University Timetable Scheduling Using Genetic Algorithm Approach Case Study: Rajarata University OF Sri Lanka

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ABSTRACT
This paper proposes a genetic algorithm approach for university timetable scheduling problem. The semester timetable of the Faculty of Technology, Rajarata University of Sri Lanka was scheduled using the above algorithm as a case study. Faculty of Technology lacks many of the resources such as lecture halls and laboratories because it is a newly established faculty.When scheduling the timetable for this specific case study there were more constraints to satisfy than a general timetable scheduling problem. Manual scheduling of the timetables prone to many issues such as long time and effort, favoritism to one or more of the staff members, human errors, non-optimal solutions, conflict of interest. The process can be very complexsince there are a lot of constraints to consider. The main objective of the research is to come up with an algorithm to optimize the resources at hand while satisfying all the hard constraints and most of the soft constraints.
Keywords –Evolutionary Technique,Genetic Algorithm (GA), Timetable Scheduling.

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I. INTRODUCTION

Timetable scheduling problems have received tremendous attention from disciplines like Operations Research and Artificial Intelligence [1] throughout the years and optimization techniques are used to solve them and produce optimal or almost optimal feasible solution instead of exact solution [2].In universities however the semester timetable scheduling process has become very complex since there are three or four batches of students and many student groups and some of the student groups follow some of the courses together. There are some courses which are followed by all the students in a particular batch. When scheduling the timetable one has to make sure that there are no clashes among the student groups, lecturer and lecture halls. Large scale timetables such as university timetables may need many hours of work spent by qualified person or team in order to produce high quality timetables with optimal constraint satisfaction [1].

In this particular use case at the moment the facultyconsists of only two batches of students but there are three groups in first year batch and there are five groups in the second year batch. The reason for the different number of groups in the two batches is because when the students enrolled to the faculty they are enrolled in three streams as Information and Communication Technology (ICT), Engineering Technology (ENT) and Bio Systems Technology (BST). When they advance to the second year they can choose their favorite field. BST students can choose to do either Bioprocess Technology (BPT) or Food Technology (FDT) and ENT students can choose either Materials Technology (MTT) or Electrical and Electronic Technology (EET) while the ICT students continue as a single group. Therefore there are five departments in the faculty.

Faculty of Technology (FOT)was started as a department under the Faculty of Applied Sciences. It was started even without a building of its own. Still we are using the facilities of the Faculty of Applied Sciences and other faculties. Timetable scheduling has become more complex and time consuming than a typical scheduling problem because of this situation. The problem with doing it manually is that as the number of variables increases the complexity and difficulty of the task grows exponentially [3].

1.1 Literature Survey

There are many algorithms suggested in solving timetable scheduling problems throughout the years. Some of those algorithmsare discussed in the following section.

In "A Graph-Based Hyper-Heuristic for Educational Timetabling Problems" Burke, Mccollum, Meisels, Petrovic and Qu develop a graph based method for timetable scheduling and a Tabu Search approach is used to search for permutations of graph heuristics [4]. This approach was considered as a highly applicable approach when comparing to the literature at that time (2007).

"Solving University Course Timetable Problem Using Hybrid Particle Swarm Optimization" research focuses on generating a feasible timetable using the particle swarm optimization approach by satisfying hard and soft constraints. The algorithm has been validated using real data for university course timetabling problem [5]. The Particle Swarm Optimization (PSO) approach is also an evolutionary technique but it differs from the Genetic Algorithm approach. In PSO there is no DNA related genetic evolution but instead the process based on the experience gained by the particles.

Abdullah, Turabieh, McCollum, and Burke investigated a genetic algorithm combined with a sequential local search for the curriculum based course timetabling problem [6] in "An Investigation of a Genetic Algorithm and Sequential Local Search Approach for Curriculum-based Course Timetabling Problems". The algorithm consists of two stages as initial construction stage and improvement stage. The construction stage consists of three phases as largest degree heuristic, neighborhood search and tabu search.

In "Fuzzy Genetic Heuristic for University Course Timetable Problem",ArindamChaudhuri and Kajal De present Fuzzy Genetic Heuristic Algorithm to solve the problem [1]. The method incorporates Genetic Algorithms using indirect representation. The Fuzzy set method deals with the soft constraints violation. This approach has a significant improvement in satisfying soft constraints.

In this paper "Solving the class timetable problem by using genetic algorithm and tabu search algorithm"Premlata A. Sonawane, LeenaRagha discusses combination of two approaches genetic algorithms and Tabu search [2]. First in the algorithm they use the Genetic Algorithm approach to select the best chromosome with the better fitness value. Then the Tabu search algorithm is used to enhance the quality of the solution.

II. PROBLEM DESCRIPTION

Under the problem description, the problems face by the FOT are discusses.

