Student Scheduling for Bachelor State Examinations

Beáta Kochaniková · Hana Rudová

1 Introduction

Bachelor state examinations take place at the Faculty of Informatics two times a year at the end of each semester. Each Bachelor student who wants to complete his/her Bachelor study must successfully complete the Bachelor state examinations. Since it necessitates the presence of many people at various times, timetabling must be accomplished. In the timetable, each student is assigned to a commission which typically consists of three people, the chair and two other examiners. Timetabling problem to be solved consists of two parts. First, commissions must be created and assigned to particular days of the examination week. Each commission is timetabled to one day and one room. There are four or five examination days and it is typically necessary to timetable from two to five commissions a day. The second part of the problem involves a specific student scheduling: assignment of students to committees in time such that it is acceptable for all involved teachers (examiners, supervisors and referees). Mostly, the exam of one student takes half an hour and contains two parts, thesis defense and exam based on the written preparation. Each student has its own thesis supervisor and referee of the thesis. Both these people must be able to attend the state exam of the student. An example of the timetable for one commission is demonstrated in Table 1. The timetable of each commission is given by a sequence of students split by a lunch break.

This problem was up to now solved manually with the help of the supportive graphical user interface [3]. One of the authors, Hana Rudová is responsible for state examination timetabling as a vice dean for Bachelor and Master studies. She has an experience with a manual construction of timetables for four semesters. In this paper we will describe results of the Bachelor thesis [2], which concentrates on the student scheduling part of the problem. The work describes main characteristics of the problem and discusses implementation of a new local search solver which has been applied

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Table 1 Example of the timetable for one commission.

Commission: doc. RNDr. Petr Hliněný, Ph.D. (chair)
Mgr. Aleš Křenek, Ph.D.
RNDr. Jaroslav Pelikán, Ph.D.
Thursday 21. 6. 2012, room B411

	Student	Supervisor	Referee
8:30 – 9:00	Rentka Michal	Škrabálek	Pavlovič
9:00 – 9:30	Štěrba Jakub	Osovský	Pavlovič
9:30 – 10:00	Kuročenko Andrej	Pavlovič	Kolář
10:00 – 10:30	Forman Jiří	Ráček	Kolář
10:30 – 11:00	Kolář Milan	Ludík	Ráček
11:00 – 11:30	Svitková Monika	Ráček	Ludík
11:30 – 12:00	Janošek Václav	Ludík	Ráček
12:00 – 13:00			
12:00 – 13:30	Laštůvka Zdeněk	Ludík	Ráček
13:30 – 14:00	Šimanský Dávid	Ráček	Toth
14:00 – 14:30	Jurč Michal	Ráček	Toth
14:30 – 15:00	Škrabal Jan	Pelikán	Dohnal
15:00 – 15:30	Coufal Jakub	Pelikán	Dohnal
15:30 – 16:00	Lenčo Milan	Křenek	Kulhánek

on two real-life data instances. Timetables generated by this prototype solution have been compared with manually created timetables and they have been shown to be comparable with them.

2 Characteristics of the Problem

We will describe the main constraints which are important for our problem. The base hard constraints are related with the structure of the schedules.

(C1) There is one commission in each room each day.
(C2) There is one student scheduled in each commission in one time period (with exception of two lunch break periods which are free).

The problem consists of hard constraints requesting the presence of each *teacher* (examiner, supervisor or referee) in one place only and the presence of each supervisor and referee in the exam of their students. Also it is not possible to schedule same teachers in the consequent time periods in different rooms since even a small latency would cause a teacher absence.

(C4) The supervisor and the referee of the thesis must be able to attend the corresponding exam.
(C5) The same teacher cannot be at the same time in more than one room.
(C6) The same teacher cannot be scheduled in different rooms subsequently.

Other important hard constraints are related with the availability of particular teachers since they may not be available all days or in some time periods only.

(C7) The teacher cannot be scheduled during time periods of his/her unavailability.

It is important to realize that the same teacher may be present in the examiner, supervisor or referee role. Actually it is a good idea to timetable students of examiners in their commissions.

(O1) Minimize the number of students which are not assigned to commissions where their supervisor or referee is the examiner.

Other good recommendation is timetabling of teachers consequently such that they do not need to come to the state examinations many times. These considerations led to the definition of two optimization criteria O2 and O3. First the number of blocks for each teacher is minimized. We consider the *block* for each teacher as the longest continuous sequence of exams where this teacher is present, i.e., no breaks are allowed in this sequence (see Table 1 where Dohnal has one block and Ráček has two blocks).

(O2) Minimize the sum of the blocks for all teachers.

This criterion would be a bit tricky for examiners since it is not necessary to group their students together. As a consequence the number of blocks always equals to one for each examiner (in his/her commission). This approach also allows an easy integration of the criterion O1 since any placement of the examiner's student to a different commission increases the number of blocks for the teacher. To conclude that, the criterion O1 is considered as a part of the criterion O2 only.

