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" Enhanced Ant Colony Algorithm with Tabu Search and Memory Solution for Solving Scheduling Problems "

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Abstract: *The core business for the universities and other academic institution is course timetabling problem, seminars, practical session, number of teachers, number of students, and examinations.*
This study aims at investigating and exploring the benefits and advantages of using enhanced Ant Colony Algorithms, with tabu list and list of memory solution for solving the scheduling problem which are many and different, and all of the components of scheduling problems have the influence in reaching the near optimal solution for this problem. And Based on the obtained results, we have a promising outcome to be used in different domains to solve the scheduling problems, and the necessity for conducting training workshops for those who work in the programming domain to be able to reach the optimal solutions for the scheduling problems and compared the proposed algorithm with standard Ant Colony algorithm using benchmark dataset used the track 3 of the second international competition schedule (ITC2007) and taking consideration hard and soft constraints.

Keywords: *Ant Colony Optimization, Tabu Search, Timetabling, ITC2007, Scheduling.*

1. Introduction

Although The difficulty of any particular condition depends on many factors, and the assignment of the rooms makes the problem more difficult because there is often the problem with the available resources, because of the importance of timetabling, it must be feasible & relevant, for these reasons' ant colony based timetabling tool has been developed and enhanced with the objective to solve such problems (Thepphaken, T & Pongcharoen, P, (2013)).

Scheduling describes a variety of difficult optimization problem with considerable practical impact, typically is concerned with the assignment of activities to available resources, since these resources provide timeslots in which the activities may be assigned subject to certain side constraints, with the focus on the objective to find feasible assignment of all events (Gass & Harris, 2001).

In this study, ant colony optimization will be used to solve the scheduling problem and to modify the parameters in the original Ant colony optimization, using memory solutions and tabu search to reach a good quality solution to the scheduling problems

based on the course described in the second international competition schedule (ITC, 2007).

The Ant Colony optimization (ACO) is a meta-heuristic, algorithm which uses the best path and is called pheromone path and depends on the presence as many pheromones as possible.

The weight of this track depends on the collective research experience, where ants collectively occupy the path to reach the shortest distance to take the food to their nest. Ant Colony Optimization has been successfully applied to several collective problems' improvements (Ayob & Jaradat, 2009).

2. Statement of the Problem

Universities' timetabling problems and difficulties are increasing each year due to increase in the number of new students attending the colleges and universities, to solve the problem of timetabling, ant colony optimization is one of the meta heuristic algorithms that has been used to optimize solution quality for many problems, but the search space can be trapped in one local optimum solution during the search space causing a problem to the logarithm developer, therefore, Tabu list which is the ability of the memory to prevent searching the previously seen areas will be used.

The research problem is to propose a new technique called memory solution to change the search space when the solution stuck in local optimum, replacing the poor-quality solution by a good promising quality saved at memory solution, to establish a timetabling without any violation of the hard constraints and as minimum as possible violation of the soft constraints at a given time.

3. Ant Colony Optimization

The (ACO) is a metaheuristic method proposed by Dorigo etal (1996), it is an algorithm which uses the best path and is called pheromone paths and depends on the presence of as many pheromones as possible. Where ants collectively occupy taking the food to the nest.

A specific random list is used and represented to a schedule and then constructed in a sequentially sequential strategy, ACO algorithm has been successfully applied to several collective improvement problems (Ayob and Jaradat, 2009).

Table 1 summary of presented ant colony optimization from the literature

Author	Mechanism
Abdullah et al.(2012)	Presented in their study entitle "A Hybrid Metaheuristic Approach to the University Course Timetabling Problem" the development of a novel metaheuristic that combines electromagnetic like mechanism and the great deluge algorithm for the university course timetabling problems, this approach is able to produce improved solution due to the combination of both approaches and the ability of the resultant algorithm to converge all solutions at every search process.
Nothegger, et al. (2012)	Study entitle "Solving the post enrolment course timetabling problem by Ant Colony optimization" the researcher has applied ACO to (ITC-2007), they represented two separate matrices to store pheromone information instead of the traditional single matrix.
Ayob and Jaradat (2009)	Study entitle "Hybrid Ant Colony System for Course Timetabling Problems" has presented a solution to the scheduling problem by improving Ant Colony optimization, using the application of two algorithms. An Ant Colony algorithm, and simulated annealing using Tabu search where the ants for probability chose timeslot compatible to the course and reaching the best solution based on the pre-ordered list.
Geiger, M. (2008)	Research entitle "Application of the threshold Accepting Meta heuristic for curriculum based course timetabling" presented a local search approach for the solution of timetabling problems , the researchers reached that he was successfully able to derive a good candidate solution approach for the final track 3 of ITC 2007.

