Faculty of Information and Communication Technology

EXAMINATION TIMETABLING USING HARMONY SEARCH ALGORITHM

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Master of Computer Science (Software Engineering and Intelligence)

2015

EXAMINATION TIMETABLING USING HARMONY SEARCH ALGORITHM

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**A thesis submitted
in fulfilment of the requirements for the degree of
Master of Computer Science (Software Engineering and Intelligence)**

Faculty of Information and Communication Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

DECLARATION

I declare that this project entitled "Examination Timetabling Using Harmony Search Algorithm" is the result of my own research except as cited in the references. This project has not been accepted for any degree and is not currently submitted in the candidature of any other degree.

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Date   : …………………………………

APPROVAL

I hereby declare that I have read this dissertation/report and my opinion this dissertation/report is sufficient in terms of scope and quality for the award of Master of Computer Science (Software Engineering and Intelligence).

Signature   : …………………………………….

Supervisor Name   : Dr Norzihani Binti Yusof

Date   : …………………………………….

DEDICATION

Special for my lovely mothers, Misnah Binti Mokhtar & Dr Mumtaz Begam Binti Abdul Kadir

ABSTRACT

The examination timetabling problem concerns with the process of assigning exam entities to the particular slots and rooms in a timetable. The aim is to fulfil the hard constraints as well as the soft constraints to the highest grade possible in order to construct an optimum timetable. In this project, the Harmony Search Algorithm (HSA) has been applied to develop the examination timetable for Kolej Profesional MARA. The HSA consist of five steps, which are initialize the HSA parameters, initialize the Harmony Memory (HM), improvise new solutions, update the HM and achieve the termination criteria. The results stated in this research has been showed that the proposed examination timetable system capable to construct the timetable in fewer time compare with the current approach.

ABSTRAK

Masalah penjadualan peperiksaan menekankan tetang process penetapan entiti peperiksaan kepada sesuatu slot masa dan bilik peperiksaan ke dalam sesebuah jadual. Tujuan utamanya adalah untuk memenuhi kekangan sukar dan kekangan mudah sebaik mungkin bagi membangunkan jadual peperiksaan yang optimum. Dalam kajian ini, Algoritma Harmony Search (HSA) telah diaplikasikan bagi membina jadual peperiksaan untuk Kolej Profesional MARA. Algoritma ini mengandungi lima langkah iaitu penetapan parameter HSA, penetapan memory Harmony (HM), menambahbaik penyelesaian baru, mengemaskini HM dan mencapai kriteria penamatan. Keputusan yang telah ditunjukkan mendapati sistem yang dicadangkan berkebolehan dalam membangunkan jadual peperiksaan dalam jangka masa yang lebih singkat berbanding kaedah semasa yang digunakan.

ACKNOWLEDGEMENTS

Alhamdulillah and a thousand thanks to Allah for giving me bless and opportunity to complete this thesis. I would not have the strength to write this thesis without the full support from the people around me.

I would also like to express my greatest gratitude to my supervisor Dr Norzihani Binti Yusof from Faculty of Communication & Information Technology, UTeM for her advice, guidance and encouragement in order to make sure that I manage to complete this project. Special thanks also go to the panel of this project, Dr Asmala Bin Ahmad, Associate Professor Dr. Goh Ong Sing and Dr Zeratul Izzah Binti Mohd Yusoh. Thank you so much for your supportive comments and idea.

I also would like to express my deepest thanks to my colleagues Norsyarina, Zatul Alwani, Waheedah, Halizah, Asmarizan, Aiza, Nad and Mawardi for your sharing of joys, happiness and difficulties until the end of this period. Lastly, I would like to sincerely say a very big thank you to my family, especially for my lovely mothers, Misnah Binti Mokhtar and Dr Mumtaz Begam Binti Abdul Kadir for their full support and existences whenever I need them. Not forgotten to my siblings, Norzana, Pendi and Shafiee. I truly love you all.