- Timetables had to be adjusted according to the schedule of the other faculties from which the resources are shared.
- The staff is limited therefore some of the courses were facilitated by visiting lecturers.
- Their courses were needed to schedule at a convenient time for them according to their requests.
- Some of the lecturers are unavailable on some time periods
- We used Lecture halls in two different places it takes about fifteen minutes to go from one place to another. Therefore we had to consider that when arranging lectures.
- Students could not go back and forth to these two places. It is time wasting and not fair to students.

Timetable scheduling was a huge burden because of all the abovementioned problems. Manual Scheduling took so much time and the clashed occurred more often.

In timetable scheduling there are some of the constraints to be satisfied. There are hard constraints which should be satisfied no matter what to come up with a feasible solution and there are soft constraints which are not that essential to satisfy better to satisfy as much as possible[4]. The following constraints have been identified in order to find a feasible solution..

2.2 Hard Constraints

- No two courses can be scheduled at the same time for the same student group.
- No two courses can be scheduled at the same time in a particular lecture hall.
- A lecturer cannot be teaching two courses at the same time
- The lecture hall should have the capacity to hold the number of students following the scheduled course.
- Courses handled by other departments or visiting lecturers will be scheduled according to their requested time.
- Two practical sessions cannot be scheduled in one laboratory at the same time.
- Practical sessions should be scheduled in the requested laboratory.
- All the courses should be scheduled.

2.2 Soft Constraints

- Preferred time slots of the lecturers.
- Preferred lecture halls of the lecturers
- No lecturer should be overloaded with more than five lecture hours for a day.
- Lecturer may prefer to have free days
- Distance between the consecutive lecture halls
- Work Load of the students must spread throughout the week

III. INPUTS AND OUTPUTS

In this section the Inputs and outputs of the timetable scheduling algorithm are discussed.

2.2 Inputs

- Courses with Lecturer Student group, Student number, how many sessions, how many in one session, number of hours per week, department, hours together or apart
- Lecture Halls with Capacity and available time slots, venue
- Lecturer with available time slots

2.3 Outputs

Printable versions of the following types of timetables are needed as the output.

- Timetable of each department separately
- Timetable of each lecturer
- Timetable of each lecture hall
- Timetable of each laboratory

IV. TIMETABLE SCHEDULING ALGORITHM

- First of all the visiting lecturer with request on specific times need to be scheduled at that time as requested.
- Then focus on the practical sessions according to the availability of the laboratories as requested.
- Check whether parallel sessions can be scheduled in two laboratories. Ex: ICT and CS Labs (both are computer Labs).
- Then focus on the courses done by all the students of a particular batch.
- According to the case study since we have more students in the first year they have been considered before the second year students.
- Then focus on the courses done by more than one group of students and schedule them.
- At last the courses done by one group of students can be scheduled in parallel.

V. GENETIC ALGORITHM APPROACH

The basis of the Genetic Algorithm approach is natural selection. In this approach first of all the initial population is generated randomly. Then the fittest parents will be able to generate the next population. This is an optimization algorithm rather than finding the exact solution.

5.2 Representation

Population:

The population consists of a set of selected parent members. Each member is a fully prepared timetable.

[Member 1, Member 2, Member 3, Member 4, Member 5, …]

Member:

Member consists of timetables of all the available lecture halls.

[Chromosome 1, Chromosome 2, Chromosome 3, Chromosome 4, …]

Chromosome:

Chromosome consists of a time table of one lecture hall. In the following manner there are chromosomes relevant to all the lecture halls.

[Gene 1, Gene 2, Gene 3, Gene 4, Gene 5, …]

Table 1 illustrates the representation of Chromosome 1.

Table 1: Chromosome 1 (Timetable of Lecture hall 1)

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8.00 – 9.00	Gene 1	Gene 11	Gene 21	Gene 31	Gene 41
9.00 – 10.00	Gene 2	Gene 12	Gene 22	Gene 32	Gene 42
10.00 – 11.00	Gene 3	Gene 13	Gene 23	Gene 33	Gene 43
11.00 -12.00	Gene 4	Gene 14	Gene 24	Gene 34	Gene 44
1.00 – 2.00	Gene 5	Gene 15	Gene 25	Gene 35	Gene 45
2.00 – 3.00	Gene 6	Gene 16	Gene 26	Gene 36	Gene 46
3.00 – 4.00	Gene 7	Gene 17	Gene 27	Gene 37	Gene 47
4.00 – 5.00	Gene 8	Gene 18	Gene 28	Gene 38	Gene 48
5.00 – 6.00	Gene 9	Gene 19	Gene 29	Gene 39	Gene 49
6.00 – 7.00	Gene 10	Gene 20	Gene 30	Gene 40	Gene 50

Gene:

A time slot was represented as a gene. Within that time slot ID for the course, Lecturer and Student Group are mentioned.

