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Real World Optimisation through Spin Out Activity

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1 Introduction

A key research issue in Scheduling and Operational Research is the goal of closing the gap between theory and practice [1]. All too often researchers content themselves with working on abstractions of problems [2] which can make it difficult to implement actual solutions for real world problems. Within the fields of optimization and scheduling, heuristic approaches are used extensively in helping provide solutions. It is often the case that tuning of these approaches to individual problem domains, representations and indeed datasets are required in the search and provision of better solutions. Hyperheuristics [3] have recently been introduced as a concept to encompass the development of more general techniques which have applicability across different problem domains. More research initiative is required to aid the applicability of leading edge research within industrially defined real world problems. The approach taken here is to describe and discuss two cases where solutions have been provided to real world problems. EventMAP Limited and Tracsis plc are two spin out companies which provide solutions to real scheduling problems where optimization is a central issue. This paper describes the different approaches taken by the Companies, which reflect the underlying differences in the problems to be solved. The aim is to understand how the linkages between research based techniques and spin out activity can help solve other key real world industrial optimization problems [4,5]. At the conference, both approaches will be discussed highlighting experiences, similarities and differences.

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2 The EventMAP Approach

Timetabling of EventMAP Limited provides software to the university sector for the purpose of timetabling and managing resource. The Company currently has two offerings, OptimeExam and OptimeEvent, to deal with different institutional timetabling scenarios. While OptimeExam helps with the production of the examination timetabling, OptimeEvent helps timetable all aspects of an institution's curriculum.

Timetabling represents an organisational task which requires the interaction of humans and technology. To varying extents, individuals keep data issues updated and ensure individual and institutional preferences are taken care of. The software aides the process by allowing electronic representation of the timetabling issues within the institution. This is achieved by providing an intuitive interface through which timetable scenarios can be modeled. This modeling process takes place in terms of events to be placed, the availability and preferential use of time and resource and student qualitative considerations. Importantly, once a representation of the problem is achieved, the software, powered by the EventMAP Scheduling Engine, is capable of providing high quality solutions through the employment of research led search methodologies.

Solutions are produced in a two phased process [7,8]. Initially the problem is modeled as a graph coloring problem allowing events to be ordered in a predefined list before being placed in a timetable structure, i.e. times and rooms. The ordering of events is determined by an adaptive heuristic ordering. At the end of this phase the feasible solution e.g. one that satisfies all hard constraints obtained, is improved by remodeling the problem as one of search and the associated application of metaheuristic techniques e.g. extended great deluge. Other search based techniques are maintained and used as required. An overview of achievable results will be presented. Evaluation of the resultant solution is driven by flexibility for students and staff and efficiency of resources e.g. space. This is therefore a combination of qualitative and quantitative issues and must be defined for each institution. Indeed, prior modeling is often used to help establish the amount of potential flexibility available to the provision of an institution wide solution.

Powered by the EventMAP Scheduling Engine, the software is able to provide high quality solutions for students in terms of spread throughout the designated timetabling session. It is clear that issues associated with examination and centralized course timetabling must be understood and represented before optimisation techniques can produce effective solutions [2]. The provision of course timetabling solutions to large decentralised institutions requires a combination of leading edge optimization within an effective information management software product. EventMAP have teamed up with CELCAT® in the development of such a solution. Central to the collaboration is addressing the gap which currently exists between research and practice in timetabling research. Various areas have been outlined [5] and progress will be discussed.

3 The Tracsis Approach

Tracsis plc provides an automatic crew scheduling software called TrainTRACS [6] for use by planners within train operating companies. The software is also used by train franchise bid teams in major franchise tendering exercises.

Crew scheduling is mission critical in operating passenger rail services. Validity of solutions is therefore of utmost importance. Nearly right is simply not acceptable. However, the problem is made difficult by a very wide variety of complex rules, constraints, and local knowledge, which are hard to capture and model fully and accurately.

For franchise bidding, the solutions do not have to be proven to be operable at the detailed level. However, the consequences of making a wrong estimate of crewing levels required could be dire, particularly so if the bidder won the franchise but is not able to implement what has been planned and costed. It is also important for the bidders to evaluate

many alternative plans before going for the best one. However, the timescale of the bidding process is extremely tight and that calls for an automatic crew scheduling software.

The Tracsis approach works on a comprehensive model of input data and parameters such that virtually all problem scenarios from different train operating companies can be accommodated. This has been achieved incrementally over many years directly collaborating with the train companies. The Generate and Select approach [9] employed helps: hundreds of thousands of legal potential crew shifts are first generated by heuristics; then the cheapest subset, of say a few hundred shifts, is selected to form the solution schedule. Since in the Generation Phase there is no consideration of how individual potential shifts would fit in with each other, so long as they individually have satisfied all the local rules and constraints, heuristics can be added relatively easily to cater for new scheduling conditions. Powerful optimization is achieved in the Selection Phase, which essentially can be solved generically as a set covering integer linear programme.

There are only two main objectives, which are the minimization of the total number of shifts and the minimization of the total wage costs. An objective function can be formulated easily as a weighted sum of these two aspects to be minimized. With respect to the stakeholders, mainly the management and the planners, they normally would not be in conflict in terms of the crew scheduling objectives.

The capability of TrainTRACS reflects the accumulation of a tremendous amount of research over time in association with the University of Leeds. However, the research has been not just on pure theoretical grounds, but has always ensured that real life scenarios and data are used. Through the University's commercial arm in early years and through Tracsis since the spin-out was founded in 2004, vital industrial links are fostered. The collaboration with a train company usually starts in a project piloting the use of TrainTRACS. The industry has to be convinced of optimization software by solving their problems using their own real data. Often, new scheduling scenarios and conditions would arise in these pilot trials. They are good tests on the versatility of the optimization system. Most of the time, existing system features could cope even though they might have been designed for other scenarios and conditions originally. In other cases, new features could be added to the Generation Phase quite quickly as explained above. And after the pilot trials from time to time, any temporary or new fixes would be incorporated into the system model in an incremental manner. As train companies have become established users of TrainTRACS, new problem scenarios and scheduling conditions would be fed back as support requests to Tracsis which informs further research.

4 Conclusion

This work is motivated by the need to close the gap between research and practice which currently exists in many areas within the areas of optimization and planning. The transfer of the achievements and skill developed within research to industrial real world problems is a central knowledge transfer issue. The situation is complicated by two major issues i.e. over simplification of problem representation and the fragility of the search techniques used. Heuristic based techniques, although providing good results in many cases, are fragile in the sense that their setup is often over dependent on the problem domain, representation and dataset investigated.

Both EventMAP and Tracsis represent companies which are linking research and practice within the area of optimization and scheduling. It is proposed through analyzing and understanding differences between the associated approaches, much light will be shed on the requirements of techniques to help with real world scenarios. While EventMAP deal with many stakeholders with many, often conflicting, objectives, the nature of the problem faced by Tracsis is closer to a hardcore combinatorial optimization problem where near absolute precision in modeling is required. In general stakeholders are in unison in their objectives. Another major difference is the style of implementation of the associated approaches. While the EventMAP approach often requires a high degree of customization, particularly for large institutions, Tracsis implementations are largely generic. The techniques,

similarities and differences will be discussed in helping to understand the nature between research and practice.

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