Solving the class timetable problem by using genetic algorithm and tabu search algorithm

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Abstract —The Class Timetable scheduling problem deals with the assignment of classes to a limited set of resources such as rooms, timeslots, set of lecturers and group of students in such a way to satisfy predefined constraints. All hard constraints must be satisfied, to obtaining a feasible solution. This problem is in class of NP-hard problem and is very difficult to solve by classic algorithm. Therefore optimizations techniques are used to solve them and produce optimal or almost optimal feasible solution instead of exact solution. In this paper we present the research on class timetable scheduling and to solve this problem we have used two search algorithms i.e. Genetic Algorithm (GA) and Tabu search algorithm. Because GA has ability to handle a very complex search space with high probability of success in finding the optimal solution and Tabu search is used its memorized ability to prevent from searching previous visited area, therefore it is easier to obtain optimal solution in a short time. Here we have introduced the modified approaches which do not allow violations of any hard constraints, and it produces only feasible solutions. For the departmental class timetable fitness value is evaluated by solving room wise timetable and according to that reaming class wise, lab wise and faculty load wise time table is being sorted and finally we got the feasible departmental class timetable

Keywords: Genetic Algorithms, Tabu Search Algorithm, Timetabling, Constraints

I. INTRODUCTION

Scheduling [5]-[7]-[9] and planning are most difficult problems with a long and varied history in the areas of operational research. Scheduling problems are challenging as there is no agreed technique for representing the problem or a solution as individuals. Scheduling problems belong to the class of combinatorial optimization problems. A combinatorial optimization problem is either a minimization or maximization problem and consists of (1) a set of instances, (2) a finite set of candidate solutions for each instances, and (3) a function that assigns to each instance. These combinatorial optimization problems are solved by finding optimal solution for each instance of the optimization problem. These problems are NP-hard [3]-[5]-[7]-[16]-[19] and it is extremely unlikely that someone could find an efficient method (i.e. a polynomial algorithm) for solving them exactly. There are some different scheduling problems such as, Job-Shop Scheduling Problem [7]-[11], Processor Scheduling Problem, Timetable Scheduling Problem [5]-[12]- [14]-[15].

The timetable scheduling problem is computationally a NP-hard problem and has been modeled as constraint-satisfaction problem (CSP); therefore, it is very difficult to solve using conventional optimization techniques. Timetabling problem have been widely studied due to their wide range of applications, such as the flight timetable problem, employee timetabling problem[9], universities[3]-[16]-[18] or high school timetabling problem[19]. Here we have tried to solve the class timetable scheduling problem, which is the planning of allocating a number of subjects into a set of timeslots and resources (rooms) while respecting some other constraints. Many of these problems are tackled in manually which is a tough and time consuming task. In addition, the solution obtained may be unsatisfactory in some aspect. The impact of generating a timetable manually was when preconditions change; then whole work becomes unusable and has to be restarted from scratch. Therefore, the aim of this research is to describe and experimentally verify the Genetic Algorithm [1]-[3]-[4]-[5] and tabu search algorithms [11]-[16] which is applicable to class timetable problems. Moreover, with such an algorithm, we would like to tackle a real-life class timetable problem of institute by minimizing the violation of constraints. There are many research has developed several heuristics approach to solve the timetabling problem like graph coloring algorithm [17], Ant colony optimization, Simulated Annealing [3]-[6], Constraint Satisfaction, local search methods particle swarm optimization (PSO)) [2] etc. A large number of diverse evolutionary methods have been already proposed by many authors in the literature for solving timetabling problems.

II. LITERATURE SURVYE

There are several algorithms have been suggested to timetable scheduling problems.

Ho Sheau Fen, Deris, Safaai, Mohd Hashim, Siti Zaiton solved the timetable scheduling problem by using a hybrid of particle swarm optimization approach [2]. They have used two different kinds of hybrid PSO for experiment purpose. The hybrid PSO-local search (LS) and hybrid PSO-constraint-based reasoning (CBR). As shown in their result the hybrid PSO-CBR algorithm is capable in finding feasible and near-optimal solution compare to hybrid PSO-LS and standard PSO algorithm, but it requires more time i.e. hybrid PSO-CBR slightly longer than hybrid PSO-LS because of backtracking solutions.