For an example the first gene of the chromosome represents the course and the lecture hall which is relevant for Monday 8.00 a.m. to 9.00 a.m. time slot.

[Course, Lecturer, Student Group]

Altogether we have

- 50 genes in one chromosome.
- 10 chromosomes for the 10 lecture halls in one member
- There can be any number of members in a population.

5.3 Fitness Evaluation

Fitness value of each of the memberswere calculated such that, they satisfy all the hard constraints and soft constraints as much as possible. When the number of satisfied constraints increases the quality of the member increases [2]. Therefore the fitness value increases as well.

5.4 Parent Selection

The members with the best fitness values were selected to procreate. The number of parents to be selected can change according to your requirement. Sometimes the best solutions could be there in the initial population as well. Therefore if such solution is identified then they were preceded to the next generation without going through the crossover and mutation process.

5.5 Crossover

Crossover is the method that is used in GA to reproduce. The selected members were taken two by two and mated to create a new member.

5.6 Mutation

Mutation is a genetic operator that changes the gene sequence by altering one or more gene values in a chromosome from its initial state to reproduction state and may be able to arrive at better solution [2].

5.7 Flowchart

Fig.1 shows the flowchart of the proposed algorithm.

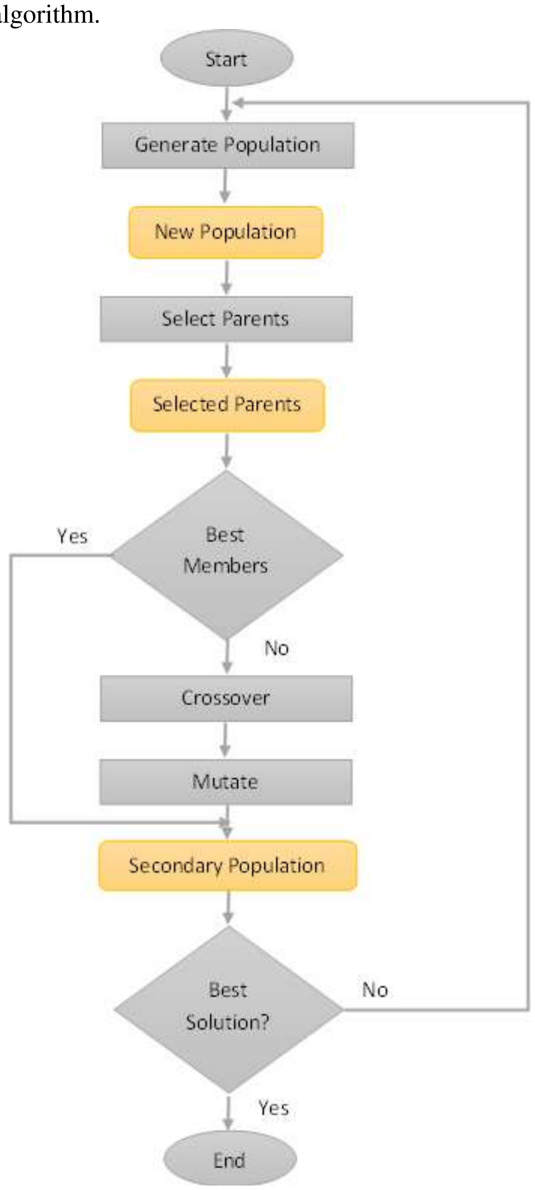

Figure 1: flowchart of the algorithm

5.8 Algorithm

- First of all generate the initial population.
- Evaluate the fitness of all the members in the initial population and select the better members to carry on the generation.
- If the selected parents have higher fitness value above from a decided value then they are passed to the secondary population without crossover or mutation.
- The rest of the members (selected parents) are going through cross over.
- In the crossover process we select chromosomes two by two and select a random crossover point and do the crossover.
- Mutate the new population according to a selected percentage
- If the solution is the best solution which satisfies all the hard constraints and the soft constraints finish the algorithm.

VI. CASE STUDY

6.2 Student Group Representation

Seventeen number of student groups were identified who followthe courses. Students are enrolled in the first year in 3 basic streams. In the first year, they are ICT, BST and ENT. A subset of subjects is followed according to the stream. There is another subset of subjects followed by all of the students. Some other set of subjects are followed by only ENT and BST students while some set of subjects are followed by only ICT and ENT students. No subjects are followed by only ICT and BST students. Therefore six groups of students were identified according to the above theory. Fig. 2 shows the numbering of first year student groups.

