A Local Search Approach to Solve Teacher to Examination Sections Scheduling Problem in an Iraqi School

Dalia Sami Jasim
Daliasami99@gmail.com

,

Abstract : **assigning teachers to examination sections is a type of Proctor Assignment Problem (PAPt) that require scheduled a timetable. assigning teachers to examination sections involves assign a teacher for each section and finally come up with list of (teacher-section) and list of teachers names that free of duty for same day Taking into consideration hard and soft constraints . To solve this problem we proposed a simulated annealing local base technique. we proposed an appropriate neighborhood structure for our problem by searching the problem space to exchange the values that make the solution far from feasible with values that make the solution near to optimality this heuristic behavior of our neighborhood structure is the main factors leads us an optimal solution. The performance of our approach is tested over one of biggest schools in Babylon province , Iraq ,this school contains 43 sections versus 50 teachers . Experimental results show that our approach is able to generate successfully the required timetable.**

Keywords- **timetable scheduling; simulated annealing; local search.**

INTRODUCTION

The development of the personal computer in terms of software and hardware and its entry into all institutions in Iraq including schools, at the same time , the presence of researchers as teachers in Iraqi schools all this made the problems in Iraqi schools a new fields for research. One of the nowadays problems in Iraqi schools is the increasing number of students versus an almost fixed number of teachers, this issue led to many problems that the staff suffers from.

One of these problems is assigning teachers to examination sections. What complicated the problem is the increasing number of examination sections to fit the increasing number of students and we have to assign a teacher to every section. Hence, we are confronting a timetable scheduling problem , scheduling is characterized as the allocation of resources over time to carry out a collection of tasks [1] and the objective is to allocate a set of entities to a limited number of resources over time, in such a way to meet a set of predefined schedule requirements. Our problem belongs to Academic Scheduling Problems that can be categorized into two different types which are either course or exam timetabling [2].examination timetable is a multidimensional assignment problem that educational institutions necessity to solve orderly. They need to assign exams to time slots in a particular interval and at the same time assign rooms as well as invigilators to exams to satisfy diverse and complex constraints [3]. This problem is a type of Proctor Assignment Problem (PAPt) where a university assigning teaching assistants to serve as a proctor in final exams. A (PAPt) problem is an NP-hard problem [4]. Nearly the optimization techniques have been adopted in all

domains to discover best solution from the feasible solutions.

It is NP-hard to solve problems with partial information and few assumptions. Different meta-heuristic techniques are utilized to optimize the solution of NP-hard problems [4]. Many papers described the usage of meta-heuristics methods to solve the Academic Scheduling Problems, in [5] researcher formulated the problem as a mixed-integer program with a single objective and carried out a scatter search solution procedure. [6] Developed a hybrid genetic algorithm (GA) solution for the initial assignment problem. Also [7] used a mixed integer programming to formulate the assignment problem, and to derive an optimal assignment the researcher developed a prototype system based on spreadsheet software.

In Iraqi schools, the exam is conducted twice a year in the middle of the academic year for ten days and in the end of the academic year also for ten days. Scheduling teachers to sections are carried out by the school staff before starting the exam in a short time to update the list of teachers to record changes in the teaching staff. According to the opinion of experts in this field, every day takes between two to three hours of preparation, all this lead to time-consuming and inaccurate scheduling.

In this paper, we propose a local search approach using Simulated Annealing algorithm to solve teachers to sections scheduling problem.

several researchers used Simulated Annealing to solve timetable scheduling problem, [8] came up with an approach includes instead of swapping two assignments as in a standard Simulated Annealing, a series of swaps between pairs of time slots performed heuristically. A new structure of the neighborhood solution was proposed to find the best neighbor. This experiment using the proposed heuristic show that this strategy is better than existing approaches.

the researcher in [9], Integrate the Honey Badger Algorithm (HBA) with sand cat swarm optimization (SCSO) to address the limitations of the HBA, thereby enhancing the quality of the solutions. The SCSO is capable of efficiently identifying optimal solutions.

[10] Employed a Dual-sequence Simulated Annealing algorithm as an improvement algorithm. To control the selection of neighborhood structures within the Dual-sequence Simulated Annealing. The Round Robin (RR) algorithm was utilized. The performance of the proposed approach is tested over 11 benchmark datasets. Experimental results show that this approach is able to generate competitive results when compared with other state-of-the-art techniques.