4. Related Work

The where this problem are not new and increasing year after year forming huge burdens on the universities year after year forming huge burdens on the universities and colleges to deal with the increasing numbers of students attending higher education institution, The other objective is to satisfy the needs of the students for suitable rooms, sufficient areas, and for the teaching staff to arrange their time and to reduce useless time as well as efforts.

Figure 2 explains the Study model and the mechanism of using Ant Colony optimization with Tabu list and store other solutions in memory, and making a second Tabu list to avoid solutions repetition. Where the ant move to the desired location, and selecting two solutions randomly, storing them in the Tabu list to avoid their repetition, and reuse, updating this list, and then choosing one of the solutions, working on it, and storing the other solution in memory solution in order to be used to enhance the potential of pheromone.

The model of the study explains the mechanism of using Ant Colony optimization algorithm with Tabu list storing other solutions in the memory and making a second tabu list to avoid solution repetition.

Reach the best possible solution after a specific period of time.

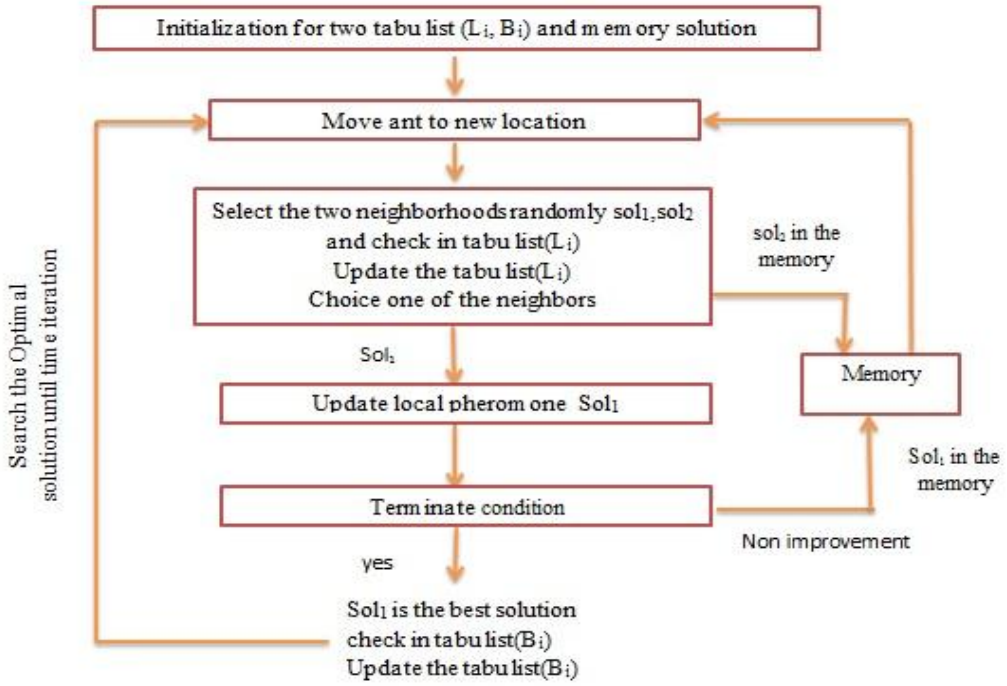

Figure 1: Representation enhance ACO with memory solution with tabu list

Where the ants move to the descried location and selecting two solutions randomly, storing them in the list of tabu to avoid reusing them, then updating this list, choosing one of the solutions and work on it, and store the other solution in memory solution in order to be used. If the solution is suspended, taking it again in order to enhance the

precept of pheromone and to reach the best possible solution after a specified period of time.

The Model begins by creating a table for the tabu list and memory solutions. The ants in each repeat process select a random number of two timeslots and examine them in a tabu list. The stigmgr information is represented as a matrix N x T→ R where a set of cycles and a set of time periods. Based on the function P (pheromone matrix), the ti, t1 and t2 are added to the tabu list and the t2 is stored in memory and t1 is used to find the best solution and we perform an update of the matrix each time, and stored it in the memory menu and repeat this process to get the best solution based.

