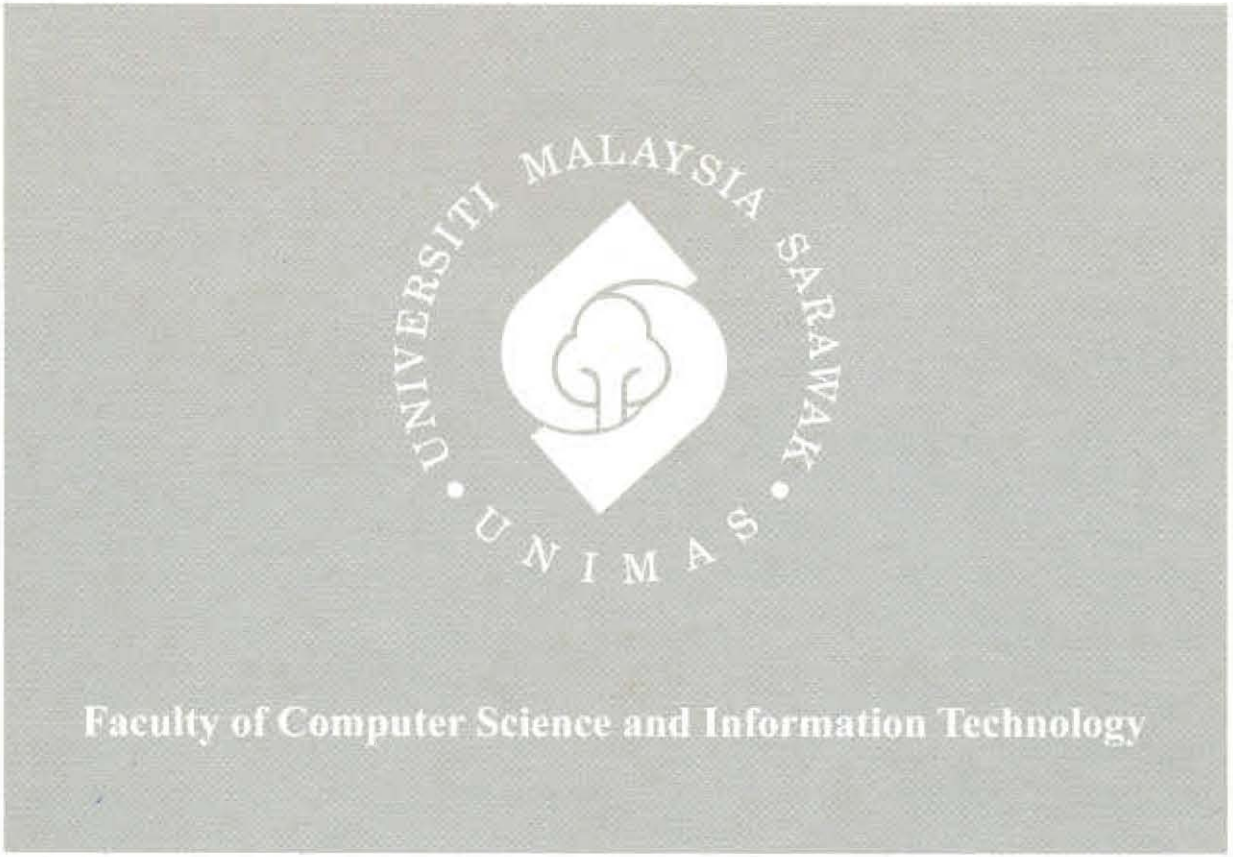

Computerised Faculty Course Timetabling with Student Sectioning

Bong Chia Lih

Master of Science
2016

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report ☐

Masters ☑

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Computerised Faculty Course Timetabling with Student Sectioning

Bong Chia Lih

A thesis submitted
In fulfillment of the requirements for the degree of Master of Science
(Computer Science)

Faculty of Computer Science and Information Technology
UNIVERSITI MALAYSIA SARAWAK
2016

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation, which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