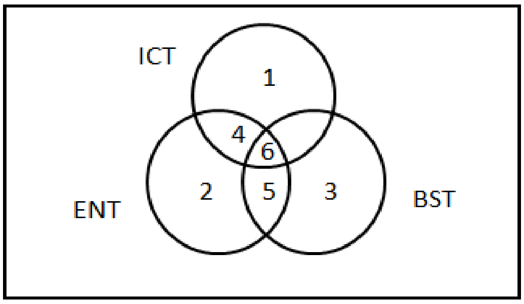

Figure 2:first year student groups

When the students are in their second year ENT students can choose either MTT or EET and BST students can choose to do either BPT or FDT while all the ICT students follow the same course. In the second year batch we have five different groups of students. They follow separate course as well as combined courses. From the second year batch eleven groups were identified. Altogether there wereseventeen groups of students. Figure 3 shows the numbering of the second year student groups.

6.3 Time Slot Representation

The following method represents the time slot of the hours of the week. There areten hours in one day and altogether fifty hours in one week. Using this representation it is easier to identify the available timeslots of lecture halls as well as lecturers. Table 2 illustrates the time slot representation.

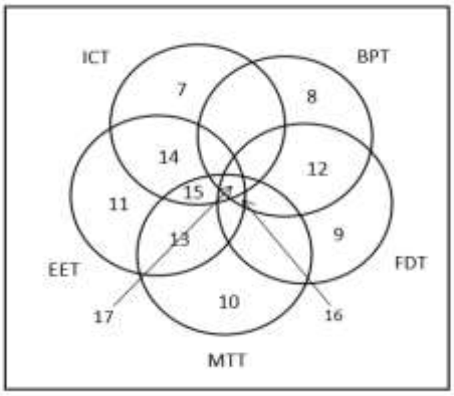

Figure 3:second year student groups

Table 2: Time Slot Representation

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8.00 - 9.00	1	11	21	31	41
9.00 - 10.00	2	12	22	32	42
10.00 - 11.00	3	13	23	33	43
11.00 - 12.00	4	14	24	34	44
1.00 - 2.00	5	15	25	35	45
2.00 - 3.00	6	16	26	36	46
3.00 - 4.00	7	17	27	37	47
4.00 - 5.00	8	18	28	38	48
5.00 - 6.00	9	19	29	39	49
6.00 - 7.00	10	20	30	40	50

6.4 Lecture Hall Representation

Lecture halls used are in two separate places. Some of the lecture halls are in Faculty of Applied Science premises and the other lecture halls are in Faculty of Social Sciences premises.

Students have to go back and forth. That information was considered when scheduling. If the students are in the faculty of Applied Sciences in the previous lecture, then the algorithm look for the lecture rooms in the same venue when scheduling the next lecture.

An ID number was given for each lecture hall. Since the lecture halls do not belong to the FOT available time slots had to be considered as well. Above mentioned time slot representation were used when identifying the available time slots.

6.5 Lecturer Representation

In the data table of the lecturers an ID was identified as the primary key. Lecturer information consists of the Name of the lecturer, Department attached to, Available time period. Preferred time periods and preferred lecture halls.

6.6 Course Information Representation

Course information was gathered according to the following criteria.

Course Code, Course Name, Lecturer or Lecturers in charge of the course, Student Group, Theory/Practical, Preferred Time, No of Sessions, No of Hours, Lab Required.

There were some visiting lectures which need to be scheduled on a given time because of the availability of the lecturer. These lectures should be arranged according to their requests.

VII. RESULTS

The proposed algorithm was programmed using python programming language. Following are the constraints used in implementing the algorithm.

Population Size: 80
Crossover Probability: 0.8
Mutation Probability: 0.02
Crossover Type: Two Point

The algorithm was tested using the real data of the Department of ICT of the Faculty of Technology. The algorithm satisfied all the hard constraints and 60% of the soft constraints. The algorithm performed well when the above mentioned constraints were satisfied. Using the above algorithm all the types of outputs which were mentioned in the section named Inputs and Outputs were able generate.

VIII. CONCLUSION

The Timetable scheduling problem has been tackled through a genetic algorithm based generalized approach [7]. The class timetable scheduling consists of allocating a set of courses followed by a different student groups and teach by different lecturers in to a limited set of lecture halls and laboratories considering Hard and Soft constraints. Genetic Algorithm approach is one of the efficient ways to come up with a feasible solution. The genetic algorithm gives the optimized solution to the timetable scheduling problem.

IX. FUTURE WORK

The algorithm will be improved further in two different areas. They are:

- **Examination timetable**

Examination timetable will focus on the end semester examinations. Scheduling of exam halls, scheduling of supervisors, invigilators and hall attendants will be considered in this.

- **Timetable Reservation**

Another aspect is timetable reservation. In that case the users are able to request to reserve free time slots of lecture halls. Users can cancel the already scheduled timeslots if the lecture is postponed. This will be a dynamic allocation.

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