[11] outlines the creation of a web-based course scheduling system that employs an advanced genetic algorithm. The improved approach incorporates a heuristic mutation that specifically targets the alteration of infeasible genes, thereby enhancing the algorithm's ability to explore and exploit solutions effectively.

[12] Applied the Simulated Annealing algorithm for the nurse scheduling problem. The results of experiments showed that more accurate solutions can be obtained from Simulated Annealing algorithm. Also, applied SA offers meaningfully better solutions in a reasonable time compared to other methods.

In the same context, we used Simulated Annealing algorithm to convert manually scheduling of assigning teachers to examination sections to a computer problem gives us an accurate result for all ten days of the exam within 2 seconds.

Transforming manually problems into computer problem in Iraq schools is a new step toward Exploit time and experiences that already exist in Iraqi schools, what is important here is the right accomplishment to these problems in an efficient way by computer programming and artificial intelligence tools to be a compelling reason for this transformation.

MATERIALS AND METHODS

1. PROBLEM DESCRIPTION

In this study we examined one of biggest schools in Babylon province, Iraq ,this school contains 43 examination sections versus 50 teachers; we have ten days of exam every day we have to assign a teacher to each section and at the same time every teacher have to be out of duty for at least one day. Finally come up with list of (teacher-section) and a list of teachers names that free of duty for same day.

For this problem we have two type of constraint hard constraint that is :

1- Teacher name must not appear twice in a single day.

2- Exact teacher name must not appear in the same section for all ten days.

And we have a soft constraint that is every teacher has to be free of duty for one day at least. An improvement in the quality of any solution for the timetabling problem is concerned with the minimization of soft constraint violations, which includes the number of teachers affected by the violations. The objective cost function is calculated as the sum of the number of violations of the soft constraints, in our problem it will be:

$$\sum (\text{reptetion\_exact\_teacher\_name\_for\_all\_ten\_days}) <= 9.$$

2. META-HEURISTIC

Solving hard problems considerable a research challenge which could not be effectively addressed by the exact or heuristic methods. This lead to the application of meta-

heuristic or hybrid meta-heuristic approaches in the recent past. These hybrid meta-heuristic approaches are said to be superior in giving an optimal or at least feasible results within a specific time period [13]. Meta-heuristic techniques are divided into two classes:

First one is the local search based methods that deals with a single object in one iteration .local search based techniques are also called single solution based techniques. In this approach, a single solution is created, and then modified using local search. Simulated Annealing is one of the local search based method [14]

The second one is local search with population based search: Population-based optimization algorithms are

nature-inspired usually locate a near-optimal solution to optimization problems. Every population-based algorithm has the common characteristics of finding out a global solution to the problem. A population begins with initial solutions and gradually moves toward a better solution area of search space based on the information of their fitness [15].

3. SIMULATED ANNEALING

Simulated Annealing is a local search method and was first introduced by [16] which mimic the principles of the metallurgy of metals boiling and cooling to achieve a fixed crystal lattice structure with lower energy state. The algorithm initializes by generating an initial random solution. After that, an adjacent solution is being generated and these two solutions will be evaluated by an objective function. If the cost of the neighbor is lower than the cost of the initial solution and lowers the energy of the system, the neighbor will be accepted as an improved solution. As for a non-improving solution, it will gradually be accepted with a probability value given by a probability function. In SA, the performance of the algorithm is highly dependent on its parameters.

Well explored neighborhood gives us the chance to good quality solutions to be obtained as demonstrated in the works of [17].We used the Simulated Annealing algorithm that presented in [18] and the pseudo code for the used Simulated Annealing algorithm is illustrated in figure 1.

We use the same parameters as in [18] where the initial temperature *T0* is equal to 5000 and the final temperature *Tf* is equal to 0.05. The number of iterations, *NumOfIte* is set to be 10000000 at every iteration, *T* is decreased by a where a is defined as:

a = (log (*T*) – log (0.05)) / *NumOfIte*

```
Generate initial solution S ;
Calculate fitness, f(S);
Set best solution, Best ← S;
Set number of iteration, NumOfIte;
Set initial temperature T0;
Set final temperature Tf;
Set decreasing temperature rate as α
where
α= (log (T0) – log (Tf))/NumOfIte;
Set currT ← T0;
Do while (currT > Tf)
Generate neighborhood solution S';
Calculate f(S');
If (f(S')≤ f(best)) then
S ← S';
Best ← S';
Else
Generate a random number R;
C=f(S')-f(S);
If (R ≤ exp (-C/currT) then
S ← S';
cuurT = currT- currT *α;
End do;
```

