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A Framework for University's Final Exam Timetable Allocation Using Genetic Algorithm

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Abstract: Nowadays mostly all of the human tasks were replaced or at least assisted by the use of computer system to ensure the task in completed in timely manner. This includes the University's Final Exam Timetable Allocation. However in UniSZA remote campus, the allocation for Final's Exam Timetable is still being done manually and it took much time and manpower to generate it. The aim of this study is to present a University's Final Exam Timetable Allocation using Genetic Algorithm (GA) method. This method is used to find an optimal solution of solving timetable by using a real data from UniSZA's academic department. The result for these solution is minimizing the time taken in timetable allocation because it been done automatically and more efficient.

Key words: Heuristics algorithm · Genetic algorithm · Exam timetabling · NP-hard problem · Constrained optimization

INTRODUCTION

The timetabling construction at a university is proven to be a non-deterministic polynomial time hard (NP-hard) problem under multiple constraints and limited resources [1]. The hardness appears as a result of the complexity created following to the expansion of the number of facilities, lecturer, lecture, capacity of class and so on. A timetable is a documentation of events arranged according to the time it is taken place. The events are usually a list of meeting between two or more parties at a particular location. In university, timetabling can be about assigning room for lectures, assigning examination to students and assigning laboratory [2].

Final exam timetable is a subclass of timetabling for which the events take place at educational institution such as school, college or university. Final exam timetable allocation is a difficult task that appears to be a tedious job in every academic institution that happens for every semester. The process of making final exam timetable for university is more complex because it involves many hard constraints and soft constraints that are shaping the final results.

Back then, exam timetable has to be done manually by academic administer with a single person or some group involved and this could take days or even weeks to complete depend on the number of subjects, students, exam halls and so on. In doing this, administer sometimes run through mistakes such as assigning two exams for the same student at the same time or assigning the same exam hall for two different exams at the same time. Such human errors are becoming more difficult to avoid as the volume of data increases. This can be seen when we compare the construction of timetable for a single faculty to a all faculty throughout the university. Moreover, it will lead to time wasting because it requires more time to complete and thus becoming less efficient. An escape route from this old technique to a new computerized based final exam timetable allocation system is required with the fast growing and updated internet technology and availability.

The fact is, there are some commercial applications out there which were succussfully used by universities such as Timetable Plus 2014, Scientia Exam Scheduler 2012, Evolvera Timeedit 2010, Infosile Encampus 2010 and Celcat Timetabler 2010. However, they are lacking in the ability to adapt to specific requirements. Indeed, different universities imposes different set of requirements and limitations. Due to this issue of robustness, some existing solutions may not be suitable for a particular institutions.

Currently, the availability of web based application for final exam timetable allocation is not widespread especially at the Universiti Sultan Zainal Abidin (UniSZA). Administrator has to do the timetable manually using the traditional method and this causes many

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inconveniences especially when the number of programs and student enrolments increases and more new subjects are introduced. This may take from several days to even weeks to complete after getting the feedback from the lecturers and students. This practice can incur cost and also loss of time to academic administrator. In the end, the violation of constraint may still be present. Consequently, we need to use a computational technique to solve this so-called constrained optimization problem. The objective is to find the most optimal solution by running through the large search space according to some guidance operator by abiding some rules given by hard constraints and soft constraints. Hard constraints physically cannot be violated, if exist it can never be acceptable. On the other hand, soft constraint are less straight forward to define. It usually must be fulfilled as much as possible but the timetable that violate these constraint is still valid for students and teachers.

An appropriate technique needs to be implemented for the final exam timetable allocation. In fact, a lot of research needed to be done before deciding which one is the most suitable technique for this problem. As a result, in this paper, the system timetable allocation for final examination is proposed using genetic algorithm. Genetic algorithm mimics the process of natural selection and can be used to solve a complex problem for both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution. The algorithm repeatedly modifies a population of individual solutions to achieve an optimal solution. Genetic algorithm is the method that has been proven successful for solving the scheduling problem in general [3, 4].

