SOLVING SECURITY STAFF SCHEDULING BY USING GENETIC ALGORITHM

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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The opportunity to write at here

represented

the goal is achieved

Thank you

everyone

I met

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ABSTRACT

The scheduling problem has been studied for a few decades where many researchers have successfully solved scheduling using different approaches. However, in the new era, flexible working hours is the latest trend compared with the traditional way, fixed working hours. Therefore, in this research, a flexible shift scheduling is studied because the scheduling problem should be humanized to follow the trend. But, it is a complex problem due to the scheduling involving the staff and their preferences. A heuristic method, the genetic algorithm is selected to solve this research problem as it is a powerful tool, shown in addressing the scheduling problem. It is because it is familiar used to solve large scale population and able to produce an optimal solution. This research not only fulfils the demand of shift but also calculates the preference of staff toward shift as the hard constraints. The combination of gender, preferred shift and preferred day off of the staff are represented as the gene while the chromosome represents a schedule. From the existing method, it requires the user to collect and key in the preference of staff manually before generating a result. It may take longer time if there have a larger number of staff. From the result in this research, 76.37% of the staff were allocated at their preferred shift while only 23.63% of staff were not allocated at their preferred shift. This research also proposed an offline system, known as the Flexible Shift Scheduling System to smooth the job. In the sensitivity analysis, the system could provide a satisfactory result in three minutes.

ABSTRAK

Masalah penjadualan telah dikaji selama beberapa dekad. Terdapat banyak penyelidikan berjaya menyelesaikan masalah penjadualan dengan pendekatan yang berbeza. Walau bagaimanapun, dalam era baru, waktu bekerja yang fleksi adalah trend baharu berbanding dengan cara tradisional, waktu kerja tetap. Oleh itu, dalam penyelidikan ini, masalah penjadualan juga harus diubahsuai untuk mengikuti trend baharu. Walaubagaimanapun, masalah penjadualan adalah masalah yang kompleks kerana ia melibatkan kesukaan pilihan kakitangan. Kaedah heuristik, genetic algorithm dipilih untuk menyelesaikan masalah penyelidikan ini kerana ia merupakan kaedah yang susuai dalam menyelesaikan masalah penjadualan. Penyelidikan ini bukan sahaja memenuhi permintaan kakitangan tetapi juga mengira keutamaan kakitangan. Gabungan jantina, pilihan shift dan hari cuti yang pekerja sukai diwakili sebagai gen manakala kromosom mewakili satu jadual. Melalui kaedah dalam penyelidikan, pengguna perlu mengumpul data kesukaan pilihan daripada kakitangan untuk menghasilkan satu jadual. Hal ini akan mengambil masa yang lebih panjang jika jumlah kakitangan sangat banyak Daripada hasilnya, 76.37% daripada kakitangan telah diperuntukkan pada pilihan mereka manakala hanya 23.63% daripada kakitangan tidak diperuntukkan mengikut pilihan mereka. Penyelidikan ini juga membina sistem luar talian, iaitu Sistem Penjadualan Fleksi untuk melancarkan kerja. Dalam analisis kepekaan, sistem ini dapat menghasilkan jadual yang memenuhi semua permintaan dalam masa tiga minit.

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LIST OF SYMBOL AND ABBREVIATIONS

I	-	Set of the security staff (i.e., $i \in I$)
J	-	Set of shift types (i.e., $j \in J$; note that J = {1 (day shift), 2 (evening shift), 3 (night shift)} in this paper)
K	-	Set of days off (i.e., $k \in K$)
$P_{i,j}$	-	The preference of each security staff, $P_{i,j}$ = {0 (not preference), 1 (preference)}
$A_{i,j}$	-	The availability of each security staff, $A_{i,j}$ = {0 (not preference), 1 (preference)}
$W_{i,j}$	-	The preference weight of each security staff
$D_{j,k}$	-	Manpower demand in shift j on day k
$N_{j,k}^{max}$	-	The maximum number of staffs allowed to have day off in shift j on day k
τ_j^{min}	-	Lower bound of the staff assigned in shift j in a week
τ_j^{max}	-	Upper bound of the staff assigned in shift j in a week
$s_{i,j}$	-	The number of shift for security staff to be assigned in each day
Z	-	The overall preference of the security staff towards work shifts and days off

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LIST OF PUBLICATION

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CHAPTER 1

INTRODUCTION

1.1 Research background

Operation research is a field of studying analytical tools of problem-solving and decision making, useful in the management organizations. The development of the operation research becomes evident after War World II, focusing on resource planning and strategies. After then, its evolution was dramatically rapid with the technology development of the microprocessor. Until today, the applications of the operation research have been deeply investigated and widely applied in various areas such as engineering, production, manufacturing, business, and sciences (Takashi *et al.*, 2017).

