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Automated Timetable Generation using Bee Colony Optimization

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ABSTRACT
Timetable problem is a NP-hard problem where different constraints and various resources are applied but the resources are limited. Optimization problem is a technique which can handle different constraints. This paper focuses the Bee colony Optimization (BCO) for finding the optimal solutions of course time table.BCO is a Meta heuristic optimization scheme where NP-hard with different parameter settings are solved. There are two objectives, first objective is to provide the introduction to timetabling and second objective is the BCO and their variations with timetable design. The proposed algorithm is used to construct the course time table and optimized that time table.

Keywords
Optimization, Bee colony Optimization (BCO), Course time table

1. INTRODUCTION
The preparation time table manually in schools, colleges and universities is very time consuming and tedious job which requires lots of effort as we have to look after various constraints and criteria. Also proper use of resources is neither effective nor efficient by using this approach. In order to overcome all these problems and to produce a satisfactory result we propose to make an automated system which will generate timetable automatically. The system will take various inputs like number of subjects, number of teachers, subject limits of each teacher, preference value for each subject given by each teacher, etc. By taking the help of above all these inputs it will generate possible time tables making optimal use of all resources in a way that will best suit the constraints. In 1996 Wren defines the timetable as the allocation of subject teachers, subject to different constraints, with various resources to objects are being placed in space time. It also satisfies a possible set of desirable objectives, as a result, a timetable specifies at which location and what time the teacher is allocated. The timetable must satisfies a number of requirements and also satisfy the desires of all people as possible. In a college, there are different courses are available, so there is no conflict of free timeslots available for every student within that time. Therefore teacher tries to find the timetable with the minimum conflicts [9]. An appropriate timetable is then chosen from the optimal solutions generated. Timetable is the task of creating a timetable while satisfying various constraints. Bee Colony Optimization (BCO) is very useful in designing the optimized time table where less conflict arises.

This paper is organized as follows: Section-2 illustrated to literature survey and research in this specific area.Section-3 described bee colony optimization.Section-4 explained the proposed approach and working of proposed approach.Section-5 illustrated the result and discussion and Section-6 described the conclusion and future scope.

2. LITERATURE SURVEY
Sophia et al. [7] described the timetable construction which satisfies all operational rules in an academic institution, at the same time timetable fulfills the wishes and requirements of the faculty members and the students. It is an important and difficult task for the staff those are involved. Generally, this task is left to the administrative staff to replicate the timetables of previous years with little changes to accommodate new situations .Adriano Denise [1] compared the PSO to Genetic Algorithm (GA) in generating lecturer timetable schedule. Based on the computational results, the amount of penalty obtained by the PSO is much smaller than the GA on 500th iteration. Fen Irene et al.[8] proposed University Course Timetabling Planning UCTP) through hybrid particle swarm optimization with constraint-based reasoning (PSO-CBR). This algorithm is to allocate lessons in a weekly timetable, such that all students can attend all their events (lessons) without having to attend two events at the same time (called a student clashed). According to Emilio Fortunato et al. [4] the objective function derivative is needed for the initial position to be set by PSO. It also sets the feasibility of the initial position of the particles. Elizabeth et al.[11] described such as the appearance of the new lectures and exams during the semester which more difficult to handle. So Shu-Chuan [5] focused the discrete PSO algorithm which is used to schedule exam timetable. Some soft constraints, such as preferences have to be handled. A penalty will subtract the optimal value on every single violation of the constraints. Betar and Khader[2] focused on the university timetabling problem through harmony search method. It generates the near optimal solution. According to Lai et al.[10]various artificial intelligence techniques are used for complex course time table generation. Bhaduri,A[3] proposed several studies in the field of timetabling by using operational research, artificial intelligence and computational intelligence. Paulus et al.[12] explained that the code needs some mapping, from PSO to timetable and vice versa. This mapping works well. The effectiveness of the solution is relatively low since it is solved by ordinary PSO. Lastly, this paper attempts to solve many problems faced by administrative staff, such as handling preferences as it may vary in every semester.

3. BEE COLONY OPTIMIZATION
Artificial bee colony optimization algorithm (ABC) is based on the intelligent foraging behavior of honey bees and is proposed by Karaboga in 2005.

The Artificial Bee Colony (ABC) is a meta-heuristic algorithm which is population based stochastic method which is derived and motivated by the behavior of honey bees. The food source position represents a possible set of solutions and the amount of nectar represent corresponding fitness values or quality off all solutions or the food source. There are three types of bees used in Artificial Bee Colony Algorithm:-

- Employed Bees
- Onlooker Bees
- Scout Bees.

Initially new candidate solutions are produced for each Employed Bees and the solutions of employed bees are copied to new candidate solution.

