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Research Paper

A study on optimization methods for solving course timetabling problem in university

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Abstract

Course timetabling is one of the most important processes faced by any educational institution. However, the course timetabling process is time consuming and tiresome as it needs to be done for each regular semester. This paper aims to study on the Optimization methods to solve the course timetabling problem. The study is obtained and discussed by categorizing between the classification of Hard Constraint and Soft Constraint and the classification of Optimization Methods. From the study, it shows that Meta-Heuristics are the mostly method used in solving the course timetabling problem. It is concluded that this method is suitable for future used compared to other techniques studied. An analysis and observation will be carried out for the research future.

Keywords: *Course Timetabling; Classification; Meta-Heuristics; Optimization; Hard Constraints; Soft Constraints.*

1. Introduction

Timetabling problem represent a very difficult task, where many restriction and demands must be satisfied by a feasible solution. During the last decade, timetabling problems has received a lot of attention [1]. Moreover, the problem of timetabling is to allocate the whole events to fix stipulated timeslots and rooms which can satisfy the constraint. For most of the scheduling problems, it has been shown that they are NP-Hard and different from one institution to another [2]. Since this problem happened, the researchers attempted to use various methods to produce a better solution of timetabling process [3-4]. The course timetabling problem is relied on the proper decisions and systematic plan strategies to get the best result.

A course is a set of events that need to take place in timetable [5]. Timetabling is the process of producing a timetable while satisfy the soft and hard constraints. A course timetabling usually involve the allocation of resources and time slots to each given meeting while maintaining constraints. There are basically two types of constraints which are soft constraints and hard constraints [6-7]. Hard constraints must be satisfied in the problem completely makes the timetable suggestion feasible. Soft constraints are rules that improve the quality of timetable, but not absolutely essential. If soft constraints will not be able to meet all the hard constraints, those with lowest rank will be excluded until a suitable time or space can be timetabled. In many cases, soft constraints will work far better than hard constraints.

Timetabling problem usually deals with effective distribution of resources where the resources are lecturers, student, courses and particular rooms to a fixed time period [8]. In recent time, various heuristical approaches have been developed. Most of them come from the fields of operation research for example graph coloring [9], case-based reasoning [10] and artificial intelligence like simulated annealing [11], tabu search [12], local search [13], genetic algorithm [14-15] and ant colony optimization [16-18]. The purpose of this paper is to study on the Optimization Methods by categorizing between the classification of Optimization Methods and the classification of Soft Constraints and Hard Constraints.

This paper will briefly describe the course timetabling problem at the University. Besides, the section 2 will focuses on the Problems and Methods on classification of the methods and searching techniques and also hard and soft constraints, followed by the Discussion of this study. The last section will highlight the overall conclusion of the paper.

2. Problems

Basically, there are two types of constraints that normally involved in solving the timetabling problems which are hard constraints and soft constraints. Hard and soft constraints are fundamental elements for creating a great and working timetabling. The detailed concepts and applications of the hard and soft constrains is shown in Table 1.

2.1. Hard constraints

Hard constraints are those which definitely want to be satisfied under any circumstances [4, 7]. It is an element of the timetable that is equally weighted and must be abided by. To put it simply, if the constraints are broken, the timetable will not work properly. Each of the hard constraints is built on the same principles that control most aspects of our lives, especially space and time. Hard constraints will allow you to create a schedule that works, providing that you have the resources available to allow you to accommodate activities within the hard constraints.

2.2. Soft constraints

Soft constraints are the other side of the coin and composed of elements that can turn the working timetable to the better timeta-

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ble, but it is dependent on what you are looking to achieve and the availability of resource you have [19]. The principle of soft constraints is placing constraints on the timetable, which will help to improve your schedule and actually is not a necessity. Each of these is a soft constraint, as if they are all ignored but still have a timetable that works. Therefore, these soft constraints are typically put into timetabling and ranked according to their importance.

3. Methodology

Nowadays, significant research on Course Timetabling Problems has been carried out in solving the timetabling problems. There are numerous methods have been utilized to overcome the problems. By using classification, each method can be divided and categorized to provide better review of approaches used. For this study, Heuristics Methods and Meta-Heuristics Methods of course timetabling problem is carried out to identify the problems.