Next the number of commissions for each teacher where this teacher must be present, is minimized. These commissions of each teacher are called *assigned commissions*.

(O3) Minimize the sum of the assigned commissions for all teachers.

This criterion is somewhat involved in the primary criterion O2 but it is reasonable to consider it in different parts of the solution process. The criterion O3 can be minimized first. The goal is to place students with the same teachers to the same commission. Consequently the criterion O2 can be applied to group examinations of one teacher in one commission together.

Finally the length of examinations should be fair for all commissions.

(O4) The lengths of examinations for all commissions must be fair.

Having the same length of time periods for all exams, the fair timetable has the number of students same for all commissions or it may differ by one student at most. In manually created timetables, this criterion is often not optimally satisfied since a small unfairness is often sacrificed by a smaller number of blocks for the teachers.

3 Components of the Solver

The overall timetabling process consists of three parts implemented by three components. Initially the timetable is constructed such that all hard constraints C1-C7 are satisfied. It is not a hard problem, it is basically sufficient to add students one by one to commissions starting with assignments of students with their supervisor or referee in a commission. To avoid a high number of students of one teacher in different commissions, students are primarily assigned to commissions where students of this teacher are. If it is not possible to assign a student to the processed time period and commission due to some conflict in hard constraints, this student is assigned later. Construction of the student schedules in this stage allows an easy integration of the criterion O4 concentrated on fair lengths of timetables for all commissions. Students are just assigned to commissions to keep the same number of students at each commission or to have it different by one student only. Even more importantly this property is kept during overall timetabling process since there are only swaps of students between two commissions or changes in the order of students in one commission.

The second component of the solver is aimed to reduce the number of assigned commissions for each teacher (the criterion O3) by the local search. The evaluation of the timetable corresponds to the sum of assigned commissions for all teachers. To evaluate student suitable for some local change, we basically take into account the sum of assigned commissions divided by the number of students for his/her supervisor and referee, i.e.,

$$\frac{\text{assigned commissions}_{\text{supervisor}}}{\text{number of students}_{\text{supervisor}}} + \frac{\text{assigned commissions}_{\text{referee}}}{\text{number of students}_{\text{referee}}} \; .$$

This is important to have a better balance among teachers — teachers with more students certainly may be assigned in more commissions. In the procedure, we subsequently take teachers one by one sorted by the number of their students decreasingly. Their worst evaluated students are subsequently chosen for the swap with other students. Simulated annealing [1] is applied to swap each chosen student with other students in committees where his/her teacher has a student. Such move is considered since it may possibly improve evaluation (the number of assigned commission) of this teacher — we basically try to group his/her students to the same commission(s), improve his/her evaluation and improve the overall evaluation of the timetable by means of the criterion O3. This procedure is repeated several times to go through each teacher repeatedly and to get improvements for him/her.

The second component aims to reduce the number of assigned committees for all teachers. However, it often happens that the main criterion O2 is worsen. Optimization of this criterion is completed by the third component of the solver. It takes the timetable of each commission one by one and optimizes number of blocks for its teachers. Students of each commission are split into several disjoint sets such that students in different sets do not share any teacher (see Table 1 where are three disjoint sets, the first one involves Lenčo Milan, the second one equals to {Škrabal Jan, Coufal Jakub} and the last one includes all other students). Within these disjoint sets containing a small number of students only, the number of blocks is improved by a tabu search [1] swapping and inserting students to different time periods. The best fit of disjoint sets to time periods is also processed to take into account block increases due to lunch break. The third component is again run repeatedly to improve the timetable iteratively.

4 Experimental Evaluation

The solver has been applied to solve two real-life data instances. The problem for Spring 2012 (Autum 2012) has 19 (11) commissions, 246 (97) students, and 195 (116) teachers. In Table 2 we compare the best timetables generated by the solver and the manually created timetables which were used during state examinations for particular semesters. We can see that the automated timetables are comparable with the timetables created manually. There is still some room for improvement since the number of blocks is still a bit better in the manual solution for the Spring 2012. On the other hand, the automated timetables are fair with respect to the length of the examination for particular commissions (the criterion O4). This is different for the manual timetables since they sometimes differ by two exams or even more. Both automated and generated timetables are available at `http://www.fi.muni.cz/~hanka/bc_state_exams`.

Table 2 Comparison of manual and automated solutions.

	Autumn 2011		Spring 2012	
	automated	manual	automated	manual
Commissions	128	121	258	259
Blocks	132	130	280	264

5 Conclusion

We have described and defined an examination timetabling problem which belongs to the class of assignment problems. This problem has been solved manually each semester and the ultimate goal of this work is the application of the automated process in practice. Future work consists in completion of the solver to handle specific exceptions and make it applicable in real life. Also it is related with the automated generation of commissions which introduces another interesting timetabling problem.

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