A Case Study of Practical Course Timetabling Problems

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Abstract
This paper deals with the Course Timetabling Problem at MARA Professional College Beranang (MPCB), Selangor, Malaysia. In this paper we gather views from the leader and members of Timetabling Unit at MPCB on their current course timetable problems and what they hope will be taken into account in the next generation of course timetabling software. We also modeled the MPCB hard and soft constraints using mathematical representation and addressed the limitation in the standard benchmark datasets.

Keywords
Course timetabling problem, hard constraints, soft constraints, MARA Professional College Beranang

1. INTRODUCTION

The course timetabling problem are difficult tasks faced by educational institutions [1]. Usually, many institutions only modify the previous year's timetable to be used for the next year. However, they still have problem when the course combination taken by the students are totally different from the previous year. This happens when some students repeating certain courses and have to take those courses together with the current courses offered to their batch. Moreover, changes to the courses teach by the lecturers causes more changes to the previous year's timetable. Therefore, having a good automated timetabling system which can solve all the problems is really needs.

Educational timetabling problems are usually classified into two categories which are exam timetabling and course timetabling. Course timetabling can be divided into two sub-categories which are post enrollment-based and curriculum-based. The main difference is that in the post enrollment-based, the conflicts between courses are set according to the student's enrollment data, whereas the curriculum-based is scheduled on the basis of the curricula published by the institutions [2].

Nowadays, many advances have been made with respect to the development of search techniques. However, most of the researchers only used the standard benchmark datasets to test their algorithms. [3] comment that somewhat surprised to discover that there are very few course timetabling papers that actually report that the (research) methods have been implemented and used in an institution. Moreover, [4] stressed that the contribution of timetabling research must address more wide-ranging issues than the tuning of algorithms to work well on particular datasets.

[3] defined the course timetabling problem as a multi-dimensional assignment problem in which students, teachers (or faculty members) are assigned to courses, course sections or classes; events (individual meetings between students and teachers) are assigned to classrooms and times.

By the definition, we identified that there are 5 elements which we should consider in order to solve the course timetabling problem. The 5 elements are:

1. Student
2. Lecturers / teachers
3. Events
4. Classrooms (rooms)
5. Times (timeslots)

Unfortunately, standard benchmark datasets for Post Enrolment-based Course Timetabling Problem only consists of the following information:

1. Students
2. Events
3. Rooms and room-features
4. Timeslots

The standard benchmark datasets for post enrollment-based did not provide the information about lecturers and courses teach by them. Refer [5] for details information about the standard benchmark datasets. In our views, this datasets assume that one lecturer taught only one course. Therefore, they are not considered to the lecturer's information and preferences.

Whereas, the standard benchmark datasets for curriculum-based did not provide the information about students and courses took by them. Therefore, the datasets not consider the repeaters. Because of that, some students especially the repeaters have to drop their course due to the clashing problem occurred in their course timetable. Refer [6] for details information about the standard benchmark datasets for curriculum-based.

In the real world problem, we have to consider all the 5 elements. The information about lecturer and student should be considered together because it will affect the quality of the course timetable. For example, if we want to

Manuscript received October 5, 2011
Manuscript revised October 20, 2011

slot the event X in the timeslot Y, we have to check the student availability, lecturer availability, room availability, timeslot availability and the conflict between events. We only can slot it when all the availabilities are checked with no clash and no conflict. Therefore, all the 5 elements are very important and have to be considered in solving the course timetabling problem. Because of that, we noticed that there are limitations in the standard benchmark datasets.

Due to those limitations, in this paper we introduce a new course timetabling dataset from the course timetabling problems at Mara Professional College Beranang (MPCB), Selangor, Malaysia. These problems have a different structure from the existing benchmark datasets. We have studied the problem extensively and model its hard and soft constraints (which are not same to the existing standard datasets) using mathematical representation.

This paper is organized as follows: the next section defines the course timetable problem generally. Section III introduces the MPCB problem description with their parameter values. In section IV, we discuss about course timetabling problems at MPCB and listed all their hard and soft constraints. Whilst section V, model the constraints using mathematical representation. Finally, conclusion and future work are presented in section VI.

2. COURSE TIMETABLING PROBLEM

The problem involves assigning student activities to timeslot in the room subject to laborious hard and soft constraints. The objective function of this problem is to minimize the soft constraints violations while maintaining the feasible timetable (which satisfy all the hard constraints). The quality of the timetable is calculated based on the violation of the soft constraints. The total penalty is calculated based on the sum of penalty for all students and lecturers. A good quality timetable should have a small total penalty value.

3. PROBLEM DESCRIPTION

MARA Professional College Beranang (MPCB) situated at Selangor, Malaysia. The college offers 4 programs which are Diploma in Accountancy, Diploma in Business Studies, Diploma in Agro Business and Higher National Diploma (in Computing). Now, MPCB have 1131 students, 86 lecturers and 232 courses to be scheduled into 36 timeslots in any 37 rooms. Table 1 specifies the 36 timeslots in a week and Table 2 present the parameter values of MPCB data.