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CHAPTER 1

INTRODUCTION

1.0 Background of Study

Timetabling is a huge field which is used to solve many problems especially in organizing the time based on particular requirements, such as place, event, person in charge and so on. Timetable refers to an organized list that provides information about a series of arranged events in a specific location and duration (Burairah, Hussin, Basari, Shibghatullah, Asmai and Othman, 2011). Basically, a timetable would be in a tabular form created by using the room-time slot matrix information. Timetables shows when particular events are take place and it do not necessarily imply the allocation of resources. But, in a real world, it is very crucial to make sure that the resources provided are sufficient enough for the given event to take place at a particular time.

Normally, the timetable development involves a dynamic and continuous process because it might be change due to situation and constraints. The development of timetable can be considered as NP-hard problem. In other word, it cannot be solved in polynomial time using deterministic algorithm. Each of problem execution will produce a different solution. Furthermore, the greater the size of the model will lead the more complexity of the optimum solution.

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Timetabling problems can be represented in a variety forms such as transportation or vehicle timetabling, work scheduling, sport timetabling and educational timetabling. Every timetabling problem has its own functions, methodologies, rules, requirements, constraints, and so on. For example, transportation timetables such as bus, airline and train timetable will cater the time of that particular vehicles arrival and departure in a specific routes and time.

The same thing goes to the educational timetable, where this kind of timetable has its own rules and characteristics. Basically, the three general educational timetables are school timetable, college or university timetable and last but not least is the examination timetable. Compare with the school timetable, the college or university timetable is more complex. The length of the time slot for the timetable is not the same, where there are some subjects will be taught every week in weekdays, some of them will be taught during weekends and perhaps some of them only taught in first half semester. Normally, most of educational institutions will produce a set of examination timetable at the end of that semester and these kinds of timetables will be reused for the next sessions. Maybe, there are some minor changes need to be done due to certain current requirements.

Examination timetabling is part of timetabling problem that happens in college. Examination timetabling refers to a process of assigning exam entities to the particular slots and rooms in a timetable (Hussin et al. 2011). Each of students is required to seat for a particular exam in the specific room at the specific time based on the subjects taken. Other than that, examination timetabling is considered as one of the NP-hard problem which is hard to be created in manual approach. There are several factors that contribute to the complexity of the examination timetable such as a large number of student enrolments, resources limitations, etc.

1.1 Problem Statements

There are several approaches and algorithms used to solved the scheduling problem, nowadays. But, certain of them are only capable to cater the certain environments and do not have enough ability to fulfill the large educational institutions requirements. Even though, exam timetable is a dynamic and complex problem, but the methods applied to overcome this problem is still emphasis on the static processes, like deterministic algorithm. With that approach, it will lead to conflicts such as clashing, overlapping and adding the new constraints to the current timetable system. As a result, the timetabling process will be back from the scratch and we have to reschedule all over again. This will drive to cost and time consuming.

Kolej Profesional MARA (KPM) is an educational institution that operates under the management of Higher Education Department of Majlis Amanah Rakyat (MARA). Altogether, there are six branches of KPM in Malaysia, which are Kolej Profesional MARA Seri Iskandar (KPMSI), Kolej Profesional MARA Indera Makhkota (KPMIM), Kolej Profesional MARA Branang (KPMB), Kolej Profesional MARA Bandar Melaka (KPMBM), Kolej Profesional MARA Ayer Molek (KPMAM) and lastly, Kolej Profesional MARA Bandar Penawar (KPMBP). There are two categories of subjects taught by each college, which are the stand-alone subjects and common subjects. The stand-alone subject will be taught only in the particular college. For example, subjects for Diploma in Entrepreneurship (DEn) will only available at KPMBM because that program only exist at that college. In the other hand, the common subjects are the subjects taught in more than one college, such as subjects for Diploma in Accountancy, where this program is available at three colleges among KPM. At the end of every semester, the examination timetable will be developed by the Examination and Certification Unit (UPP) staff of every college. There will be a specific

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meeting for them to discuss and built the examination timetable for the common and stand-alone subjects by using the manual approach. A few of considerations will be emphasized in order to make the most perfect timetable that fulfill all the requirements of every college, such as numbers of students, facilities constraints, gap between two examinations and so on. All of these processes are hardly done; therefore a suitable approach should be applied to solve this timetabling problem.