Related Works: Scheduling is a type of decision-making process used in almost all production and service sectors including education sector. It deals with allocating resources to tasks in a given time period while optimizing one or more objectives functions to satisfy a list of constraints [5]. Timetabling in essense is one of the scheduling problems, a subset of combinatorial optimization problem which many studies have been done [6,7,8]. Examination timetabling is similarly complex to other counterparts such as course timetabling and likewise many studies have also been conducted with many heuristics solutions have been proposed for solving exam timetabling, that include genetics algorithm [9], particle swarm optimization [10], ant colony optimization [11], simulated annealing [12], great deluge algorithm, [13] and many more. All these techniques compete among each other and each having its own advantages over certain environment with particular conditions in terms of requirements and constraints. However, GA stands out due to its performance achievement with an ability to escape local optima and diversity [14].

Genetic algorithm are a class of powerful and general purpose search algorithm based which model problem based on the principles from Darwinian biological evolution. In 1975, it has been formalized by John Holland and growing in popularity, further described particularly for solving problem with a large irregular search space [15,16]. The generic process that genetics algorithm follows can be described according to Figure 1.

```
Create a population of creatures
Evaluate the fitness of each creature
While the population is not fit enough
{
  Kill all relatively unfit creatures
  While population size < max
  {
      Select two population members
      Combine their genetic material to create a new creature
      Cause a few random mutations on the new creature
      Evaluate the new creature and place it in the population
  }
}
```

Fig. 1: Pseudocode of Genetic Algorithm

Constraints are what restrict the choices of search space, thus limiting its size. The subject of the constaints linger around students, subjects and exam halls. Hard constraints would be those restrictions that are not supposed to be violated or else the solutions would be rejected. In exam timetabling case, some examples of hard constraints are each student can only sit for a single exam at a time and the hall should be equipped enough to accommodate all students. Meanwhile, soft constraints are those restrictions that affect the quality of solutions. The more we violate, the less quality of our solutions due to an increase in number of requiments that are not fully or partially satisfied. Some examples of soft constraints are, there should be no two or more exams scheduled for the same student in the same day or the difficult subject should be interleaved with an easy ones just to be fair to all students.

Figure 2 shows a genetic algorithm working framework for exam timetabling that comprises of seven steps. First step is the initialization of population. The population here is define as program, subject, lecturer, lecture, facilities. Second step is the evaluation of the fitness value. Fitness value evaluation can be gained from the population value that satisfied the requirement in

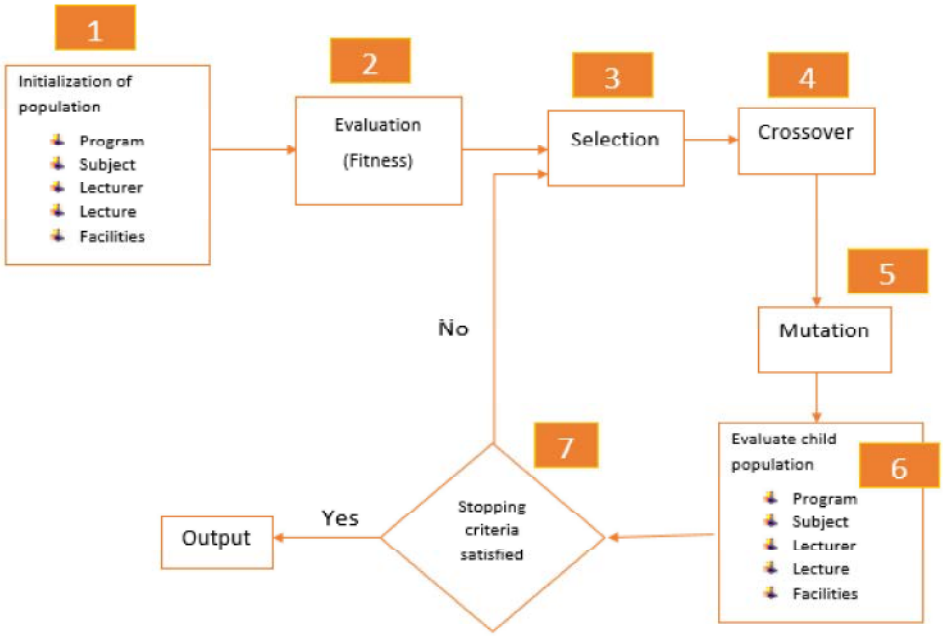

Fig. 2: Genetic Algorithm Cycle for Exam Timetable

population stage. Once the fitness value is obtained, the selection population process will be carried out for further crossover stage. Next stages, crossover the chromosomes of the population and this will create a new population (mutation). This mutation process will generate child population. The new child population will then be evaluated before the decision to check for the criteria satisfaction. If it already satisfied the criteria, it will produce the output which is the final exam timetable otherwise it will goes to the selection stage again.

