M-Sched: A University Course Timetabler

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Abstract We consider the problem of scheduling instructors and courses in a typical academic department at a post-secondary institution. The software implementation *M-Sched* that we present in this note emphasizes the interaction with the "human expert" to produce qualitatively superior schedules. The methodology reflects the complex nature of the scheduling problem where important constraints of qualitative nature cannot be accurately incorporated in the model and consequently, a fully automated solution is not feasible.

Keywords Multiphase Approach · Integer Programming · User Interface

Mathematics Subject Classification (2000) 65K05 · 90C11 · 90B35 · 68N01

1 Introduction

In this paper we present a software implementation for solving the university course timetabling problem. Our timetabling implementation schedules instructors and courses taking into account the instructors' preferences on courses, days, and times. Typically, instructors have different levels of expertise in different areas. Furthermore, the instructors might have personal preferences on courses, and the times of days the

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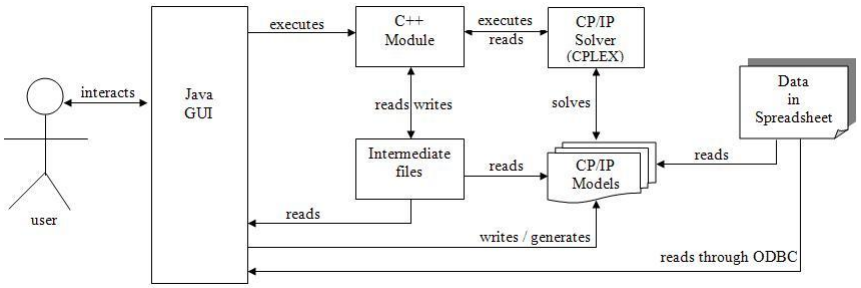

Fig. 1 Software architecture of M-Sched.

courses are offered. On the other hand, for various reasons the administration may have timetabling goals conflicting with those preferences. Therefore, the "instructor-course assignment" is an important subproblem in any course timetabling exercise. Fully automated timetablers are often not useful when a subset of constraints make the problem infeasible [8]. Hence, a high level of flexibility and user involvement is necessary to resolve such constraints during the timetabling process. Courses offered by different academic departments often have interdependencies. So, flexibility to examine subdivision of events is also important [5]. As timetabling requirements widely vary among academic institutions it is extremely hard, if not impossible, to develop a general purpose black-box timetabler [5,6]. Therefore, having the flexibility of dynamic customization of timetabling constraints is useful.

Our timetabling implementation focuses on course timetabling in academic departments at the University of Lethbridge (UofL). The instructors indicate which courses they would like to teach, as well as the day and the time of day (morning or afternoon) they prefer to teach. At UofL the professors teach only lectures, the academic assistants (lab instructors) conduct labs and tutorials, and the teaching assistants (graduate students) conduct only labs. We decompose the entire problem into several smaller subproblems and solve them separately in a sequence of phases. In phase-1a, we assign the lectures to the professors. Phase-1b assigns the labs and tutorials to the academic assistants and the teaching assistants. In phase-2, the lectures are allotted to the days. Then we allocate the time-slots to the lectures in phase-3. Finally, phase-4 assigns the labs and tutorials to the week-days and available time-slots. At each phase, the objective is to maximize a set of preferences subject to the given constraints. All software architectural complexities are hidden behind a carefully designed graphical user interface. Our implementation allows the user to customize constraints as well as to generate new solutions extending the partial solutions from perviously generated timetables.

2 Software Architecture

M-Sched has a modular architecture as shown in Figure 1. Necessary input data are provided via MS Excel spreadsheets. For each of the subproblems we have separate

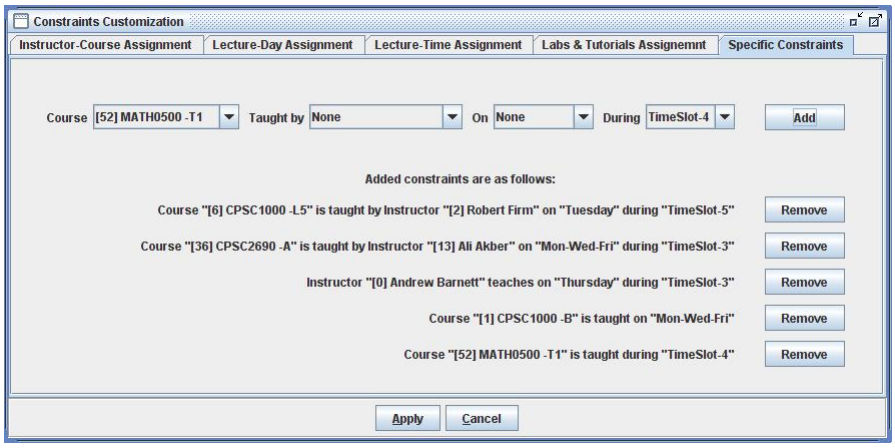

Fig. 2 GUI for constraint customization.

constraint programming (CP) or integer programming (IP) models written in OPL [2]. The CPLEX solver is used to solve these CP/IP models. The C++ module invokes the solver on the appropriate CP/IP model in response to the user input in the graphical user interface (GUI). The GUI is implemented using Java following the ergonomics and usability guidelines of Human Computer Interaction (HCI) [7]. This makes the GUI user-friendly for the purpose of constraint customization (see Figure 2), as well as for generation and modification of schedules.

The modular implementation using object-oriented techniques makes our timetabling tool scalable and easily modifiable. For example, the CPLEX solver may be replaced by a different solver without much affecting the other modules. Moreover, the software architecture conforms the MVC (model-view-controller) pattern [1] of software engineering paradigm. The GUI constitute the 'view', the C++ module along with the solver works as the 'controller', whereas the 'model' portion includes the spreadsheets and CP/IP models.

3 Conclusion

The multi-phase approach [3,9] allows us to work on a smaller problem at a time. Besides, it enables us to exploit the problem structure of each phase and apply different solution strategies (CP or ILP) as appropriate. One of the objectives of this work is to provide the user enough flexibility so that customized schedules can be produced in a user-friendly way. In the current implementation the software permits the inclusion or removal of constraints on the fly, loading and modifying a previously saved solution, and computing a new solution from a partial solution. In such cases, the new solution is attained quickly as it is not necessary to solve the problem from scratch [4]. Since the phases are solved separately, partial solutions may be generated, examined and amended. Furthermore, the graphical user interface on top of the

actual computational modules makes our timetable implementation flexible and easy to use.

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