1.2 Research Questions

The following are the research questions:

1. What are the problems or issues faced by the UPP that lead to the implementation of new approach for examination timetabling?

2. How does the Harmony Search algorithm help in developing intelligence module for examination timetable?

3. How effective the Harmony Search Algorithm compare with the current approach in terms of time consume to construct the examination timetable?

1.3   Research Objectives

This research is concerned on the examination timetabling problems in KPM. A real examination timetabling problem has several constraints precisely to the requirement of an institution.

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The objectives of this study are:

1. To investigate the examination timetable in order to understand the current process and the problems occurs during the development process of that timetable.

2. To model an intelligent module for examination timetable by using the Harmony Search Algorithm.

3. To apply and test the intelligent module of examination timetable using the appropriate data sets.

1.4 Research Scope and Limitation

Enhanced the current management of examination timetabling problems with the intelligent computerized examination timetabling system that fulfils the requirements of KPM institutions. The scopes of study that need to consider are:

1. The proposed examination timetable will be used to assign the patterns based on batches and sessions.

2. The patterns assigned by the system only for the common subjects.

1.5 Significance of Study

This project will bring benefits to the KPM institutions. With this intelligent system, it can help the UPP staff to produce the most ideal and better solution for developing an examination timetable by reducing the time and effort consuming. In this near future, some improvement can be done to make this such system more intelligent, effective and can be

used to the other educational institutions with greater capacity such as college universities and universities.

1.6   Conclusion

The aim of this research is to design and develop a system that could produce a better solution of examination timetabling problem for KPM institution that can cater a several constraints mentioned before.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, the explanation will be focused on the studies and review on examination timetabling problem. The first section will be started with a general review of examination timetabling problem and continued with examples of metaheuristic methods. The last section continues by reviewing the existing literature of implementing the Harmony Search Algorithm to solve some problems.

2.1 Timetabling

Timetabling is at large covering many different types of problems which have their own unique characteristics (Burairah, Hussin, Basari, Shibghatullah, Asmai and Othman, 2011). The typical timetabling problem consists in assigning a set of activities/actions/events (e.g. work shifts, duties, classes) to a set of resources (e.g. physicians, teachers, rooms) and time periods, fulfilling a set of constraints of various types (Norberciak 2006). Real timetabling problems have many forms like educational timetabling (course and exam), employee timetabling, timetabling of sports events, timetabling of transportation means, etc (Bhaduri 2009). By having a good timetable, a list of tasks or events can be allocated at the appropriate time. This could be more crucial for a large organization with complex activities

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and tasks that has to be done in a time frame. A manageable and well organize planning is really important in order to make sure that all the things can run smoothly. It can be achieved with a great timetable or scheduling, or otherwise the tasks distribution will be chaos and lead to the failure.

Timetable is always considered as one of the NP-hard problem. The construction of a timetable can be an extremely difficult task and its manual solution can require much effort (Burke and Petrovic, 2010). Timetabling becomes a problem when the assigning task becomes hard to imply when specific requirements need to be followed (Sabri, Husin and Chai, 2010). Based on research by, Adamuthe, Mane and Thampi (2012), scheduling problems are difficult to solve because of their huge search space, highly constrained nature, difficulty in representation, inherent dynamic nature, variations of the problem depending on domains and applications.

Timetable problems are subject to many constraints that are usually divided into two categories: "hard" and"soft" (Burairah, Hussin, Basari, Shibghatullah, Asmai and Othman, 2011), (Norberciak, 2006)(Nandhini & Kanmani, 2009)(Guo, Chen, and Zhu, 2011)(Deng, Zhang, Kang, Wu and Deng, 2011)(Raghavjee & Pillay 2009). Hard constraints are rigidly enforced and have to be satisfied in order the timetable to be feasible. Soft constraints are those that are desirable but not absolutely essential (Deng, Zhang, Kang, Wu and Deng, 2011).