This research focuses on a faculty course timetabling at the Faculty of Computer Science and Information Technology (FCSIT), Universiti Malaysia Sarawak (UNIMAS). In this case study, course pre-registration is not a practice. Therefore, there is no precise estimation on course registration and causes faculty's experienced planners to arrange the timetable by *curriculum-based*. Curriculum-based timetable will create a lot of changes after the semester has started, where "repeaters" students tend to face clashes in their course timetable. Besides, students are increasing consistently from semester to semester although the number of venue resources remains the same. Due to all these issues, the objective of this study is to develop a computerised algorithm to minimise the clashes issue and increase venue utilisation. A two-stage heuristic method is proposed to solve the faculty course timetabling problem by *student-based*. Data pre-processing algorithm was carried out to predict course registration based on students' curriculum course plan and previous examination result. "Repeaters" are taken into account in order to solve the problem comprehensively. The two-stage heuristic method divided courses into course groups in first stage to ease the timeslot-venue allocation in the second stage. Student sectioning was also considered to solve venue inadequacy by dividing large size courses into several course sections. Different course sections will have lecture in different venues either during the same or different timeslots. The simulator was tested with three real semesters' data from FCSIT. Three datasets were varied in problem size. The computational time of the simulator ranging from less than 1 minute to about 10 minutes depend on the problem instances. All the timetable

solutions generated by the simulator are no-clash solution with minimum unallocated courses. In term of venue utilisation, two-stage heuristic solution manages to allocate exactly with the demand up to 98% but real solution can perform best at only 75%. For timetable distribution, statistic graphs based on student clusters have been plotted on number of lecture days per week, number of lecture hours in a timetable day and number of highest continuous lecture hours in a timetable day. On average, 86% timetables have more than three lecture days per week, more than 93% of timetable days have acceptable range of 5 lecture hours and more than 90% of timetable days have less than 5 highest continuous hours. Moreover, two-stage heuristic timetabling also provides the convenience in editing the data attached to the problem and re-generate solutions in seconds. The computational result demonstrates that proposed heuristic algorithm outperform current practices in all datasets. A sets of sensitivity analyses have been conducted with different scenario of student size, number of timeslots and number of venues. All the sensitivity analyses results demonstrate that the proposed solution is effective and robust in solving FCSIT course timetabling problem for different scenario.

Keywords: course timetabling, two-stage heuristic, student sectioning

ABSTRAK

Kajian ini memberi tumpuan kepada penjadualan jadual waktu kursus untuk Fakulti Sains Komputer dan Teknologi Maklumat (FSKTM), Universiti Malaysia Sarawak (UNIMAS). Dalam kajian kes ini, pra-pendaftaran kursus tidak dilaksanakan. Oleh itu, anggaran yang tepat mengenai pendaftaran kursus pelajar adalah tidak diketahui. Situasi ini menyebabkan perancang jadual waktu fakulti yang berpengalaman terpaksa untuk menguruskan jadual waktu berasaskan kurikulum. Jadual waktu berasaskan kurikulum akan menyebabkan masalah pertembungan jadual waktu dalam kalangan "pelajar ulangan" apabila semester bermula, justeru memerlukan pengubahan jadual waktu. Selain itu, terdapat satu trend pada peningkatan jumlah pelajar dari semester ke semester manakala bilangan sumber tempat dikekalkan. Oleh kerana semua isu-isu tersebut, objektif kajian ini adalah untuk membina satu algoritma berkomputer untuk mengurangkan masalah pertempuran jadual waktu dan meningkatkan penggunaan tempat secara menyeluruh. Satu kaedah heuristik yang terdiri daripada dua peringkat telah diperkenalkan untuk menyelesaikan masalah penjadualan jadual waktu kursus fakulti berasaskan pelajar. Algoritma data pra-pemprosesan bertujuan untuk meramalkan pendaftaran kursus berdasarkan pelan kursus kurikulum pelajar dan keputusan peperiksaan sebelumnya. "Pelajar ulangan" diambil kira dalam usaha untuk menyelesaikan masalah ini secara menyeluruh. Peringkat yang pertama dalam kaedah heuristik membahagikan kursus kepada kumpulan kursus untuk memudahkan pengagihan slotmasa-tempat di peringkat yang kedua. Pembahagian pelajar juga digunakan untuk menyelesaikan

