



Faculty of Information and Communication Technology

**OPTIMIZING DRIVER SCHEDULING FOR UTeM
SHUTTLE BUS USING HARMONY SEARCH**

Zatul Alwani binti Shaffie

**Master of Computer Science in
Software Engineering and Intelligence**

2014

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SHUTTLE BUS USING HARMONY SEARCH**

ZATUL ALWANI BINTI SHAFFIEI

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

Faculty of Information and Communication Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

DECLARATION

I declare that this thesis entitled “Optimizing Driver Scheduling for UTeM Shuttle Bus using Harmony Search” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

APPROVAL

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

Signature :

Supervisor Name :

Date :

DEDICATION

To my beloved mother, Tengku Rofiah binti Tengku Zainal, father, Shaffiei bin Mohd and siblings, Adishahrol, Zatul Amilah, Alif Izanil, Zatul Fariha, Puteri Zakirah and Arif Sulaimi.

ABSTRACT

Scheduling is one of the decision-making forms that play a vital role in manufacturing and service industries. The main problem in scheduling is fairness, so a good schedule is the key to maintain the effectiveness of an operation. Scheduling is very important when dealing with task distributions and time management. The important tasks can be covered at appropriate times with the existence of proper scheduling. It will be more productive; well organized and manageable. There are many fields that required the scheduling such as transportation (bus, train and flight scheduling), medical field (nurse scheduling), manufacturing (production and workers' shift scheduling) and education (course and examination scheduling). This project is focus more on driver scheduling for UTeM shuttle bus. Driver scheduling (DSP) can be defined as the process of assigning shift and route to driver according to the bus schedule that has been provided over a scheduling period. Bahagian Pengurusan Kenderaan Universiti (BPKU) is one of the departments in UTeM which plays the role to organize the driver schedule every month manually. The process of generating the schedule is complicated since the shift and route given to drivers should be balance based on some constraints. Therefore, this project is carried out to generate an optimized schedule automatically using Harmony Search (HS). HS is one of the new optimization techniques that already solved many optimization problems. For DSP, all data are collected during interview session with BPKU. The problems arise in DSP in UTeM were analyzed and related to HS techniques. It is important to consider all hard constraints and soft constraints in order to produce a balance schedule. The DSP is implemented based on 5 steps of HS. The goal of this project is to minimize the objective function, which is minimizing the soft constraint violation. The result produced for this project is quite promising since the objective function obtained is better than real schedule which is done manually. The t-test is performed to compare these two samples. The value obtained is less than 0.05, so, there is a significant difference between the means of these two samples.

ABSTRAK

Penjadualan adalah salah satu bentuk membuat keputusan yang memainkan peranan penting dalam industri perkhidmatan dan pembuatan. Masalah utama dalam penjadualan ialah keadilan, jadi, jadual yang bagus adalah satu kunci untuk mengekalkan keberkesanan sesuatu operasi. Penjadualan sangat penting apabila berkaitan dengan pembahagian tugas dan pengurusan masa. Tugas-tugas penting boleh dikawal dengan masa yang sesuai dengan adanya jadual yang bagus. Ianya akan lebih produktif, teratur and terurus. Terdapat banyak bidang yang memerlukan penjadualan seperti pengangkutan (penjadualan bas, keretapi dan kapal terbang), bidang perubatan (penjadualan jururawat), pembuatan (pengeluaran dan pembahagian tugas pekerja) dan pendidikan (jadual kelas dan peperiksaan). Projek ini lebih fokus kepada penjadualan pemandu bas ulang-alik di UTeM. Masalah penjadualan bas (DSP) boleh didefinisikan sebagai proses pembahagian syif dan laluan kepada pemandu berdasarkan jadual bas yang telah disediakan mengikut tempoh penjadualan. Bahagian Pengurusan Kenderaan Universiti (BPKU) adalah salah satu bahagian di UTeM yang memainkan peranan untuk menghasilkan jadual pemandu setiap bulan secara manual. Proses untuk menghasilkan jadual ini sangat rumit kerana syif dan laluan yang diberi kepada pemandu mestilah seimbang berdasarkan beberapa kekangan. Oleh itu, projek ini dijalankan untuk menghasilkan satu jadual yang optimum secara automati menggunakan Harmony Search (HS). HS adalah salah satu teknik pengoptimuman yang baru yang telah menyelesaikan banyak masalah pengoptimuman. Untuk DSP, semua data telah dikumpul semasa sesi temu ramah bersama BPKU. Masalah-masalah yang timbul dalam DSP di UTeM telah dianalisa dan dikaitkan dengan teknik HS. Ianya sangat penting untuk mempertimbangkan semua kekangan sukar dan kekangan mudah dalam usaha untuk menghasilkan jadual yang seimbang. DSP telah dilaksanakan berdasarkan 5 langkah dalam HS. Matlamat projek ini adalah untuk meminimumkan fungsi objektif, iaitu meminimumkan pelanggaran kekangan mudah. Keputusan yang dihasilkan untuk projek ini agak memberangsangkan kerana fungsi objektif yang diperoleh adalah lebih bagus daripada jadual sebenar yang dihasilkan secara manual. T-test juga telah dijalankan untuk membandingkan kedua-dua sampel ini. Nilai yang diperoleh adalah kurang daripada 0.05, jadi, terdapat perbezaan yang nyata antara kedua-dua sampel ini.

