An Investigation of Timetable Satisfaction Factors For A Practical University Course Timetabling Problem [1]

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Abstract - **University Course Timetabling Problem (UCTP) is an educational timetabling problem that deals with the task of assigning educational events (lectures, tutorials, and laboratories) and lecturers to timeslots and classrooms or lab; to generate a weekly schedule. The UCTP has gathered great research interests for decades. Many solution approaches and models have been published in the literature. However, different institutions may have different requirement, which results in a gap between benchmark UCTP and practical problems. Therefore, in this work, we have conducted a survey to investigate the satisfaction factors of a course timetable for a Practical University Course Timetabling Problem at Fakulti Teknologi dan Sains Maklumat, Universiti Kebangsaan Malaysia.**

Keywords - scheduling; practical university course timetabling; penalty and reward.

I. INTRODUCTION

The University Couse Timetabling problem (UCTP) is a difficult process faced by universities every semester. The aim is to generate a weekly timetable of registered courses for the semester. The UCTP is defined as a problem to assign teachers and classrooms to each lecture in the given timeslots [1]. To solve the UCTP problem, two types of constraints need to be concerned, which are the hard and soft constraints. The hard constraints are to ensure the feasibility of the generated schedule, therefore, no violation is allowed. Whilst, the soft constraints is acceptable to be violated, but should be minimized. Each violation of the soft constraints will result in reducing the general satisfaction of the generated schedule.

As a non-deterministic polynomial-time hard problem, which is difficult to solve for optimality, the UCTP has gathered many researchers' interests since the 1980s [2]. In the early days, researchers usually publish their models and results for a single institution [3]. The first UCTP benchmark dataset was published in 2001 for the First International Timetabling Competition (ITC-2002) [4], which is a reduction of a typical university course timetabling problem. A detailed description of this problem can be found in [5]. To the current point of view, this first benchmark dataset is greatly simplified compared to other practical course timetabling problems. To bridge the gap between research and practice, another two benchmark UCTP was proposed for the Second International Timetabling Competition (ITC-2007), which are post enrollment-based CTP (ITC-2007-track 2) [6] and curriculum-based CTP (ITC-2007-track 3) [7]. The major difference between these two problems is: for post enrollment-based problem, the conflictions between courses are defined based on students' enrollment data, whilst for the curriculum-based problem, the confliction between courses is defined based on the curriculum provided by the institution [8]. These new benchmark UCTP have introduced a significant degree of complexity to the course timetabling problem and make the problems closer to real-world situations[9].

However, the constraints between institutions differ from each other[10]. Therefore, effectively modeling of a practical problem closed to the real-world situation is important [11]. Interested users can read these works for further information about this issue [12], [13], [8] and [14].

In this work, we are concentrating on the UCTP at Fakulti Teknologi dan Sains Maklumat (FTSM), Universiti Kebangsaan Malaysia. The faculty has three types of courses every semester, which are: (1) undergraduate courses for undergraduate programs, (2) Post Graduate Courses for Post Graduate program and (3) CITRA courses for non-FTSM students. A brief description of the problem will be discussed in Section 2.

The purpose of this work is to identify what are the factors that affect the timetable satisfaction level for a practical university course timetabling problem, i.e. FTSM Course Timetabling Problem (FTSM-UCTP). These factors are the schedule patterns which may appear in a generated time table. In this work, we mainly concentrate on the undergraduate course timetabling problem of FTSM. To accomplish this task, we conducted a survey and developed two questionnaires for lecturers and undergraduate students.

This paper is organized as follows. Section 2 briefly describes the FTSM-UCTP. Section 3 presents the questionnaires for both lecturers and students, and the result we obtained from this survey. In Section 4, we discuss the result we gathered from the questionnaires. Finally,

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Conclusion and future works will be presented in Section 5.

II. DESCRIPTION OF FTSM-COURSE TIMETABLING PROBLEM

In FTSM-UCTP, each course requires a certain number of events weekly. The duration of event of different type of courses is different. For undergraduate and CITRA courses' events, the duration is two hours. Whilst for the event of post-graduate courses, the durations are three hours.

There are three types of events for the courses in FTSM-UCTP, which are: classes, tutorials, and labs. Each course may require any number of events of these three types. For the classes-type event, all students taking this course should attend the event. Whilst for labs and tutorials, each student must attend only one slot for each type. For the groups of elective courses, students are only allowed to select one from each elective group. All the class-typed events for each course in the same group of elective courses should share same timeslots such that, only one course from each group of elective courses can be selected by a student.