Vibhor Bhatt, Ritvik Sahajpal solved the Lecture Timetable problem by using Hybrid Genetic algorithm [5]. The soft constraints consider according to satiability (SAT) factor. And theirs result shows that by using this technique make good and convenient timetable and also decrease the computational time for this Np-hard problem. There concept of optimizer is new but does not cover the entire frequently occurring situation.

Abdullah, Turabieh, McCollum, and Burke investigated a genetic algorithm combined with a sequential local search for the curriculum based course timetabling problem [12]. The problem solved by the construction phase and the improvement phase. After the recombination process, a repair method is applied to transform an infeasible solution to a feasible one.

After studying many heuristics methods for timetabling problem we found that the Genetic Algorithm can handle both continues and discrete optimization problems, it has the advantageous over other search algorithm and it is one of the powerful global optimization technique. And another algorithm is Tabu search is one of the most efficient heuristic techniques in the sense that it finds quality solutions in relatively short running time. So in our class timetable problem we will combine the advantageous of both Genetic algorithm and Tabu search algorithm to satisfy the hard and soft constraints and to reach the optimal or near optimal solution.

Here we have solved the class timetable problem by using Genetic algorithm and Tabu search algorithm. The paper is organized as follows; the next section introduces the class timetable problem with a set of all hard and soft constraints. In section IV we represent our Genetic and Tabu search Algorithm and in section V represent main concepts about proposed algorithm, in section VI shows the result and finally conclusion are represented in section VII.

III. PROBLEM DESCRIPTION

The Class timetable scheduling problem consists of a set of classes that are to be scheduled into a set of timeslots and a set of rooms and also consists of a set of constraints that are expected to be satisfied. The general timetable problem can be expressed as , a number of events (class) must be timetabled by associating them with the timeslots. In class timetable, a set of events is scheduled into a fixed number of rooms and timeslots within a week. The problem presents a set of N class to be scheduled in 5 days of a week and of 9 periods each, which time T=45 timeslots, among of that 40 timeslots for theory and laboratory work of the particular department. Remaining hours for the launch break and extra curriculum activity.

Set R= Rooms (each with set of F feature and capacity).
Set P= Number of Professors/ Lecturers.
Set G= Group of Students who attends the classes.
Set S= Require Seats of classroom.
Set L= Require Lab Equipment in Laboratories

Each student attend a subset of classes solution in which all classes are assigned to periods and rooms and satisfy all hard constraints are called feasible solution.

A. Hard constraints

H1: No student can be assigned to more than one class at the same time.

H2: The Room should satisfy the all the features required by the course.

H3: No more than one class is allowed at a timeslot in each room

H4: No lecturer should have different classes at the same timeslot.

H5: No faculty must be overloaded with more than four timeslots in a day.

H6: The number of student of the class should be less than or equal to the capacity of the room.

H7: Certain timeslots must be reserved for the special activities.

H8: Sufficient or more enough number of rooms and labs available for the classes.

H9: Lab should not be allotted by more than one class.

H10: If Lecturer of the class is not available to teach that course at a given period then that lecture can be utilized for extra activity like Group discussion, Aptitude tests etc.

H11: To allocate the lab hour to particular class group the lab should have sufficient equipment.

B. Soft constraints

S1: Professor /Lecturer may prefer the timeslots.

S2: Professor /Lecturer may prefer the classrooms.

S3: Subjects handled by other department lecturers will be allocated based upon the timeslots requested/given by that lecturer.

S4: Each class assigned to the professor that is in his area of expertise.

S5: The attendance of each student per day must be satisfied by maximum number of hour.

IV. GENETIC ALGORITHM AND TABU SEARCH ALGORITHM IMPLEMENTATION

A. A Genetic Algorithm

Genetic Algorithms [10] are metaheuristic methods based on Darwin's theory of evolution that aims to find solutions to NP-hard problems. The GA to evolve an appropriate permutation and then use a heuristic method to construct feasible solutions according to the permutation, so as to satisfy the hard constraints and soft constraints. GA techniques can be applied to our class scheduling problem is as follows.