masalah kekurangan tempat dengan membahagikan kursus yang bersaiz besar kepada beberapa bahagian kursus. Bahagian kursus yang berbeza akan mengadakan kuliah di slotmasa-tempat yang berlainan. Simulator tersebut telah diuji dengan data sebenar untuk tiga semester yang dikumpul dari FSKTM. Tiga dataset adalah berbeza dari segi saiz masalah penjadualan Simulator ini boleh membina jadual waktu fakulti dalam masa kurang daripada 1 minit kepada kira-kira 10 minit. Semua penyelesaian jadual yang dihasilkan oleh simulator tiada pertembungan penyelesaian dengan minimum kursus yang tidak diagihkan. Dari segi penggunaan tempat, simulator berjaya mengagihkan kursus berdasarkan permintaan tempat secara tepat sehingga 98% tetapi penyelesaian sebenar terbaik pada 75%. Untuk pengedaran jadual, graf statistik berdasarkan kelompok pelajar telah diplotkan pada bilangan hari kuliah seminggu, jumlah jam kuliah pada hari jadual dan jumlah tertinggi jam kuliah berterusan dalam sehari. Secara purata, 86% jadual waktu mempunyai lebih daripada tiga hari kuliah seminggu, lebih daripada 93% hari jadual waktu mempunyai julat yang boleh diterima iaitu 5 jam kuliah dan lebih daripada 90% hari jadual waktu mempunyai kurang daripada 5 jam berterusan tertinggi. Selain itu, simulator juga menyediakan kemudahan untuk melaraskan data bagi mendapatkan penyelesaian dalam saat. Analisis sensitiviti telah dijalankan dengan senario yang berbeza dari segi saiz pelajar, jumlah slot masa dan bilangan tempat. Semua keputusan sensitiviti analisis menunjukkan bahawa penyelesaian yang dicadangkan adalah berkesan dan mantap dalam menyelesaikan masalah jadual waktu FSKTM untuk senario yang berbeza.

Kata kunci: *penjadualan, heuristic dua-peringkat, pembahagian pelajar*

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Timetabling problem is defined as the problem of assigning a number of events into a limited number of timeslots and resources subject to list of constraints with the aim to satisfy a set of state objectives to the highest possible extent (Burke & Petrovic, 2002; Adewumi, Sawyerr, & Montaz Ali, 2008). The constraints in timetabling can be generally classified into hard and soft constraints. Hard constraints must be satisfied under any circumstances. Timetables with no hard constraints violations are called feasible solutions. Soft constraints are those satisfaction is desirable but not mandatory. The number of soft constraints violations and its respective degrees of severity are usually used to evaluate the quality of the solutions especially in the comparison of algorithms.

The timetabling problem is not a new phenomenon and has existed since 1960s. It began as a small problem, which can be solved manually without a hectic task. As the problem size became bigger with the increasing student population, timetabling problem started to be solved by the aids of computer systems. During that time, the automated timetabling was simply transforming the manual method into a computerised one. The timetabling problem turned out to be very complex when the number of students involved increased, or when institution started to offer more number of courses and students were given the freedom in choosing their preferred course and time. Not only that, the problem becomes more constrained when there are limited timeslots and venue resources given. Most of the timetabling problems have

been simplified for academic research purposes. According to McCollum (2007), the study of the relationship between the research works in the academic literature and the requests of university administration is critical if the aims of research are to benefit every day users.

Over the past decades of research on university course timetabling, many effective methods have been introduced. Timetabling software started to flood into marketplace well-equipped with these methods. Despite plenty of timetabling software available in the market with ease of accessibility, many institutions still solve their timetabling problems manually. The reason behind this is that although timetabling problems for different institutions do share most of the general constraints there are different strategies, rules and structures that added more customised constraints in making them differ from each other. There is no fit-for-all software that can fit exactly to every institution due to wide-ranging differences in structure. This makes problem varies in many way and thus, solving them requires different techniques and consideration of constraints. Therefore, most institutions prefer to solve their timetabling problem manually in order to include all the considerations of their own. The downside of manual method is it could be very time-consuming and labour-intensive when the problem size is big (Gora et al., 2010).