All the events need to be scheduled in 5 days. Due to the Friday praying activity in every Friday, timeslots from Monday to Thursday is different with Friday. From Monday to Thursday, all the undergraduate events should be scheduled into 3 timeslots: 08:00- 10:00, 10:00 - 12:00, and 12:00 – 14:00. For postgraduate courses, their events should be scheduled into 3 timeslots: 09:00 to 12:00, 14:00-17:00 and 18:30 - 21:30. The CITRA courses' events should be scheduled in 16:00-18:00 every day. Whilst for Friday, there are only two timeslots available for undergraduate courses' events which are: 08:00- 10:00 and 10:00 - 12:00. It should be noticed that if an undergraduate event is failed to find a feasible arrangement in the three timeslots, it is acceptable to be scheduled in the timeslot reserved for CITRA courses (16:00-18:00). Whilst in this case, a penalty should be given to indicate a quality decrease of the timetable.

There are two types of instructors in FTSM-UCTP: lecturers, and teachers. Each course is delivered by at least one lecturer. When scheduling classes, the lecturer(s) should be occupied when the class is held. Whilst the teachers are to assists the lecturers deliver labs and tutorials, but not the classes. The labs or tutorials require occupying only one instructor (either lecturer or teacher).

Twelve classrooms are provided to locate the events of all courses. The rooms are with different facilities and capacities. The number of students attending an event should not exceed the capacity of the room holding it. Another issue needs to be considered is, each event may require different facilities. Therefore, the events should only be held in one of the classrooms fulfill the facility requirements.

III. QUESTIONNAIRE DESIGN AND THE RESULTS

This section describes the investigation of what factors may affect the users' satisfaction when scheduling undergraduate courses at FTSM. The factor represents a schedule patterns which may appear in the timetable. To identify these factors, we developed two questionnaires to gather users' feeling on each schedule patterns. Each questionnaire contains four sections. The first section is to describe the problem model. The second and third sections, list all the possible schedule patterns in a day (3 timeslots). The patterns that we listed in the questionnaire contain the schedule patterns user may prefer, dislike or not-care. Therefore, we require the responder to rate their feeling of each pattern from -5 (Mostly Preferred) to +5 (Most Dislike). Therefore, we are able to collect for each type of arrangement, how is the responders' feeling, and how strong their feeling is? Furthermore, for the lecturer's questionnaire, as the total workload of a lecturer is also based on the postgraduate and CITRA events they should conduct, questions about maximum working hours preference is also asked. The questionnaires for both students and lecturers is showed in TABLE I and TABLE II.

TABLE I QUESTIONNAIRE FOR STUDENTS

Section 1		
1	Basic Information: For undergraduate courses, each course may have 3 types of events to be scheduled: (1) class-type event, (2) tutorial-type event, and/or (3) lab-type event. Each event (for the undergraduate course) has 2 hours duration. If possible, these events are required to be scheduled into three available time-slots every working day: 8:00-10:00, 10:00-12:00 and 12:00-14:00. Otherwise, the event will be scheduled to the time-slot reserved for CITRA time only in the afternoon which is 16:00-18:00.	
Section 2 *Please mark the satisfaction of the following schedule patterns from -5(most preferred) to 5(most dislike)*		
	Schedule Pattern	Mark
2	A Class-type activity scheduled in the early morning (8:00-10:00)	
3	Lab/Tutorial-type event scheduled in the early morning(8:00-10:00)	
Section 3 *Please mark the satisfaction of the following schedule patterns from -5(most preferred) to 5(most dislike)*		
	Schedule Pattern	Mark
4	Having 3 consecutive Class-type activities in a day	
5	Having 3 consecutive Lab/Tutorial-type activities in a day	
6	Having 2 classes and 1 Lab/Tutorial in a day	
7	Having 2 Labs/Tutorials and 1 class in a day	
8	Attending only one class-type event (not tutorial or lab) in a day (no other activities scheduled in this day)	
9	Attending only one Tutorial/Lab - type event in a day (no other events scheduled in this day)	
10	Attending two consecutive classes only (not lab/tutorial) in a day	
11	Having a two-hour free-time between a class-type event and a lab/tutorial	
12	Having a two-hour free time between two class-type events in a day	
13	Having a two-hour free time between two Lab/Tutorial-type events in a day	
14	Attending a class-type event on afternoon session (16:00-18:00)	
15	Schedule a lab/tutorial type event on afternoon session (16:00-18:00)	
Section 4 Please mark the confidence of your answer for 0 (no confidence) to 10 (highest confidence)		

16	Confidence of your answer	

Section 3 in the questionnaire contains only one question about the responders' confidence level in their answers. The purpose of this is to reduce the error occurred when responder may not fully understand the patterns we listed in the questionnaire. In order to get the overall feeling about a schedule pattern, the result should be the weighted average mark of all result we gathered weighted by the confidence level about their answer. The responder should enter their confidence level from 0 (none) to 5 (fully confident). In Section 4, the questionnaire is ended with an open question about their comment or suggestion. The questionnaires have been published on Google Forms platform and we invite all the related students and lecturers to answer the question. Finally, we got the total of 107 respondents from students and 19 respondents from lecturers.