Scheduling, which is one of the crucial topics in the operation research, takes the practical usage in the real-world applications. In definition, scheduling is a process of arranging, controlling and optimizing the works and workload in a manufacturing process or a production process. In the scheduling process, plant and machinery resources, human resources, methods of plan production and materials procurement are allocated scientifically (Ernst *et al.*, 2004; Meisels & Schaerf, 2003). This situation ensures that the operation in a company is managed properly, where the profit is maximized while the cost is minimized.

In particular, the scheduling of employees is the most desired issue to be paid more attention to in the human resource unit. The allocation of some employees for a particular job task is rather challenging compared with the machinery scheduling work. This is because of human behaviour, human attitude and human ability are challenging to be handled by the human resource unit.

Moreover, there is a different pattern of shift for assigning the employees into the working shifts. It depends on the hours, such as 4 hours shift, 6 hours shift or any suitable period of shifts while the second type depends on the parts of the days such as morning shift, afternoon shift and night shift.

According to the Bureau of Labour Statistics (2004), the working shift increased by 15.1% for males and 11.0% for females with a total of 26.1% in the Netherlands and France, respectively. In Asian countries, Japan has an increase of 27.4% in the working shift due to a large number of industries in the nation. The main reason is the implementation of scheduled format, shift length, workdays and day off patterns, overtime and the scheduling policies, which are the five major components to build a working shift schedule.

However, the working shift has left some negative impacts, such as family problems, reduced social support, and mental stress indirectly (Pati *et al.*, 2001) to the social life of the employees. From the study of Ahasan (1999), the job opportunity in Bangladesh and Dhaka is meagre, and the competition to obtain a job is very high. Due to these factors, the working conditions and the number of hours for the working shift could not be negotiated. Due to the high unemployment rate and the over-population, the employers do not consider the working shift and the related effects.

On the other hand, from a number of employees interviewed, 73% of them disliked the working shift assigned to them, while 22% of them preferred the working shift systems. Only 3% of respondents expressed extremely negative attitudes and complained regarding the rotating working shift. Most of the employees indicated the effects of the working shift, which include problems in their personal, family, health and social life (Ahasan *et al.*, 1999). In Ahasan *et al.* (1999), the employees faced disturbances in their lives, such as 75% in their family life, 72% in married life and 65% in social life. In Emanuele *et al.* (2020), the sleep waking rhythm is influenced by the night shift worker.

Furthermore, the data showed that 70% of interviewed employees had problems with their family, 71% had less time spent with their family and friends, while 80% complained of no leisure time to spend with their relatives and friends. Similarly, 83% of respondents suffered from health problems, 85% of respondents had sleep disturbances, while 78% of respondents had meal time irregularities accordingly (Ahasan *et al.*, 1999; Begani *et al.*, 2013; Lazon & Zemke, 2003).

Following Aloul *et al.* (2003), the 0-1 integer linear programming model was developed by using the advanced Boolean satisfiability (SAT) and LPSolve IDE to handle reasonably sized employee scheduling problems. Therefore, useful scheduling is required in manufacturing and production, especially, when the preference of employee shall be taken into consideration (Urmila & Dinesh, 2013) such that the employee productivity can be improved (Alam *et al.*, 2012, Anna *et al.* 2019, Yang *et al.*, 2019). On this basis, comprehensive scheduling of the security staff, which covers the determination of the working shift in a week and the day off schedule, will be conducted in this thesis. From the mathematical programming model proposed, constraints of the schedule, different preferences towards each working shift and days off as well as the previous schedule are considered to maximize the preference satisfaction of the security staff in Universiti Tun Hussein Onn Malaysia (UTHM).

1.2 Problem statement

In the world, many countries adopt systems in solving scheduling problem such as Denmark (Shahrzad *et al.*, 2019), Russia (Gianmarco & Cristina, 2019), China (Wong, 2018) and Australia (Georgios *et al.*, 2019). According to Shahrzad *et al.*, (2019), crew scheduling problem is solved by using integer linear programming while Wang, (2018) developed the course scheduling system by using genetic algorithm. With the existence of the scheduling system, the process become more efficient and less time consuming. In UTHM, the management arrange the schedule manually with method, rotation.

Consider the information on the schedule for the security staff in UTHM, as shown in Table 1.1. There are three shifts, which are morning shift, afternoon shift, and night shift. Each shift has eight (8) hours. The schedule is an 8-day cycle schedule, in which the security staff work for six days continuously and then takes the day off for the following two days. Notice that for the male security staff, they are on duty for two (2) days in the morning shift, two (2) days in the afternoon shift, and two (2) days in the night shift, and takes the day off for the following two (2) days. However, this arrangement is quite different for the female security staff, where they work for two (2) days in the morning shift, four (4) days in the afternoon shift, followed by two (2) days day off, without working in the night shift.