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LIST OF ABBREVIATIONS

DSP – Driver Scheduling Problem

HS – Harmony Search

HSA – Harmony Search Algorithm

HM – Harmony Memory

HMS – Harmony Memory Size

HMCR – Harmony Memory Consideration Rate

PAR – Pitch Adjustment Rate

BW - Bandwidth

NCHV – New Continuous Harmony Vector

MRI – Magnetic Resonance Imaging

CHAPTER I

INTRODUCTION

1.1 Introduction

Driver scheduling is the process of assigning shift and tasks to driver. The scheduling of drivers is needed especially for public transport such as express buses, taxi, flight and train. In order to produce an optimized and efficient schedule, an organization or management of the public transport should consider all the constraints and problems arise.

Bus is a public transport that has been used more frequent by people compared to other public transports. Bus service is chosen among people since it is very easy and cheap. Normally people use the bus service to go to work, back to hometown, vacation trip and so on. Differently in a university that still does not has a permanent hostel in campus for their students, the shuttle buses are very crucial for students to facilitate them in attending the classes, lectures and any activities in campus. Therefore, the bus services are provided for students.

1.2 Background of Study

In planning the bus scheduling, the driver scheduling or also known as crew scheduling should be emphasized to carry out the duties, tasks or shift based on the bus schedule that has been provided. In a university that provided shuttle bus service to students, the bus schedule is produced for every semester depends on the students' course timetable and their placement. However, this project will focus more on driver scheduling problem (DSP). Driver scheduling problem (DSP) is a difficult combinatorial problem that

must be solved every semester (Valouxis & Housos, 2002). DSP can be defined as the process of assigning shift or duties to driver according to the bus schedule that has been provided over a scheduling period (typically a week or a month) (Belén et al., 2012).

This study is about how to optimize the driver scheduling using Harmony Search (HS) technique. Harmony search (HS) is a metaheuristic population-based method that is inspired by the improvisation process of musicians developed by Geem *et al.* It evolves solutions in the problem search space by mimicking the musical improvisation process in seeking agreeable harmony measured by aesthetic standards. When the musicians compose harmony, they usually try various possible combinations of the musical pitches stored in their memory (Geem, 2010).

There are many problems that have been solved by using harmony search; for example university course timetabling, wi-fi deployment, web document clustering, MRI brain segmentation, visual tracking and many more.

1.3 Problem Statements

The main problem in scheduling is fairness of the task distribution among staff. In driver scheduling, the problem is to balance the tasks or shift distribution among driver. The work of the next month is changing due to drivers' availability which might be involved in additional services, trips or having a health problem (Valouxis & Housos, 2002). The allocation of shift must be based on the set routes and some constraints. The schedule has been done manually, and this problem will be more complex if the number of drivers is increase.