TABLE II QUESTIONNAIRE FOR LECTURERS

Section 1		
1	Basic Information: For undergraduate courses, each course may have 3 types of events to be scheduled: (1) class-type event, (2) tutorial-type event, and/or (3) lab-type event. Each event (for the undergraduate course) has 2 hours duration. If possible, these events are required to be scheduled into three available time-slots every working day: 8:00-10:00, 10:00-12:00 and 12:00-14:00. Otherwise, the event will be scheduled to the time-slot reserved for CITRA time only in the afternoon which is 16:00-18:00. And for post-graduate courses, each course have only one class-type event to be scheduled, with 3 hours duration and can be scheduled in 3 slots: 09:00-12:00, 14:00-1700 and 18:30-21:30.	
Section 2 *Please mark the satisfaction of the following schedule patterns from -5(most preferred) to 5(most dislike)*		
	Schedule Pattern	Mark
2	Teaching two class-type events in a day	
3	Teaching one class-type event and one tutorial/lab event in a day	
Section 3 *Please mark the satisfaction of the following schedule patterns from -5(most preferred) to 5(most dislike)*		
	Schedule Pattern	Mark
4	Teaching two tutorial/lab-events in a day	
5	Teaching three or more events (including Class, Tutorial or Lab) in a day	
6	Teaching faculty-level class-type events on Monday	
7	Undergraduate (Not CITRA Course) Class-type event is scheduled on 16:00 to 18:00 (CITRA Time)	
8	Undergraduate (Not CITRA Course) Lab/Tutorial-type event is scheduled on 16:00 to 18:00 (CITRA Time)	
9	Class-type events are scheduled on early morning (08:00 - 10:00)	
10	Lab/Tutorial-type events are scheduled on early morning (08:00 - 10:00)	
Section 4 Please mark the confidence of your answer for 0 (no confidence) to 10 (highest confidence)		
11	Confidence of your answer	

TABLE III and TABLE IV lists all the possible patterns in the questionnaires and the weighted average mark collected from lecturers and students. Please be informed, -5 represents for most preferred, 0 represent for don't care and +5 represents for most dislikes. Follows the penalty in literature, all of the marks are rounded to integer values.

The result shows that the patterns we listed in the questionnaires to be investigated can be categorized into 3 types. The first type is the patterns that the lecturers or students have no care about whether it appears in a timetable (Not-Cared Patterns). These are the patterns marked as 0 in the TABLE III and TABLE IV, which are, L9, S1, S2, S3, S5, S6, and S10. The second type of pattern is the pattern that is not desired by lecturer or student (Penalty Patterns). These patterns are marked by positive integer. From most to least undesired patterns by lecturers are L4, L1, L6, L2, L3, L5, and L7. Whilst for students are S13, S14, S4, S11, and S12.

The previous benchmark and practical UCTP models in the literature measure the quality of a timetable only based on calculating how many times a user undesired schedule patterns (Penalty Patterns) appears in a generated timetable. The objective of the benchmark problems is to minimize the appearance of these schedule patterns in the timetable. This is accomplished by giving penalty to the timetable's quality when one of these patterns appeared. However, in our work, we also consider type of patterns preferred by the users (Reward Patterns). These are the patterns with negative marks in the TABLE III and TABLE IV, which are L8, S7, S8, and S9.

Furthermore, from the result, we also gathered the marks users (students and lecturers) provided for each schedule pattern, which indicates how much a user may "dislike" or "prefer" the timetable once these patterns appear in the timetable.

In this section, we have identified the factors affect the user satisfaction of a course timetable at FTSM. The factors are the schedule patterns for a user (student or lecturer) in a generated timetable. These factors are listed in TABLE V.