Fig1 the pseudo code for Simulated Annealing

In the do-while loop, a neighbor is defined by exchange the number (represent teacher) that repeated for ten times with numbers that repeated less than 9 times. A worse

candidate solution is accepted if the randomly generated number, *Random Number*, is less then *e*-d/*T* where is a difference between the quality of the old and new solutions (i.e. d = *f*(*Sol**) – *f*(*Sol*)). The process continues until the temperature *T* is less than the final temperature *Tf*.

5. SOLUTION STRUCTURE

In this paper, to generate an initial solution we follow a strategy that leads us to satisfy hard constraint , so with consideration of not violated the hard constraint with every new assignment we check if it violates the hard constraint to replace this assignment with another randomly initiate assignment and so on until finish all the assignment matrix, finally we will get a solution that satisfies hard constraint and ready to put it in Simulated Annealing algorithm trying to satisfy soft constraints and reach an optimal solution.

We represent our solution as a two-dimensional matrix that it is columns from 0 to nine refer to the ten days of the exam, the rows from 0 to 42 refer to the sections and the cells of this matrix is the teacher's ID numbers that represented as integers from 0 to 49.

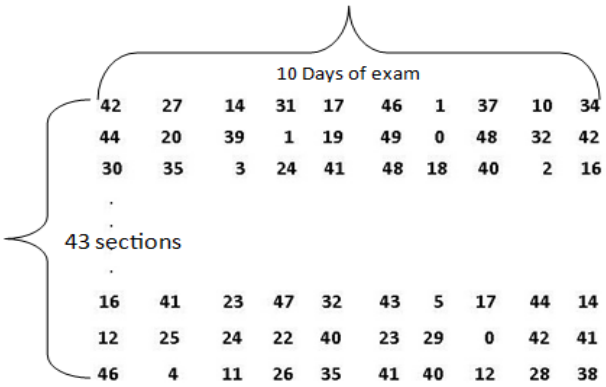

Fig2 solution structure

6. FITNESS FUNCTION

The objective function considered in this paper minimizes the number of teachers that assign to examination sections for 10 times, because every teacher has to be out of duty at least for one day ,we solved this issue by generating neighborhood solution with this consideration.

In order to generate a neighborhood that trying to satisfies the soft constraint, we presented an approach to deal with this problem by exchanging the teacher ID that we represent it as a numbers from 0 to 49,so if it repeated for ten times (there is no out of duty day for this teacher), we explore our solution to find a teacher that repeated less than nine times to replace it with this teacher ID that appears for ten times ,and at same time not violated the hard constraint, if this replacing process come up with violated the hard constraint ,we have to find another teacher ID to replace it with the present ID , in this way we may reach the optimality or not , because for some implementations we cannot find teacher ID that not violated the hard constraint so in this way we cannot reach a feasible solution .

7. RESULTS and DISCUSSION

We built our program step by step using JAVA language by NetBeans IDE 8.2 Platform, we used a local search algorithm Simulated Annealing to deal with assigning teachers to examination sections problem, the result of many times execution versus the number of iteration for each implementation represented in the figure3:

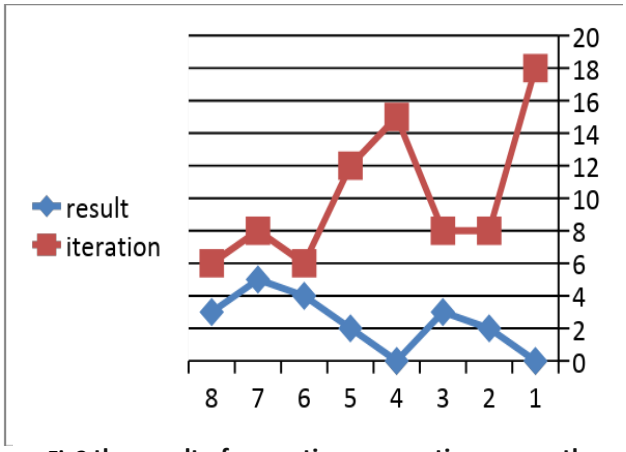

Fig3 the result of many times execution versus the number of iteration for each implementation

The behavior of Simulated Annealing algorithm that it is able to escape local optimum by allowing some "bad" moves make our program reach an optimal solution for some implementations, at same time The choice of an appropriate neighborhood structure is crucial for the performance of the local search algorithm and has to be done in a specific way.