3.1. Heuristics

Heuristics is described as any approach to find solutions among all possible ones but they do not guarantee that the best will be found [20]. Therefore, they may be considered as approximately and not accurate algorithms but usually find a solution close to the best one and they find it fast and easily. Heuristic is a technique designed for solving a problem more quickly when classic methods are too slow or for finding an approximate solution when classic methods fail to find any exact solution [21]. This is achieved by greediness, but in order to be easy and fast the algorithm ignores or even suppresses some of the problem's demands. In a way, it can be considered as a shortcut. The studies show that heuristics are capable of solving many timetabling problems [22- 26].

3.2. Meta-heuristics

Meta-heuristics is an independent problem-solving technique [27]. Therefore, it does not take advantage of any specificity problem and can be used as a black box. In general, Meta-Heuristic is a high-level framework for problem-free algorithm that provides a set of guidelines or a strategy to develop a heuristic optimization algorithm [6, 28]. They can also receive a temporary downturn solution, which allows them to explore more thoroughly the solution space and thus to obtain the expected better [29].

4. Results and discussion

Based on the literature, the classification has been carried out according to the Optimization Methods. The classification of Optimization Methods shows that the Meta-Heuristics Methods has the total of highest number mostly used in timetabling problem with the total of 19 approximately. The classification has been analyzed based on graph as shown in Figure 1. From the study, Meta-Heuristic Method shows the most widely used compared to other optimization methods in the literature. Therefore, by comparing all the optimization methods, Meta-Heuristic Method is the best suited method for solving course timetabling problem and capable of efficiently providing the feasible timetable.
On the other side, the hard constraints and soft constraints are carried out to observe the Course Timetabling Problems in classification table. The survey shows the classification table of the hard and soft constraints provides different point of view based on some literature reviews. The details of the classification table are shown in Table 1.

Table 1: The Classification of the Hard and Soft Constraints

Hard Constraints	Soft Constraints	References
• The workload of each event must be satisfied. • A teacher cannot be scheduled to more than one lesson in a given period. • Lessons cannot be taught to the same class in the same period. • A teacher cannot be scheduled to a period in which she/he is unavailable. • All lectures within a course must be scheduled and assigned to distinct periods. • Timeslots must be assigned to events according to the availability relation.	• Avoid teachers' idle periods. A period of a teacher is considered idle if she/he has lessons assigned before and after that period on the same day. • Minimize the number of working days for teachers. In this context, working day means a day that the teacher has at least one lesson assigned to him/her. • Provide the number of double lessons requested by each event.	[15, 20, 30-45]
• Classes taught by the same professor • Classes held in the same room • A class cannot be assigned to a particular room unless the capacity of the room is • A student has only one lecture in a day, • A student has more than three consecutive lectures in a day. • A student has a lecture in the last timeslot of a day. • The number of students attending the course should be less than or equal to the capacity of the room.	• Balance or spread out the lectures over the week. • Classes may request contiguous time slots. • Balance enrollment in multi-section classes. • A student has a class in the last slot of the day • A student has more than two classes in a row • A student has a single class on a day	[46-49] [21, 11, 2, 4, 25, 43, 28, 7, 50-77]
• All allocated rooms are large enough to hold the students. • Specific room requirements are taken into account. • Lessons marked as prescheduled are scheduled to the specified time. • Lessons are blocked, if so required. • Course meetings can be assigned to predefined time-slots. • A set of courses can appear as a part of multiple terms in the curriculum. This is to accommodate optional courses. • Meetings of a lecturer must not overlap.	• Some teachers wish to have a special equipped classroom. • Some lessons should not take place late in the evening. • Lunch break should not be between subjects with lectures over two or more time periods in a row • The duration between the meetings of a lecturer on a day should be within predefined minimum and maximum limits. • The order of between different course meetings can be defined. • The courses in a given term of the curriculum must not overlap.	[24, 78, 84] [85-91]