TABLE III. SCHEDULE PATTERNS AND RESPONDED WEIGHTED AVERAGE MARKS FROM LECTURERS

	Schedule Pattern	**Mark**
L1	Teaching two class events in a day	3
L2	Teaching one class-type event and one tutorial/lab event in a day	1
L3	Teaching two tutorial/lab events in a day	1
L4	Teaching three or more events (including class, tutorial or lab) in a day	4
L5	Teaching faculty-level class events on Monday	1
L6	Undergraduate (Not CITRA Course) Class-type event is scheduled on 16:00 to 18:00 (CITRA Time)	3
L7	Undergraduate (Not CITRA Course) lab/tutorial event is scheduled on 16:00 to 18:00 (CITRA Time)	1
L8	Class-type events are scheduled on early morning (08:00 - 10:00)	-1
L9	Lab/tutorial event is scheduled on early morning (08:00 - 10:00)	0

CONCLUSION AND FUTURE WORK

In this work, we have conducted a survey to investigate the satisfaction factor of a good quality course timetable from both student and lecturer's perspective for a practical Course Timetabling Problem (FTSM-UCTP). To accomplish this, we have designed 2 questionnaires for both of them. The questionnaires lists the possible schedule patterns for a user and ask the responders' feelings about each patterns (disliked, don't care, or preferred) and how strong of their feeling.

TABLE IV. SCHEDULE PATTERNS AND RESPONDED WEIGHTED AVERAGE MARKS FROM STUDENTS

	Schedule Pattern	**Mark**
S1	A class event scheduled in the early morning	0
S2	Lab/tutorial event scheduled in the early morning	0
S3	Having three consecutive class events in a day	0
S4	Having three consecutive lab/tutorial events in a day	1
S5	Having two classes and one Lab/Tutorial in a day	0
S6	Having two labs/tutorials and one class events in a day	0
S7	Attending only one class event (not tutorial or lab) in a day (no other event scheduled in this day)	-2
S8	Attending only one Tutorial/Lab - type event in a day (no other events scheduled in this day)	-1
S9	Attending two consecutive classes only (not lab/tutorial) in a day	-3
S10	Having a two-hour free-time between a class-type event and a lab/tutorial	0
S11	Having a two-hour free time between two class-type events in a day	1
S12	Having a two-hour free time between two Lab/Tutorial-type events in a day	1
S13	Schedule a class event on afternoon session (16:00-18:00)	2
S14	Schedule a lab/tutorial event in afternoon session (16:00-18:00)	2

TABLE V. SATISFACTION FACTORS FOR FTSM-UCTP

Satisfaction Factor (Schedule Patterns)	**Mark**	**Type**
An instructor teaches two class events in a day	3	Penalty
An instructor teaches one class event and one tutorial/lab event in a day	1	Penalty
An instructor teaches two tutorial/lab events in a day	1	Penalty
An instructor teaches three or more events (including Class, Tutorial or Lab) in a day	4	Penalty
An instructor teaches faculty-level class events on Monday	1	Penalty
An instructor teaches undergraduate (Not CITRA Course) class event is on afternoon CITRA session (16:00-18:00)	3	Penalty
An instructor teaches undergraduate (Not CITRA Course) lab/tutorial event is scheduled on afternoon CITRA session (16:00-18:00)	1	Penalty
A student attends three consecutive lab/tutorial events in a day	1	Penalty
A student has a two-hour free time between two class events in a day	1	Penalty
A student has a two-hour free time between two lab/tutorial events in a day	1	Penalty
A student attends a class event on afternoon CITRA session (16:00-18:00)	2	Penalty
A student attends a lab/tutorial event on afternoon CITRA session (16:00-18:00)	2	Penalty
A student attends only one class event (not tutorial or lab) in a day (no other events in this day)	-2	Reward
A student attends only one tutorial/lab event in a day (no other events scheduled in this day)	-1	Reward
A student attends two consecutive class events only (not lab/tutorial) in a day	-3	Reward
A student attends a class event is scheduled on early morning (08:00 - 10:00)	-1	Reward

The result we gathered from the survey has clearly demonstrated three types of schedule patterns based on students and lecturers satisfaction level: the first type is the not-cared patterns which have no influence on the users' satisfaction when these patterns appear in the course timetable. The second type, like in the literature, the penalty pattern, which will decrease the users' satisfaction level when this type of pattern exists in the timetable. The amount of satisfaction level decreased is generally defined as the penalty in benchmark UCTP models. Finally, the third type of schedule pattern is the reward patterns. This type of patterns has not been discussed in the previous benchmark or practical models in the literature. The reward patterns' appearance in a timetable will improve the users' satisfaction level. Therefore, we recommend future researchers to consider the reward patterns' when measuring the quality of a UCTP.

Therefore, the future research of our work will concentrate on developing a complete model for FTSM-UCTP with both penalty and reward mechanism to measure the quality of course timetable.

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