1. Initialize the maximum number of generations and generation count
2. Generate the random initial population.
3. Evaluate the fitness value of each chromosome.
4. Perform reproduction operation by using Tournament selection.
5. Evaluate the fitness of each chromosome.
6. Select the parents of two chromosomes and perform two point crossovers.
7. Calculate the fitness of each chromosome.
8. Perform the Mutation operation.
9. Increment the generation count.
10. Repeat the step 2-9 till feasible fitness value is reached.

1) Chromosome Representation

Each individual chromosome is, in itself, a time table. This means that every chromosome [1]-[10] would carry a large amount of data- regarding subjects, faculty, and rooms allotted to each slot for each student group. The structure of the chromosome would be a 5 x 9 matrix, since it must represent a time table for a 5- day week, with 9 allotted time slots per day. So total working timeslots are 45 among of that any 5 slots half hour is reserved for launch or utilized for extra curriculum activity or regular lecture and that is depend on professors. The table 1 shows Room wise timetable and colored slot shows practical hours.

TABLE 1.THE ROOM WISE TIMETABLE

Room No: 105

Days / Timeslots	Mon	Tue	Wed	Thu	Fri
9-10	Sub Prof. Class		Sub Prof. Class		
10-11					
11-12					
12-13					
13-13.30	Launch Break				
13.30-14.30	Sub Prof. Class				
14.30-15.30					
15.30-16.30					
16.30-17.30					

2) Fitness Evaluation

The fitness value of each individual determined by all hard constraints must be satisfied and it should minimize the violations of soft constraints. As the number of the constraints that a chromosome satisfied increases, so does the chromosome's quality. The fitness value can be calculated as schedule_score/maximum_score, and maximum_score is number_of_classes*5.

3) Selection Operator

The Selection [3]-[10]-[18] process is based on fitness values. In our GA algorithm we select the Tournament selection strategy provides selective pressure by holding a tournament competition among N individuals. The best individual from the tournament is the one with the highest fitness, which is the winner of N individual.

4) Crossover Operator

Crossover [3]-[4] is a primary genetic operator that used to mate two chromosomes (parents) to produce a new chromosome referred as offspring in the next generation according to a user-definable crossover probability. In our algorithm two point crossover operator combines data in the hash maps of two parents, and then it creates a vector of slots according to the content of the new hash map.

5) Mutation Operator:

Mutation [3]-[4]-[10] 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.

B. Tabu Search algorithm

Tabu search (TS) [9]-[11]-[15] is another evolutionary heuristic that updates a single solution. The idea behind TS is to start from a random solution and successively move it to one of its current neighbors.

1. Generate initial solution x.

2. Initialize the Tabu List.

3. While set of candidate solutions X‟ is not complete.

3.1. Generate candidate solution x‟ from current solution x

3.2. Add x‟ to X‟ only if x‟ is not tabu or if at least one Aspiration Criterion is satisfied.

4. Select the best candidate solution x* in X‟ .

5. If fitness(x*) > fitness(x) then x = x*.

6. Update Tabu List and Aspiration Criteria

7. If termination condition met finish, otherwise go to step 3.

1) The Tabu List

The tabu list [9]-[11]-[15] in which tabu moves or attributes of moves are listed. Short tabu lists may not prevent cycling resulting in information loss while long tabu lists may excessively prevent neighborhood so that moves are limited to some extent.

V. THE PROPOSED ALGORITHM

Fig.1. shows a pictorial illustration for the view of combination of genetic algorithms and Tabu search. The sequence of our proposed method starts from initial solutions. Applying genetic algorithms as a second step, finally applying Tabu search mechanism to enhance the quality of solution. In our implementation the each generated chromosome by GA is a solution and that will be goes through crossover and mutation operation after every mutation, solution comes at tabu list and among of them best chromosome will be selected as a best solution with the better fitness value.GA is one of the best known methods of global optimization, combining both algorithms means combine the advantages of both algorithms for solving the class timetabling problem. The structure of the proposed algorithm is as given bellow.