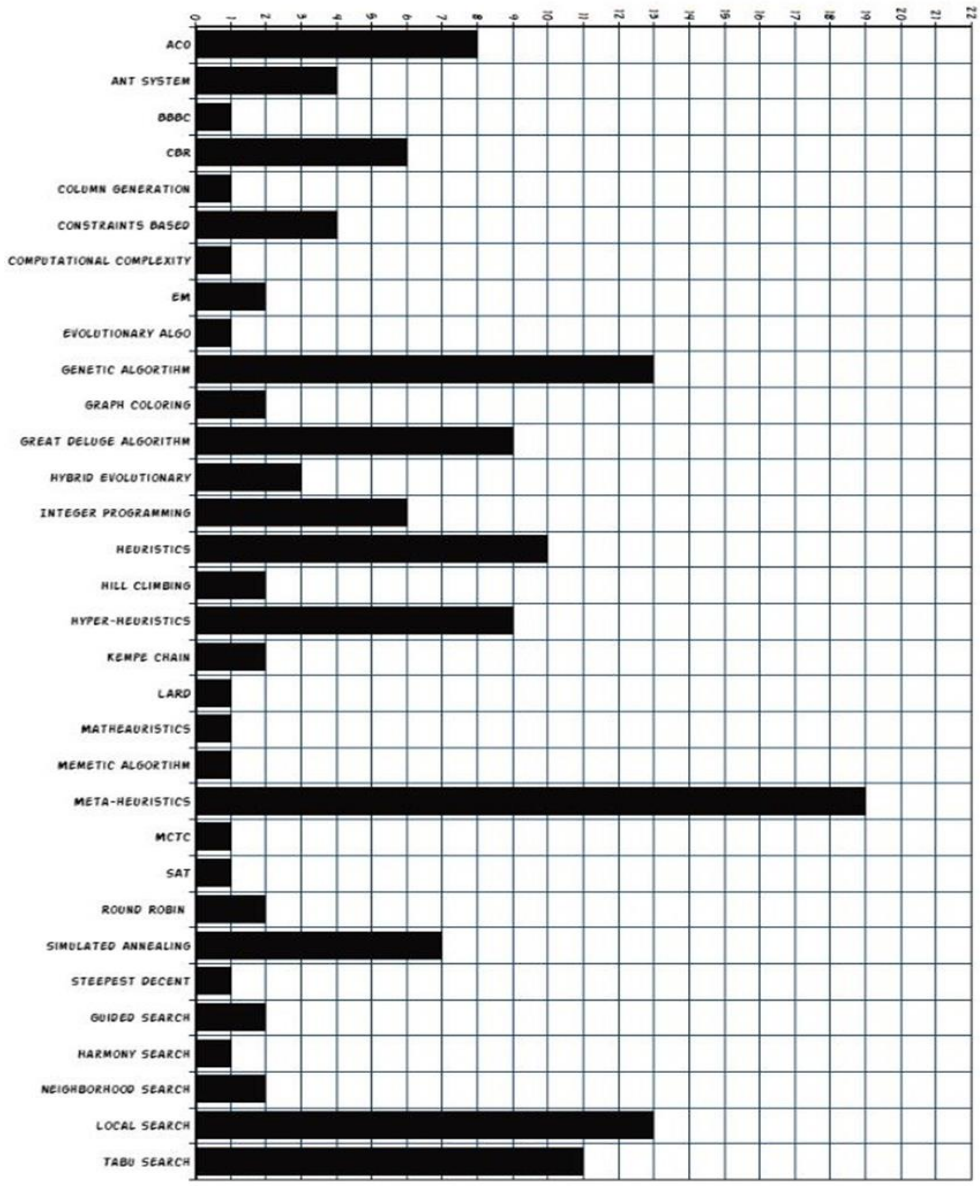


Fig. 1: The Classification of Optimization Methods.

5. Conclusion

Overall, from this study, this paper helps to determine the Course Timetabling problems by generating the classification of Optimization Methods Table. It is concluded that Meta-Heuristics Method are the most reliable and best suited methods in solving the Course Timetabling Problems. These methods are analyzed for the future data used, which help to determine the timetabling problem and reduce time constraint. Meanwhile, the classification of hard constraints and soft constraints table is utilized to show the differences point of view. The future work can be done easily if the classification had been verified earlier. Thus, this classification table helps to determine the Course timetabling Problems.

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