Another important aspect in timetabling is student sectioning. In our case study, *student sectioning* is defined as a process of assigning a group of students into a few sections. It is constraint-driven splitting due to capacity constraint or timetable constraint. Student sectioning is usually been excluded from part of the timetabling process but as the student size keep increasing, many researchers have start to realise the importance of student sectioning in solving the timetabling problem to come out with feasible solution.

1.2 Problem Statement

In this research, a case study of faculty course timetabling problem for Faculty of Computer Science and Information Technology (FCSIT), Universiti Malaysia Sarawak (UNIMAS) has been studied.

Before the start of every semester, FCSIT needs to produce a timetable of lecture sessions for all offered courses. As course pre-registration is not a practice in UNIMAS, timetabling is carried out without the course registration data by using curriculum-based criteria, in which students are supposed to follow the curriculum plan determined for their programme of study. Very few timetable adjustments are usually needed as timetable conflict issues would arise after actual course registration session is opened. These timetable conflict issues are commonly faced by students who are repeating a course or commonly known as "repeaters". "Repeaters" are a group of students who did not enrol courses according to their curriculum course plan. For example, a student who is repeating a course with unideal grade from previous semester. Although timetable adjustments are made, timetable clashes for some students remain unsolved compelling them to drop affected course. The worst impact is students have to extend their study for another semester to enrol dropped courses. Apart from that, the problem becomes more complex when the number of students increases from semester to semester. As student size increases, student sectioning has to be involved due to venue capacity constraint. Proper planning is critical in student sectioning to utilise the resources on hand but current practice do not have much experiences on this matter. At the same time, course credit hours have increased from previously range from 2 to 3 credit hours and now 2 to 4 credit hours. This implies more timeslots are needed for allocation of all courses. Often, FCSIT has to request for more timeslots and venues to allocate all offered courses.

Previously, FCSIT experienced timetable planners solved faculty timetabling problem manually. Recent years, they have obtained a commercial software to assist them in solving their timetabling problem. However, this software only solves the timetabling problem in curriculum-based scope. This means "repeaters" are not considered in the computation of the timetable. Inconsideration of "repeaters" will create a lot of timetable clashes issues when the semester started. Timetable adjustment which can take one to two weeks is needed due to these clashes and it affects a lot on the teaching and learning sessions.

1.3 Research Objectives

The objectives of this research:

(a) To develop a computerised two-stage heuristic algorithm with student-sectioning for faculty timetabling problem. The objectives of the algorithm are as follow:

   i. To minimise the timetable clashes

   ii. To minimise the number of unallocated courses.

   iii. To maximise the big venue utilisation

1.4 Research Scope

The research scope is defined as follow:

(a) Study a case study faculty course timetabling problem in FCSIT

(b) Schedule lecture sessions for faculty courses, excluding the university elective courses as timetable for elective courses offer by other faculties are plan and schedule by themselves.

(c) Apply the timetabling solutions to lecture session only. Tutorial and lab session are excluded in this case study. This is because tutorial and lab session timetabling require another level of student-sectioning before timetabling in order to conduct both tutorial and lab session in small groups. The common practice (Dammak, Elloumi, & Kamoun, 2006) solved for course lecture timetabling first, only then they proceed to do the tutorial and lab session.

(d) Lecturers' preference lecture time is not considered in this study.

(e) There is no specific student lunch break timeslot is considered with no lecture can be allocated.

1.5 Research Methodology

The flows of research methodology of this project are as followed:

Step 1: Dataset collection and interview

- Interview sessions with FCSIT timetable planners are conducted
- Real datasets are collected

Step 2: Problem formulation

- Variables and parameters are defined
- Operational constraints are defined
- Objective function is defined

Step 3: Algorithm development

- Data Pre-processing algorithm is developed to extract data needed for main algorithm.
- Main timetabling two-stage heuristic algorithm is developed
- Sub-function algorithm on student sectioning is developed

Step 4: Testing

- Developed algorithm has been tested with real datasets to test its validity.

Step 5: Conduct analysis

- Computational analysis has been done to check the performances of algorithm.
- Sensitivity analysis is carried out by adjusting the parameters and problem instances to test the robustness and quality of the algorithm.

Step 6: Result Compilation

- Thesis on full report of problem, methodology and result.