1.4 Research Questions

Based on the background of the study and the problem statement, the research questions in this study are as follows:

- How to formulate DSP into mathematical equation?
- How to solve the mathematical equation and DSP using Harmony Search?
- How to compare the result of schedule in this study with previous existing schedule?

1.5 Research Objectives

There are three research objectives to be achieved based on the research questions in Section 1.4, which are:

- To formulate DSP into mathematical equation.
- To solve DSP using Harmony Search.
- To compare the result of schedule in this study with previous existing schedule.

1.6 Project Significance

The previous existing schedules which are done manually are probably having some limitation. With the schedule that has been implemented using HS technique in this project, an optimized schedule can be produced and the schedule can be generated automatically.

1.7 Project Report Overview

This study provides six chapters of the project report. The structure of this report is as follows:

Chapter 1 – Chapter 1 is the introduction part of this study. The background of study is briefly explained in this chapter followed by problem statement, research question, research objectives, and project significance.

Chapter 2 – Chapter 2 contains the literature review part. In this chapter, the state of the art that related to scheduling and harmony search was explained in more details. All references such as books, journals and papers that are related are used.

Chapter 3 – Chapter 3 is the methodology of this study. This chapter discussed about the methodology that have been chose to achieve the research objectives. The type of research method, research design, proposed methodology, and proposed Harmony Search technique are explained in details.

Chapter 4 – Chapter 4 is about implementation. In this chapter, the problem analysis, design, coding and step by step of the implementation will be included.

Chapter 5 – Chapter 5 is describing about result and analysis. The comparison of the produced schedule in this project with the existing schedule was included. Besides, the comparison of produced schedule using different parameters also included. At the end of this chapter, the process of verification and validation are performed.

Chapter 6 – Chapter 6 will be the conclusion of this study. This section provided a conclusion; summarize all the content of this report, research contribution and also provides some suggestion and recommendation for future work.

1.9 Conclusion

This chapter is explained about the whole overview of the project. The background of study, problems, research questions and objectives and project significance about DSP are stated. In the next chapter, the literature review related to DSP and HS will be explained in details.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

A review of existing literature was carried out to support the study undertaken in this project. Literature review is an outline and summary of existing published journal, research papers, books and other information sources that related to the field of study of the project. All of these materials will be collected, studied and analyzed. From the process of analyzing, the facts and findings can be extracted. In this project, the literature review will be focused on bus and driver scheduling, metaheuristic and harmony search.

2.2 Facts and Findings

The review on existing literature of bus and driver scheduling and harmony search has been made. The next sections will be described briefly about techniques that have been used for bus and driver scheduling, explanation of some examples of metaheuristic methods and problems that have been solved using harmony search.

2.3 Scheduling

Scheduling is one of the decision-making forms that play a vital role in manufacturing and service industries (Ungureanu et al., n.d.). It is the key to maintain the effectiveness of an operation. Scheduling is very important when dealing with task distributions and time management. The important tasks can be covered at appropriate times with the existence of proper scheduling. It will be more productive; well organized and manageable. Without a schedule, the task distribution among the staffs will be chaos.

Moreover, scheduling is very usable and helpful for job planning since it could be historical reference to track the job details.

There are many fields that required the scheduling such as transportation (bus, train and flight scheduling), medical field (nurse scheduling), manufacturing (production and workers' shift scheduling) and education (course and examination scheduling).

In order to cater all the problems of scheduling, there are two types of constraints that need to be considered which are hard constraints and soft constraints. Hard constraints must be satisfied, but no need to satisfy all soft constraints. However, in order to produce the better and more optimum result, the violation of soft constraints should be minimized (Al-Betar et al., 2012, Hadwan et al., 2013, Belén et al. 2012, Anwar et al., 2013).

2.3.1 Bus Scheduling and Driver Scheduling

Bus scheduling in university is the process to compose the time travelling and the drivers' shift according to the timetabling of students which involved multiple depots (Fu & Hao, 2010, Kliwer et al., 2006, Oukil et al., 2007). The transportation planning is decompose in several sub problems due to its complexity: timetabling, vehicle scheduling, crew scheduling and roster scheduling, with relations between them as it can be seen in Figure 1 (Lourenço, 2005).