Numerous works have been successfully done in this area. It was shown that GA has been a good method for generating feasible timetable [17,18,19,20]. Most notably, that of [9] which has successfully generated the timetable with no clash exam in a short time period. The result is more efficient and reliable timetable scheduling can be achieved and can provide a good examination timetables. However, there is a drawback in that the fitness does not penalty two exams scheduled for the same student in one day. Therefore, in this paper, we design and develop our own GA based exam timetable tailoring its parameters to our faculty requirements and limitations.

MATERIALS AND METHODS

This paper considers the problems in Faculty of Informatics & Computing, UniSZA. This section describes the details framework for final exam timetable allocation as shown in Figure 3. It comprises of two entities which are Academic Management and Faculty as the end user. Academic Management user need to login before managing facilities such as the examination hall capacity, room numbers, academic management details, examination details such as duration and invigilators information and finally who can view the timetable.

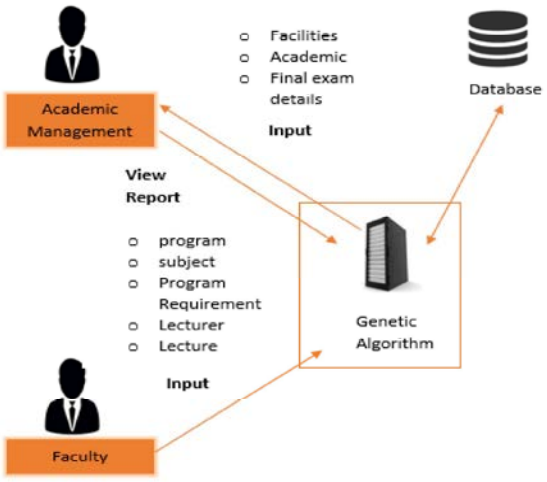

Fig. 3: The Framework for UniSZA Final Examination Timetable Allocation

The end user who is responsible in the faculty also needs to login to (1) manage the subjects/course information including course code and name, credit hour, lecture hour and tutorial hour; (2) manage student for example students should not sit for two exam at the same time;

(3) manage lecturer such as lecturer's availability as an invigilator; and (4) manage exam for example where will be the exam venue. Those information from both end users will be processed using GA and stored in the database in order to produce the Final Examination Timetable. The table generated from this developed system will benefit both the Faculty and Academic Division.

RESULTS AND DISCUSSIONS

This section discussed the about the result and generated output from this developed system. Actual data obtained from Faculty of Informatics and Computing was studied and GA method was implemented to generate automated timetable. The data from Semester 2 in 2016/2017 session which comprised of two (2) Diploma and three (3) Degree Programme conducted at the faculty. A number of 43 academic staff were also involved in the timetable allocation generation process.

Figure 4 shows the list of currently running programme in the faculty. The existing programme information can be edited for example there might be modification of study duration of the program. On top of that, the existing program can also be deleted if the program is no longer offered in the faculty. Other than that, if there is a new program offered, the faculty admin can add new program and its detail.

While Figure 5 shows the list of subject/ courses registed for each program. The information includes the duration in hours of lecture that need to be conducted for each courses. As can be seen here, the enrollment for each course is also stated here to indicate the required examination hall capacity before assigned any examination hall and the numbers of invigilatiors to the subject.