The problem key-specific choice concerns the neighborhood function definition. The efficiency of Simulated Annealing is highly influenced by the neighborhood function used. In this work we proposed an appropriate neighborhood structure in order to solve this problem by searching the problem space to exchange the values that make the solution far from feasible with values that make the solution near to optimality this heuristic behavior of our neighborhood structure is the main factor leads us to an optimal solution. The designated program produce a matrix that represents the solution (figure 4 give an example of this result) .we design a function that converts every integer value to a Corresponding text.

every column in the matrix refers to an examination day, every row in the matrix represent an examination section and every cell in matrix represent a teacher id, after reading a file of all teachers names we can Match every id to a teacher.

In this way The final step of our program is the came up with a text file that contains a schedule for all ten days of exam, this text file contains: sections numbers, teacher names for every section and a list of out of duty teachers names for every day, figure 5 shows an example of a single day from the text file that our program come up with.

In our approach, we found an optimal solution with the Simulated Annealing algorithm, and this solution used to solve real life problem of assigning teachers to examination sectors. We presented our result to the staff of the school that responsible for preparing the schedule of the teachers to examination sections in this school and our result satisfies all the persons in charge and it is very practical because of the Indiscriminate nature of the solution we can get a different teachers list every time of execution.

44	17	38	34	39	22	23	16	41	35
20	28	22	13	12	49	37	48	16	42
42	0	26	14	5	16	13	37	3	1
29	13	17	27	10	43	22	42	23	5
30	23	28	6	31	7	1	38	27	46
39	4	34	24	21	18	14	7	26	9
9	12	31	21	30	17	38	20	34	15
27	37	1	18	9	32	26	41	10	29
46	20	27	12	22	23	8	47	32	48
41	42	25	11	3	19	15	33	43	36
13	30	2	8	42	46	48	3	7	18
11	49	0	4	35	39	31	8	45	19
35	33	14	47	1	9	49	5	24	12
21	41	9	3	32	34	47	15	29	28
5	29	47	40	4	24	19	17	1	45
1	2	45	28	25	31	17	35	6	41
8	47	24	17	18	36	10	2	12	6
28	10	46	16	49	12	7	32	22	33
10	9	48	31	44	8	5	24	25	4
6	48	4	37	33	5	43	23	9	39
16	24	33	0	14	15	34	13	28	27
37	38	15	42	17	40	3	29	14	43
14	11	44	36	29	20	24	12	4	38
40	21	39	29	20	28	18	46	37	13
22	15	21	20	11	10	6	43	0	32
0	18	8	7	46	4	40	49	47	34
47	26	3	19	36	1	4	11	17	2
18	19	23	46	45	3	20	21	33	26
24	45	29	5	28	42	35	18	44	49
23	14	18	2	47	0	11	10	19	40
2	40	32	9	16	13	21	4	49	25
49	1	30	39	6	2	27	36	42	16
34	43	49	10	26	35	45	30	11	47
31	32	42	44	27	25	9	26	46	3
15	6	7	41	0	21	44	34	48	20
38	16	41	23	15	37	39	45	5	14
32	25	37	38	2	14	30	19	40	44
17	35	12	49	41	38	25	39	2	7
19	7	5	1	8	44	12	27	35	21
48	3	40	43	24	33	36	0	30	31
33	44	11	22	7	6	0	28	31	37
25	34	36	33	23	26	32	6	13	30
45	8	13	30	43	41	46	40	36	22

Fig4 the resulted integer matrix

CONCLUSION

This paper presented a local search algorithm for the teachers to examination sections assignment problem. We examined this problem on a dataset from one of the biggest Iraqi schools, we designed a program using JAVA language to solve this problem using Simulated Annealing algorithm, the program start with generating a new solution that satisfy the hard constraint then we adjust simulated annealing parameters to increase our chance to get fast feasible solution. In this work we adopted a sophisticated neighborhood structure that try to meet soft Constraint, our program came up with an optimal solution represented via an integer matrix. Last part of our program converted the integer solution to a text file that is ready to use in the targeted school (as presented in figure 5), and the random approach give us the opportunity to get different distribution for names every execution, this consider another positive point for this work.