Table 1: 36 timeslot of teaching in the MPCB

	8:00-9:00	**9:00-10:00**	**10:00-11:00**	**11:00-12:00**	**12:00-13:00**	**13:00-14:00**	**14:00-15:00**	**15:00-16:00**	**16:00-17:00**
Mon (D1)	T1	T2	T3	T4	T5	T6	T7	T8	T9
Tues (D2)	T 10	T 11	T 12	T 13	T 14	T 15	T 16	T 17	T 18
Wed (D3)	T 19	T 20	T 21	T 22	T 23	T 24	T 25	T 26	T 27
Thu (D4)	T 28	T29	T 30	T 31	T 32				
Fri (D5)	T 33	T 34	T 35	T 36					

Table 2: Parameter Values of MPCB data

Parameters	Values
Number of students	**1131**
Number of courses	**232**
Number of lecturers	**86**
Number of rooms	**37**
Number of features	**4**
Number of timeslots	**36**

4. COURSE TIMETABLING PROBLEM AT MPCB

Currently, the course timetable at MPCB is generated manually by the members in the Timetabling Unit. The process starts after the Examination Unit gives all the students' results to the Timetabling Unit. In order to avoid clashing in their course timetable, the Timetabling Unit should identify the repeaters (students who fail any subject in previous semester) and their failed courses. Then, they determine all the courses that the repeaters should take in the current semester. When finish, they start to generate

the course timetable by generating the course timetable for the repeaters first. By this current process, they have to spend about 4 weeks to finish.

However, with this current process, some students have to drop their course due to the clashing problem. It occurred when the Timetabling Unit member fail to find any suitable timeslot for the repeaters. In some cases, students have to attend three (or more) events in successive timeslots occurring in the same day. Furthermore, there are some cases where students should have to attend three (or more) events in successive timeslots occurring in the same day and there are some students required to attend only one event in a particular day. Besides, with this current process, the afternoon session is not free for students and lecturers.

Therefore, the Timetabling Unit members strongly hope for the new automated system which can generate the course timetable in a short time and solve all their problems.

A. The MPCB hard constraints

H1: All courses registered by the students must be scheduled;
H2: No student can be assigned to more than one lecture at the same timeslot;
H3: Only one event is put into each room in any timeslot;
H4: In any case the room should be big enough for all the attending students and should satisfy all of the features required by the event;
H5: No lecturer can be assigned to more than one lecture at the same timeslot;
H6: Lecturers should only be assigned to timeslot that are pre-defined as "available" for those lecturers.

B. The MPCB soft constraints

S1: Students should not be scheduled to attend an event in the last timeslot of a day;
S2: Students should not have to attend three (or more) events in successive timeslots occurring in the same day;
S3: Students should not be required to attend only one event in a particular day;
S4: Free periods on Monday, Tuesday and Wednesday should come in the afternoon session (13:00 pm to 14:00 pm).

5. MATHEMATICAL MODELING OF THE CONSTRAINTS

In this section we model the MPCB hard and soft constraints stated in Section IV using mathematical representation. However, some of the MPCB hard and soft constraints are same with the standard benchmark datasets from ITC 2007. Therefore, in this section we only model the hard and soft constraints which are not exist in the standard benchmark datasets. Table 3 shows the MPCB hard constraints compared to the ITC 2007 : Track 2 while Table 4 shows the MPCB soft constraints compared to the ITC 2007 : Track 2.

Table 3: Hard Constraints Comparison

NO	MPCB	ITC 2007 : Track 2 - (POST ENROLMENT-BASED)
1.	All courses registered by the students must be scheduled;	Same;
2.	No student can be assigned to more than one lecture at the same timeslot;	Same;
3.	Only one event is put into each room in any timeslot;	Same;
4.	In any case the room should be big enough for all the attending students and should satisfy all of the features required by the event;	Same;
5.	No lecturer can be assigned to more than one lecture at the same timeslot;	Not exist;
6.	Lecturers should only be assigned to timeslot that are pre-defined as "available" for those lecturers;	Not exist;

Table 4: Soft Constraints Comparison

NO.	MPCB	ITC 2007 : Track 2 - (POST ENROLMENT-BASED)
1.	Students should not be scheduled to attend an event in the last timeslot of a day;	Same;
2.	Students should not have to attend three (or more) events in successive timeslots	Same;

	occurring in the same day;	
3.	Students should not be required to attend only one event in a particular day;	Same;
4.	Free periods on Monday, Tuesday and Wednesday should come in the afternoon session (13:00 pm to 14:00 pm).	Not exist.

Enumerated types of parameters used in this course timetabling are:

- Students : S[1:1131]
- Courses : C[1:232]
- Timeslots :T[1:36]
- Lecturers : L[1:86]
- Rooms : R[1:37]

Predicates used to represent the components of course timetabling are listed as follows:

- Student Timetable : Student[S][C][T]
- Lecturer Timetable : Lecturer[L][C][T]
- Room Timetable : Room[R][C][T]

Hard Constraints:

H5: No lecturer can be assigned to more than one lecture at the same timeslot;

$\forall l \in L , \exists t \in T , \exists c1, \exists c2 \in C$

If Lecturer[l][t] = Course[c1][t] then

Lecturer[l][t] $\neq$ Course[c2][t]

H6: Lecturers should only be assigned to timeslot that are pre-defined as "available" for those lecturers;

$\forall l \in L , \exists t \in T , \exists c \in C$

If Lecturer[l][t] = 1 then

Lecturer[l][t][c] = 1

Soft Constraints:

S4: Free periods on Monday, Tuesday and Wednesday should come in the afternoon session (13:00 pm to 14:00 pm).

$\forall r \in R , \exists c \in C , t \in \{6, 15, 24\}$

Room[r][c][t] $\approx \Phi$

5. CONCLUSION AND FUTURE WORK

We have introduced the new course timetabling dataset from the MPCB course timetabling problems and modeled the hard and soft constraints using mathematical representation. We also addressed the limitation in the Standard Benchmark Datasets.

The ongoing research is to solve the MPCB course timetabling problems using constructive heuristic.

ACKNOWLEDGEMENT

This work was supported by The University Kebangsaan Malaysia (research grant : UKM-PTS-0011-2009). We wish to thank Pn. Intan Idris, Pn. Siti Azeyrah Ramli and Pn. Noorfazliani Shamsudin from MARA Profesional College Beranang (MPCB), for fruitful meeting and contribution of MPCB dataset.

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