From Table 1.1, the schedule reveals that the security staff works for six (6) days and rest for the following two (2) days. This arrangement is quite different compared to the standard working schedule, which is working for six (6) days and day off for one (1) day. From this point of view, the cycle of the schedule is not assigned on a weekly basis, which provides an unusual working period and influences the regular life of the security staff. Moreover, the shortage problem occurs upon unavailability of security staff in the working period, which takes leave for personal reasons.

Table 1.1: The Scheduling Information

Security Staff	Working Shift (in days)			Day off (in days)
	Morning	Afternoon	Night	
Male	2	2	2	2
Female	2	4	0	2

Other than that, the habits of each security staff are different. In particular, the preference of a security staff that wants to work in a specified working shift is not satisfied. This is a real situation that occurs among the security staff in UTHM, where they can only accept and follow the assigned working shifts with no option to choose the working shifts, as they prefer. It raises the problem of job satisfaction, which leads to an unhappy life for the security staff in UTHM.

Therefore, in this thesis, a comprehensive schedule, which takes into consideration the preference of the security staff in regards to the working shifts, will be further investigated and proposed practically. For this purpose, the optimization approach is further explored in handling this scheduling problem. With the result obtained, it is expected that the shortage problem could be solved, in general, and the preference of each security staff shall be fulfilled, and they would be happy in doing their job task in UTHM, in specific.

1.3 Research objectives

In this study, there are three research objectives given as follow:

(a) To apply and solve the mathematical modelling approach in providing a schedule for the UTHM security staff.

(b) To produce a working schedule for the security staff according to the preference in a-week period by using genetic algorithm.

(c) To build a system for the working schedule of the security staff by using the genetic algorithm.

1.4 Scope of study

This research is conducted at main campus of UTHM. The survey is carried out at gates of main campus namely Post A, Post B, Post C and Post D. There are two types of scheduling for security staff such as working in office hours and working in the shift. The area, which applies the shift schedule, is called the Closed-circuit television (CCTV) and general work sections. The CCTV section is responsible for monitoring the safety of UTHM with the CCTV located at each post. In contrast, the general work section is the duty of assigning the security staff at each post. Therefore, once the gate is opened, the security staff should be on duty to make sure the safety is guaranteed. All the security staffs with shift work in general work section are the targeted population involved in this study. This research conducts the quantitative method and considers the historical data of previous schedule periods.

1.5 Significant of study

This research is essential because the data, findings, and the results could be valuable for the Department of Security in UTHM. Not many studies have been conducted on the scheduling of security staff, which gives some significant impacts to certain parties such as airlines, security services, fire stations, and others. This research can help to further understand types of schedule and the importance of a comprehensive schedule for their staff. Hence, this research acts as a reference and a guideline to those organizations in their scheduling decision in order to develop a better schedule for their staffs. Besides, this research can also be a reference and a guideline for researchers and academicians investigating staff schedule according to the preference. This study could help them gain some information for their future research.

1.6 Thesis organization

This chapter discussed the pattern of scheduling for the security staff and the workforce on duty for 24 hours in UTHM. Short period shifts are not suitable for security staff scheduling, where the shifts are arranged depending on the parts of the day, which are morning shift, afternoon shift and night shift with 8 hours duration in each shift. Chapter 2 introduces the various type of scheduling and the methods that suitable to solve scheduling problem, optimising method and heuristic method. Chapter 3 provides a brief of how the preference of staff applied in the genetic algorithm while Chapter 4 shows the result generated by the genetic algorithm. In addition, a several sensitivity analysis are undergo. Chapter 5 introduces the pseudocode of genetic algorithm and the user manual of FSS System. Last but not least, Chapter 5 summaries this research and some direction for future work are discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the definition of scheduling is given and the type of scheduling is discussed. Next, some types of optimization approaches are deliberated, including the heuristic method. Finally, a summary of the chapter is enclosed.

2.2 Definition of scheduling and its types

Scheduling is defined as a basic method used to list all the activities of a plan in a schedule (Pinedo, 2008). A schedule is a useful plan of events or tasks to be performed in our daily life. With a schedule, the management would realize the need and the requirement in a sequence of tasks. The scheduling is crucial, especially for the manufacturing and service sectors (Takashi *et al.*, 2017; Hao *et al.*, 2004). Thus, the planning of the work schedule, which can be handled by using the artificial intelligence algorithms and the optimization methods, is delivered smoothly (Simeunovic *et al.*, 2017; Pinedo, 2008) among the employees.

Rostering is defined as the way of planning or assigning tasks (Ernst *et al.*, 2004). The planner has to decide the pattern of rostering. If the planner wants a schedule rostering for 24 hours, the rostering pattern has to be 3 shifts in a day. The shift is defined a number of workers are allocated in a certain period that fulfil the demand, as a type of planning way (Ernst *et al.*, 2004).