Converted this problem from a manual solution that needs a lot of efforts to a computer problem is a good leap. In the Same context presented a good solution within 2 seconds considered a qualitative change in Iraqi schools.

As a future work, we need to work on course timetable scheduling for schools that take about two months to complete it, and schedule examination timetable the mid and final year exams.

REFERENCES

[1] Martín-Santamaría, Raúl,López-Ibáñez, Manuel,Stützle, Thomas, On the automatic generation of metaheuristic algorithms for combinatorial optimization problems, European Journal of Operational Research,vol328,2024.

[2] Sara Ceschia, Luca Di Gaspero, Andrea Schaerf, Educational timetabling: Problems, benchmarks, and state-of-the-art results,European Journal of Operational Research,Volume 308, Issue 1,2023.

[3] Atiyeh Modirkhorasani, Pooya Hoseinpour, Decentralized exam timetabling: A solution for conducting exams during pandemics,Socio-Economic Planning Sciences,Volume 92,2024.

[4] A. Amuthan ; K. D.Thilak, Survey on Tabu Search meta-heuristic optimization, Signal Processing, Communication, Power and Embedded System (SCOPES), 2016 International Conference on,2017.

[5] R. Martí, H. Lourenço and M. Laguna, Assigning Proctors to Exams with Scatter Search, Operations Research/Computer Science Interfaces Series book series (ORCS, volume 12),2001.

[6] R. M. Awad, J. W. Chinneck , Proctor Assignment at Carleton University, INTERFACES 28: 2 March–April (pp. 58–71), 1998.

[7] T. Koide , Mixed integer programming approach on examination proctor assignment problem , 19th International Conference on Knowledge Based and Intelligent Information and Engineering Systems,2015.

[8] D. Zhang , Y. Liu , R. M'Hallah , S. C.H. Leung , A simulated annealing with a new neighborhood structure based algorithm for high school timetabling problems , European Journal of Operational Research 203 550–558,2010.

[9] Seyyedabbasi, A., Tareq Tareq, W.Z. & Bacanin, N. An Effective Hybrid Metaheuristic Algorithm for Solving Global Optimization Algorithms. Multimed Tools Appl 83, 85103–85138 (2024).
[10] S. Abdullah, K. Shaker, B. McCollum, and P. McMullan, Dual Sequence Simulated Annealing with Round-Robin Approach for University Course Timetabling , P. Cowling and P. Merz (Eds.): EvoCOP LNCS 6022, pp. 1–10, 2010.
[11] Dexter Romaguera, Jenie Plender-Nabas, Junrie Matiasa, Lea Austero, Development of a Web-based Course Timetabling System based on an Enhanced Genetic Algorithm, Seventh Information Systems International Conference (ISICO 2023).

[12] H. Jafari d an N. Salmasi, Maximizing the nurses' preferences in nurse scheduling problem: mathematical modeling and a meta-heuristic algorithm , J Ind Eng 11:439–458 DOI 10.1007/s40092- 015-0111-0, Int 2015 .
[13] S. Muthuraman and V. P. Venkatesan , A Comprehensive Study on Hybrid Meta-Heuristic Approaches Used for Solving Combinatorial Optimization Problems , Computing and Communication Technologies (WCCCT), World Congress on,2017 .
[14] R. Ilyas and Z. Iqbal , Study of hybrid approaches used for university course timetable problem (UCTP) , Industrial Electronics and Applications (ICIEA), IEEE 10th Conference on,2015.
[15] S. Satapathy and A. Naik, Social group optimization (SGO): a new population evolutionary optimization technique , Complex Intell. Syst. 2:173–203 DOI 10.1007/s40747-016-0022-8 , 2016.
[16] S. Kirkpatrick , C. D. Gelatt and M. P. Vecchi, Optimization by Simulated Annealing, Science , New Series, Vol. 220, No. 4598. , pp. 671-680, 1983.
[17] M. M. Mafarja and Seyedali Mirjalili , Hybrid Whale Optimization Algorithm with simulated annealing for feature selection, Neurocomputing Volume 260, Pages 302-312, 18 October 2017.
[18] S. Abdullah and E. K. Burke , A Multi-start Very Large Neighbourhood Search Approach with Local Search Methods for Examination Timetabling , Conference: Proceedings of the Sixteenth International Conference on Automated Planning and Scheduling, ICAPS 2006, Cumbria, UK, June 6-10, 2006.