1. Create initial population as randomly.

2. For each chromosome in current population do.

2.1. Calculate its fitness value of current chromosome.

2.2. Apply tournament selection to the selected chromosomes.

2.3. Apply two point crossovers.

2.4. Apply Mutation and calculate fitness of this chromosome.

3. If best chromosome with best fitness value is found.

4. Then insert the best solution of GA into Tabu List.

5. While Stop condition is satisfied

6. Evaluate the best solution.

7. Until population size is complete.

8. Finally get the optimal solution.

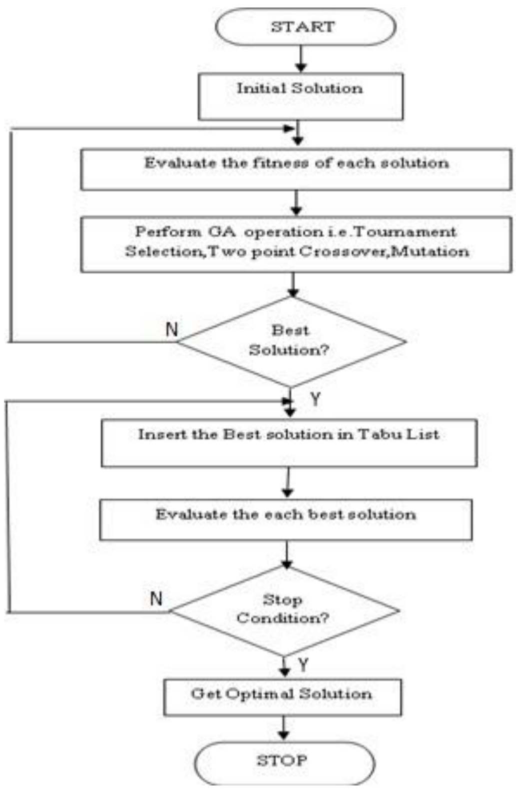

Fig.1. Flowchart for proposed algorithm

VI. RESULT

The proposed algorithm was programmed using VC++ 2008 and java 1.6 and tested over Intel core 2 Duo CPU. Table 3 shows the parameter for the GA

TABLE 2. PARAMETER SETTING FOR AN ALGORITHM

Parameter	Value
Population Size	81
Crossover Rate	2%
Mutation Rate	2%
Crossover Probability	0.8
Mutation Probability	0.03
Selection Method	Tournament
Crossover Type	Two point

We applied the real data of computer engineering department to our proposed algorithm and the algorithm satisfies all hard constraints and minimizes the violation of soft constraints. Our algorithm is best when the size of population is less than 70 and it takes minimum time for execution and fitness value calculation. To calculate the fitness value of each chromosome, hard requirement are used to calculate the fitness of class schedule. Our proposed algorithm is best to automatically sort the data room wise, class wise, lab wise and faculty load wise etc.to display the final timetable for institution. With the population size 81 it calculate 113289 generations and 1.000000 fitness values and satisfies all constraints to generate the optimal solution for class timetable.

VII. CONCLUSION

The Class timetable scheduling problem consists of allocating a number of courses or classes to a limited set of resources such as rooms, time slots, set of lecturers and group of students in such a way to satisfy predefined hard and soft constraints within efficient running time. The Genetic Algorithm and Tabu Search provide a great flexibility of use when it comes to solving combinatorial problem. We exploited this flexibility to design algorithms capable of generating timetables for any type of academic institutions, a problem intractable for approximation. The idea of hybridizing of GA and TS stems from our desire to reap the benefits of both methods, the simplicity of use of GAs and such ability to jump out from local optima through a more diversified and balanced search and its memorized ability to prevent from searching previous visited areas as provided by TS. As from the result, our proposed algorithm method capable to produce the good quality of solution for constraint based optimization problems.

VIII. FUTURE WORK

As a future extension to class timetable scheduling work will be about simultaneously generation of three to four practical batches of class.

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