E.K. Burke, Setting The Research Agenda in Automated Timetabling: The Second International Timetabling Competition, http://www.cs.qub.ac.uk/itc2007/ITC2007_Background_Techreportv1.pdf.
- McCollum (2007a), B. McCollum, A Perspective on Bridging the Gap between Theory and Practice in University Timetabling, Practice and Theory of Automated Timetabling VI, Springer LNCS Vol 3867, 2007, pp 3-23.
- McCollum (2007b), B. McCollum, T. Roche, P. McMullan, Optimising Space Through Macro and Micro Planning and Scheduling, Presentation at SCUP-42, Society of College and University Planners International Conference, July 7–11, 2007, Chicago.
- McCollum (2003), B. McCollum, P. McMullan, J. Newall, JP Lane, A workable scheduling algorithm, The 1st Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA), Nottingham, August 2003, pages 570-572.
- Qu et al (2006), R. Qu, E.K. Burke, B. McCollum, L.T.G. Merlot, and S.Y. Lee. A Survey of Search Methodologies and Automated Approaches for Examination Timetabling, Technical Report NOTTCS-TR-2006-4, School of Computer Science, University of Nottingham. Accepted for publication by the Journal of Scheduling.
- McMullan (2007), P. McMullan, An Extended Implementation of the Great Deluge Algorithm for Course Timetabling, Computational Science – ICCS 2007, Springer LNCS Vol 4487, July 2007, pp 538-545.
- Corr (2006), P. Corr, B. McCollum, M. McGreevy and P. McMullan, A New Neural Network Based Construction Heuristic for the Examination Timetabling Problem, Parallel Problem Solving from Nature - PPSN IX, Springer LNCS Vol 4193, October 2006, pp 392-401.
- Yellen (2008), E. Burke, B. McCollum, P. McMullan, J. Yellen, Heuristic Strategies to Modify Existing Timetables, Accepted for presentation at the Practice and Theory of Automated Timetabling VII, 2008.
- Yellen (2007), J.R. Carrington, N. Pham, R. Qu, J. Yellen, An Enhanced Weighted Graph Model for Examination / Course Timetabling, PlanSIG'07, Prague, Dec 2007, pp 9-16.