If the best solution is not reached, the best solution is called from memory and working on it again.

5. Results of Study

Does the enhanced ant colony algorithm with Tabu search and memory solution for solving scheduling problems prove reaching the best solution, To answer this question the experiments are designed on the following things:

- Calculation of the algorithm by an important pheromone
- Calculation of number of ants K
- Calculation of pheromone evaporation
- Calculate the steps of ants for each ant
- Tested eight sets of scheduling problems from Track 3 ITC2007 (Gaspero 2007) where they have different sizes, small, medium and large.

Table 2. Characteristics of instances for scheduling problems

roblems	.curriculum	eriod/day	ys/week	.Rooms	.Events	.Course
omp01	14	6	5	6	160	30
omp02	13	9	5	5	162	30
omp03	139	6	6	9	152	54
omp04	68	5	5	16	251	72
omp05	57	5	5	18	286	79
omp06	60	5	5	17	275	85
omp07	78	5	5	19	390	121
omp08	77	5	5	20	434	131

Timetable problems were used based on Table 2 to measure algorithm performance in terms of standard deviation to obtain the best solution. The process was repeated for each method or proposed phase 10 times and comparing the results of our algorithm with ACS in table (3).

Table 3. Comparison Standard Deviation between ACS and the proposed algorithm

	mp01	**mp02**	**mp03**	**mp04**	**mp05**	**mp06**	**mp07**	**mp08**
ACS	1.77	7.93	7.25	4.93	4.92	3.58	5.75	5.17
oposed gorithm	0.92	4.59	3.33	4.53	4.88	5.56	4.	4.53

In Table (3), there are statistically significant differences between ACS performance and our suggested algorithm, where the solution was improved at almost every stage they will be represented graphically

Figure 2 we compare the standard deviation between ACS and proposed algorithm it is concluded that the proposed approach were consistent, where the values are small the proposed approach outperformed the standard algorithm for all data sets showed in the Figure 2

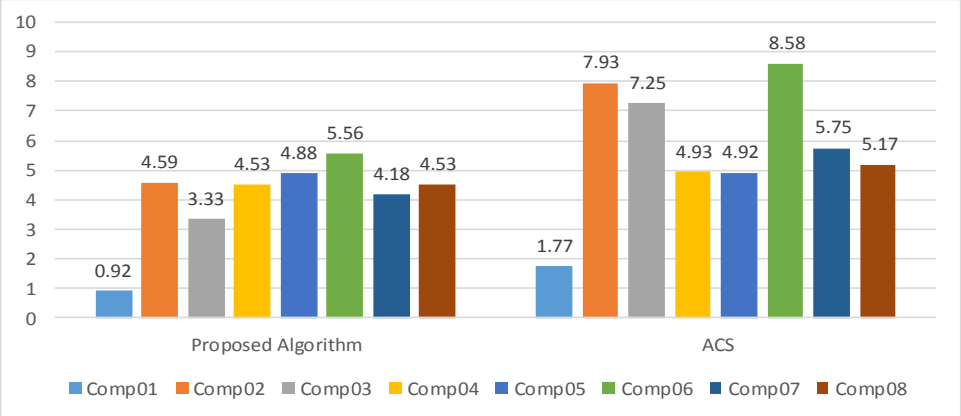

Figure 2: comparison standard deviation between ACS and proposed algorithm

We also used second trials based on track 3 ITC2007 constraints and taking into account all of the hard and soft constraints. We compared our output with Threshold accepting local search (Geiger, 2008) (L1), with each run of 600 seconds, to make a good comparison between the results. The algorithms in the table include experiments selected from the track 3 ITC2007.

Table 4. Comparison results between the proposed algorithms with Threshold accepting local search

	mp01	**mp02**	**mp03**	**mp04**	**mp05**	**mp06**	**mp07**	**mp08**
L1	10	111	119	72	426	130	110	83
oposed gorithm	5	45	86	52	303	67	25	47

Table 4 showed that our approach found the optimal solutions for one instance, which are presented in bold (Comp1 & Comp2 & Comp3 & Comp4 & Comp5 & Comp6 & Comp7 & Comp8). Furthermore, the difference between the best and the worst quality solutions for each datasets are small, which means the works are consistently producing good quality solution. From the standard deviation, it is concluded that the proposed approach were consistent, where the standard deviation values are small (standard deviation measure how widely the results for each instance are deviated from the average value).