From the scientific aspect, the scheduling is widely used to allocate the resources, tasks or workers for a part of the schedule to a particular part of the schedule to achieve the desired objective. Usually, the objectives concern are to maximize the profit, to minimize the production time, or to optimize preferences (Pinedo, 2005). In addition, the logic of the scheduling, which is applied by scientists, is to solve the scheduling problem. In economy, the scheduling is used to determine the optimal benefit, while in management, the scheduling is employed to show the result of the management decision. Figure 2.1 illustrates the types of scheduling.

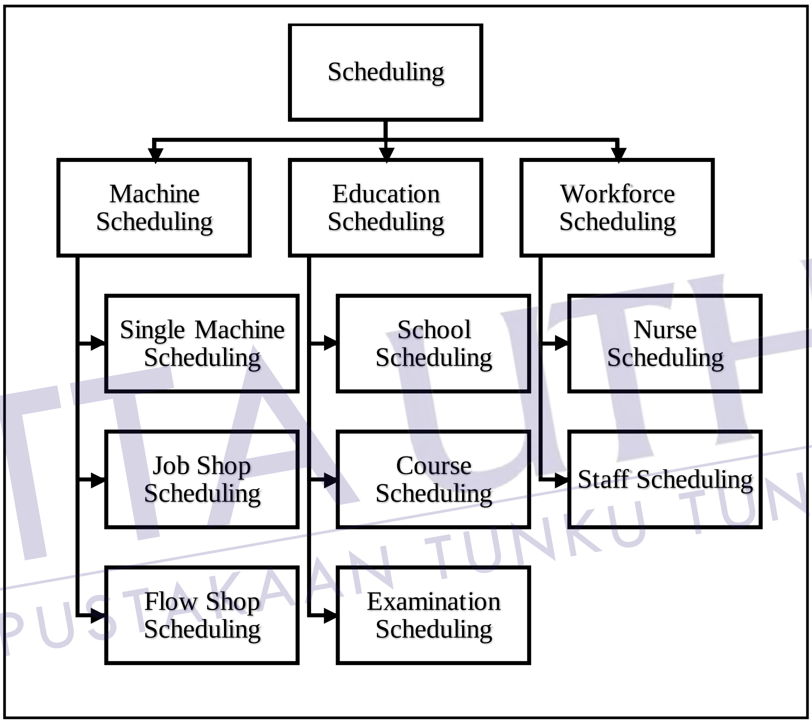

Figure 2.1: Type of Scheduling

2.3 Machine scheduling

In a factory, there are many different types of machines in fulfilling the production line. Each process uses a specific machine with a particular machine function. For example, in the glass factory, a process that is addressed from the raw glass to the tempered glass may go through cutting, drilling and tempered procedures. So, three different machines are required for these three procedures in a process. Hence, the person in charge shall need machine scheduling to arrange the orders based on customers demand.

Machine scheduling is divided into single machine scheduling, job shop scheduling and flow shop scheduling. Single machine scheduling is used to arrange the order of tasks in each machine while Job shop scheduling is a process that goes through each machine in the process line. In contrast, flow shop scheduling is a process that goes through a certain machine in the process line (Ajay, 2013). From the study of Anna *et al.* (2019) and Yang *et al.* (2019), the genetic algorithm shows a better job shop scheduling compared with the previous schedule used.

2.4 Education scheduling

In this era, education is essential to everyone. From primary school, secondary school, college to university, every education level needs an education schedule. The education scheduling shall be carried out appropriately for students, teachers and lecturers to carry on with their job. In such a way, a student follows the schedule to study, while a teacher or a lecturer follows the schedule to attend the class for teaching purpose. This is referred to as school scheduling. Moreover, course scheduling is the arrangement of the schedule created according to the courses. Both of these schedules prevent the overlapping of courses or the schedule of the teacher (Schaerf, 1999).

Besides, examination scheduling is also the central part of education used during the examination week to distribute several exams into a potential time period or slot within the examination period. It also takes into account that a student cannot take two or more exams in the same period (Carter & Larporte, 1996) and teacher preference (Saptarini *et al.*, 2017). Wang (2018) showed that the education scheduling system is well used in many universities around the world, such as Canada and China, to solve the massive task of arranging the courses timetables.

2.5 Workforce scheduling

Workforce scheduling is the arrangement of the schedule prepared for the required workforce to complete a sequence of jobs. It is divided into three different types, namely shift scheduling, days off scheduling and tour scheduling.

Shift scheduling shows the employee’s work and lunch break hours per day. Each shift can be set in certain hours decided by the management team. In general, the widespread shift is set in eight hours per shift, known as morning, evening and night

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