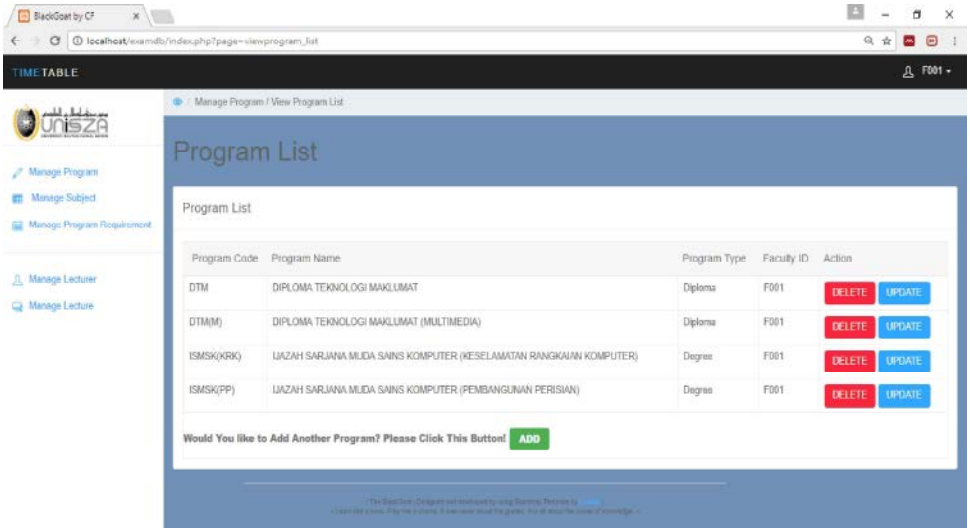

Fig. 4: Program Interface for UniSZA Final Examination Timetable Allocation

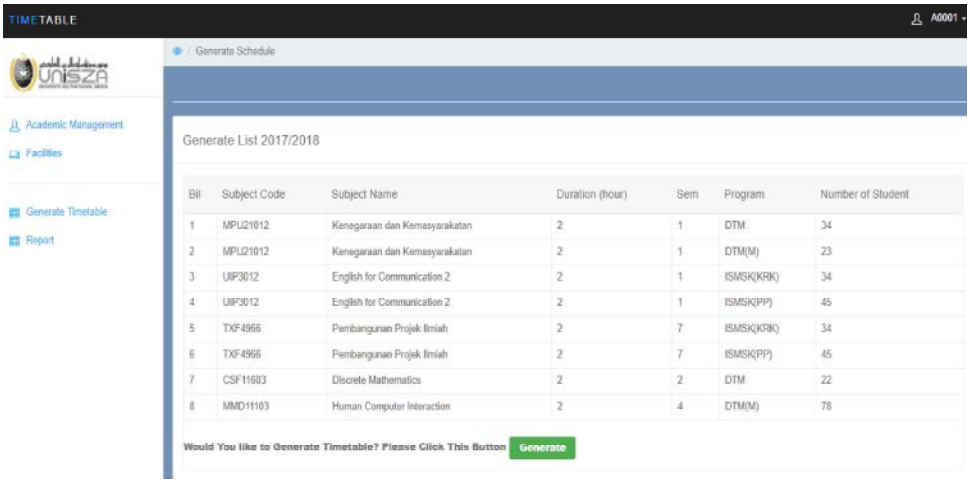

Fig. 5: Generate Schedule Interface for UniSZA Final Examination Timetable Allocation

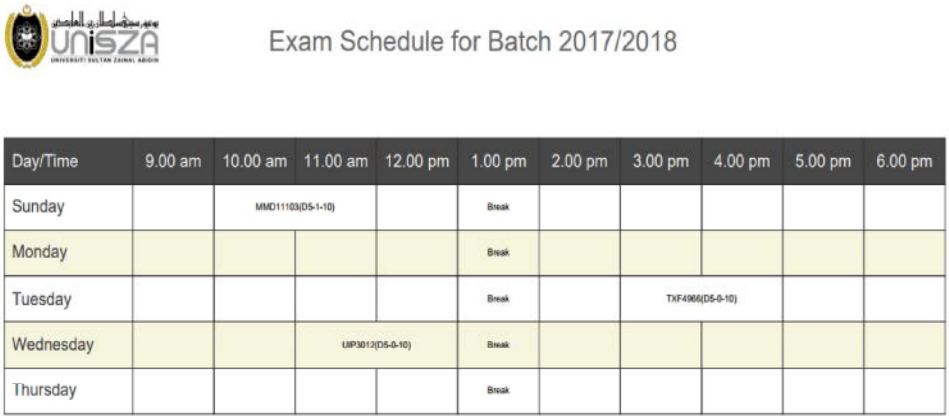

Fig. 6: Schedule Interface for UniSZA Final Examination Timetable

Figure 6 shows the final examination timetable generated from the developed system and it is found that there is no redundant slots allocatted. The result is generated in a timely manner but with very least resources and there is very little human intervention through out the timetable generation. The above results shows that this system is very useful and GA is a successful implemented in scheduling problems because of more flexibility offered and efficient to run as lately there is always changes in the enrolments and program expansion.

CONCLUSION

From this study, it can be conclude that with the implementation of GA in Automatic Final Exam Allocation System, Academic Management in University can save a lot of time in creating and managing final exam time table which is more flexible, effective and efficient process can be achieved. Other than that, the generated timetable is far more reliable compared to manually generated timetable which may lead to human error.

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