The proposed approach outperformed the standard algorithm for all data sets showed in table 2.

Figure 3 shows that our approach compared to Threshold accepting local search found optimal solutions presented in the figure 2 (Comp1 & Comp2 & Comp3 & Comp4 & Comp5 & Comp6 & Comp7 & Comp8).

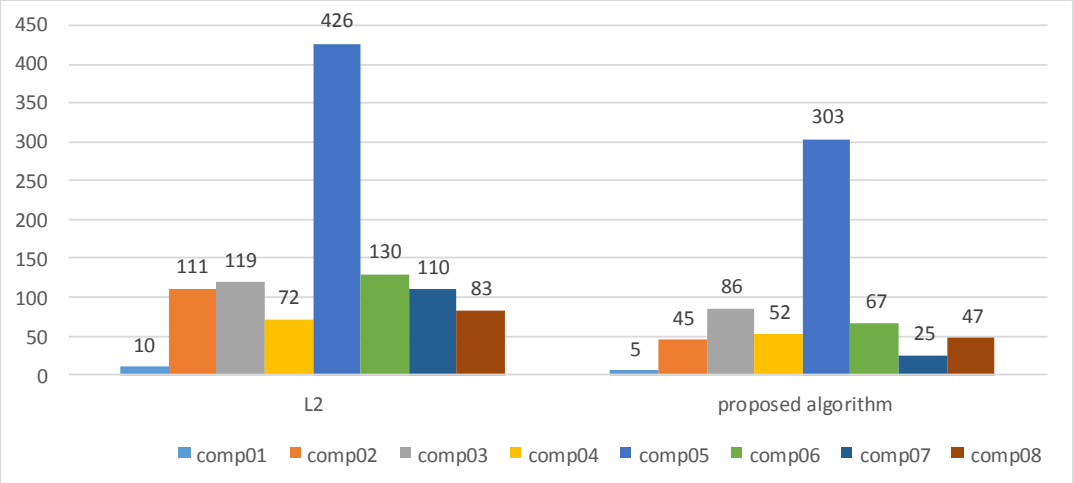

Figure 3: comparison standard deviation between proposed algorithm and Threshold accepting local search

6. Conclusion and Future Work

The goal of this thesis is to enhance the Ant Colony Algorithm and Tabu search with Memory solution, for access to good quality solutions between consecutive schedules, while respecting the constraints.

We applied proposed algorithms to the schedule problem and compared with the original ACS using memory solutions and tabu list to get a good quality solution to the scheduling problem based course on the curriculum for described in the track of the second international competition schedule (ITC2007), and compared between proposed algorithm and Threshold accepting local search we found that it is the better in all cases.

In the future, this work will be developed in more than one algorithm and applied to the scheduling instead of used one algorithm, In order to reach the closest possible solution to be applied to the scheduling and get the results of quick and appropriate placement

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الملخص :

يتمثل النشاط الأساسي للجامعات والمؤسسات الأكاديمية الأخرى في مشكلة تحديد مواعيد الدورات الدراسية والندوات والدورات العملية وعدد المعلمين وعدد الطلاب والامتحانات.
تهدف هذه الدراسة إلى استكشاف واستكشاف فوائد ومزايا استخدام خوارزميات Ant Colony المحسّنة ، مع قائمة التابو وقائمة حلول الذاكرة لحل مشكلة الجدولة العديدة والمختلفة ، وكل مكونات مشاكل الجدولة لها تأثير في الوصول الحل الأمثل القريب لهذه المشكلة. واستناداً إلى النتائج التي تم الحصول عليها ، لدينا نتيجة واعدة لاستخدامها في مجالات مختلفة لحل مشاكل الجدولة ، وضرورة إجراء ورش عمل تدريبية لأولئك الذين يعملون في مجال البرمجة ليكونوا قادرين على الوصول إلى الحلول المثلى للجدولة مشاكل ومقارنة الخوارزمية المقترحة مع خوارزمية مستعمرة النمل القياسية باستخدام مجموعة البيانات المرجعية ، استخدمت المسار ٣ من جدول المنافسة الدولية الثاني (ITC2007) مع الأخذ في الاعتبار القيود الصعبة والميسرة.

الكلمات المفتاحية: تحسين مستعمرة النمل ، بحث Tabu ، جدول المواعيد ، ITC2007 ، الجدولة.