Bus is one of the important transports for them who did not have their own transport. It is the most chosen public transportation because of the affordable fare compared to others (taxi, flight and train). Bus is extensively used by entire society. Therefore, in a company, in order to make sure all of users are satisfied with the service provided, the bus schedule should be optimum.

Generally, companies that handle bus services organized the bus schedule manually. C.H. Chen *et al.* (2009) stated that most inter-city bus carriers in Taiwan organized the bus routing and scheduling manually without optimization from a systemic perspective. The schedule will be modified further if it is not mutually suitable and this process is iterated until satisfactory results are attained. This approach is not effective and not efficient especially when the bus trip network becomes large. It will cause the inferior solutions (Chen et al., 2009).

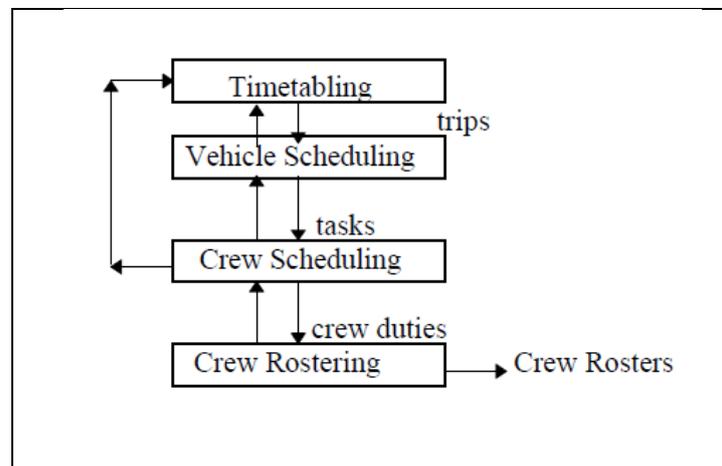


Figure 1: The Transportation Planning (Lourenço, 2005)

Based on Figure 1, in planning the bus scheduling, the driver scheduling or also known as crew scheduling should be emphasized to carry out the duties, tasks or shift based on the bus schedule that has been provided. Many researches of bus and driver scheduling have been done using various method such as genetic algorithm (Li & Kwan, 2003, Tan et al., 2011, Dias 2001, Sousa et al., n.d.), ant colony (Fu & Hao, 2010), particle swarm optimization and so on. However, this report will focus more on driver scheduling problem (DSP).

Driver scheduling (DSP) can be defined as the process of assigning shift or duties to driver according to the bus schedule that has been provided over a scheduling period (typically a week or a month) (Belén et al., 2012), based on some constraints. According to Belen *et al.*, in this process, there are two phases involved which are staffing phase; estimation of the number of drivers needed to cover the needs of working hours, and scheduling phase; development of calendars of work to cover the estimation of drivers acquired in the phase of the staffing (Belén et al., 2012). Zhao in (Zhao, 2006) stated that, it is necessary to assign shift and duties to drivers, so that every bus has a driver at all times.

DSP can be categorized as combinatorial optimization problem (Valouxis & Housos, 2002). The process of grouping, ordering and assignment of a discrete set of objects which satisfies certain constraints are included in combinatorial problem. This problem arise in many computer science domain and various application areas such as travelling salesman problem (Rego et al., 2011, Marinakis & Marinaki, 2010), scheduling or timetabling (Soza et al., 2011, Glass & Knight, 2010, Lin et al., 2010), resource allocation (Shim et al., 2010), genome sequence assembly and protein structure prediction (Stützle, Hoos Holger H, 2005).

An optimum schedule is quite complicated to be produced since there are some constraints should be considered. Rodrigues *et al.* (2006) that studied about urban transportation problem that applying integer programming models combined with heuristics method, said that, in producing a bus schedule, the number of vehicles, the number of passengers that must be transported, the fluctuated duration of each trip along the day and the vehicle capacities need to be considered. For crew or driver scheduling, the matters that should be considered are maximum number of work hours in a day and mandatory rest periods (Rodrigues et al., 2006). It will be more complex when dealing