2.2   Examination Timetabling Problems

Basically, in education, there are three general academic timetabling problems which are, school timetable, university timetable and exam timetable. Normally, school timetables will have equal time slots and it will be repeated annually. Compare with the school

timetable, university timetables are more multiplex, whereby the length of the time slot is not equal. Some of the subjects are taught during weekdays, and some of them are taught only on weekends. The examination timetable will be prepared at the end of every semester or trimester. Examination timetabling problems (ETTPs) are combinatorial optimisation problems that consist of allocating a number of examinations into a predefined number of timeslots, while satisfying a set of hard constraints that cannot be violated and soft constraints that must be minimised as much as possible (Abdullah & Alzaqebah 2013). The most common hard constraints can be summarized as follows (Burairah, Hussin, Basari, Shibghatullah, Asmai and Othman, 2011):\

    a. Every exam must be scheduled in exactly one time slot

    b. Every exam must be assigned to a room(s) of sufficient size and assigned an invigilator(s)

    c. No student must be scheduled to be in two different exams at the same time

    d. There must be enough seats in each period for all exams scheduled

    e. Certain exams must be scheduled into specific time slots or rooms

    f. Certain exams must take place simultaneously

Most of the exam timetable will satisfy enough all of the hard constraints. But in order to produce a high quality timetable, the soft constraints also need to be fulfilled. Soft constraints can be considered as the requirements that can make the high level of perfection of a timetable (Ng, Burke, Eckersley, Petrovic, Qu and Mccollum, 2004). In reality, not all the soft constraints can be fulfilled. Soft constraints are often encountered, which include the following (Burairah, Hussin, Basari, Shibghatullah, Asmai and Othman, 2011):

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a. Exams for each student should be spread as far apart as possible

b. A student should not be required to take x exams in y periods

c. Time windows for certain exams

d. No more than x exams taking place simultaneously

e. No more than y students scheduled to sit exams at any one time

f. Exams should not be split across rooms

g. No more than one exam in a room at a time

h. Teacher or student preferences

i. Distance between rooms holding a given exam should be minimized (when the exam is split across two or more rooms)

j. The total number of periods should be minimized

It is very subjective to define the hard and soft constraints and basically it depends on the institutions' requirements. For example, one education institution might have different number of rooms available for examination, compare with other institutions. Furthermore, for certain examination timetabling problems, it is very hard to seek a better resolution at all.

In universities or college, the process of examination timetabling started with the combination of examination data from some divisions, centres and faculties. It is sometimes can be a complicated because of the amount of subjects that needs to be planned. The objective of exam timetable is to make sure that all exams are arranged and students can sit all the exams. The objective function in timetabling refers to weighted penalty, where it is assigned to soft constraints that are not satisfied.(Golub & Jakobovi, 2009)

2.3   Metaheuristics

Metaheuristic methods are generally applied to problems for which there is no satisfactory problem-specific algorithm or heuristic; or when it is not practical to implement such a method (States, 2007). Metaheuristic can solve many real world complex problems. The main idea behind designing the metaheuristic algorithms is to tackle complex optimization problems where other optimization methods have failed to be effective (Gholizadeh, 2012).

There are many hard optimization problems research been done especially in engineering, management and operations research. These problems are often very hard to be solved by traditional optimization methods (Yuping, 2000). The name combines the Greek prefix "meta" ("beyond", here in the sense of "higher level") and "heuristic" (from heuriskein, "to find") (Kumar, 2014). Among the well-known metaheuristic methods, this paper discovers the efficiency of Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and Evolutionary PSO (EPSO) in solving the proposed RPP problem. Figure 2.1 below, shows the general categories of metaheuristics depends on their operational technique.