Onlooker Bee chooses an Employed Bee to improve its solution. This solution is done according to fitness values of Employed Bees by Roulette Wheel.

Scout Bees are used when the food source is exhausted. Then that food source will be replaced by random generation of a new food source by the Scout Bee.

The proposed BCO algorithm for timetable generation gives minimum execution time. The flow chart of the BCO algorithm is presented in figure 1.The main steps involved in Bee Colony Optimization Algorithm are as follows:

1. Initial food sources are generated randomly and their corresponding fitness values are calculated. This information is provided to the employed Bees.
2. In Employed Bee phase, new food source positions are randomly generated.
3. In Onlooker Bee phase, selected food sources are improved to produce better results.

At last the best food source or candidate solution is memorized.

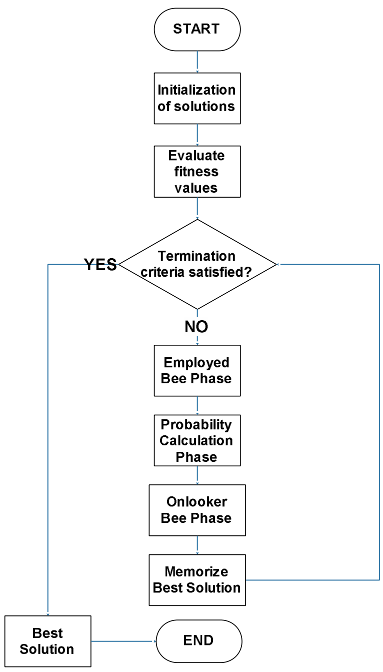

Figure 1: Flow chart of Basic Bee Colony Optimization

4. WORKING OF THE PROPOSED APPROACH

In order to study the computational effort involved in solving the timetable generation problem through BCO, the following mathematical programming model is proposed. We define the following sets to be used in the proposed model:

tno – total number of teachers available.

sno – total number of subjects to be taught.

pno- maximum number of subject preferences that a teacher can provide as his/her options.

tlim-an array which gives information about maximum number of subjects that a teacher can teach

For example, a faculty member might take more classes than a senior professor. So tlim value for faculty member might be higher than that of a senior professor. The value of tlim cannot be zero or negative.

smat- a 2-D array used to store preference matrix. Row represents the total number of subjects and Column represents the total number of teachers available.

The fitness function value of each solution is given by

For j=1 to sno

Fx(i)=Fx(i)+Pref(i,j)*Prob(i,j)

End For

Where Fx(i) – denote fitness function value of candidate solution number ‘i’

Pref(i,j) – denote preference value of teacher for that particular subject

Prob(i,j)-denote probability of selecting a particular teacher and can be calculated as

prob(i,j)=1/tlim(i,j)

For our proposed problem, we have to maximize the fitness function value to get the optimal result. Initially, a set of candidate solutions is generated which satisfies all the required constraints. Then their corresponding fitness function values are calculated and the initial best solution is memorized. In each iteration, the solutions undergoes through Employed Bee Phase and Onlooker Bee Phase. In Employed Bee Phase, any two slots of the candidate solution are chosen randomly and replaced with new random values. Then any one slot chosen randomly from the candidate solution is replaced with the value of that slot position of the current best solution. If the fitness function value of the new solution is better than the current solution then it is replaced. After Employed Bee Phase is completed, it undergoes Onlooker Bee Phase. But firstly relative fitness function value of each candidate solution is calculated. If any candidate solution is having relative fitness function value less a constant “pa” then that solution undergoes alteration by randomly replacing a slot in the candidate solution. Usually, the value of pa lies in between 0 and 1. In this case, the value of pa is taken as 0.1. If the fitness function value of the new solution is better than the current solution then it is replaced.

At the end of the iteration, the best solution is calculated and memorized. The flow chart of time table generation by using Bee Colony Optimization algorithm is depicted in figure 2.

4.1 Pseudo code of Timetable generation by using Bee Colony Optimization algorithm

Initialize the number of generation.

Initialize population size=10.

Evaluate its fitness function value 'fx'

Find the initial best solution and memorize it

While generation<MAX do

//Employed Bee Phase

Randomly change any two slots of the candidate solution.

Copy a slot chosen at random from the current best solution to the corresponding slot in the candidate solution.

Evaluate its fitness value

If (fitness (new)>fitness (old))

Then replace the older solution

End If

//Probability Calculation Phase

Calculate the probability of occurrence of each solution

//Onlooker Bee Phase

If P> a random value in the range of [0,1]

Produce a new candidate solution

Evaluate its fitness value

If(fitness(new)>fitness(old))

then replace the older solution

End If

End If

End While

Memorize the best solution so far

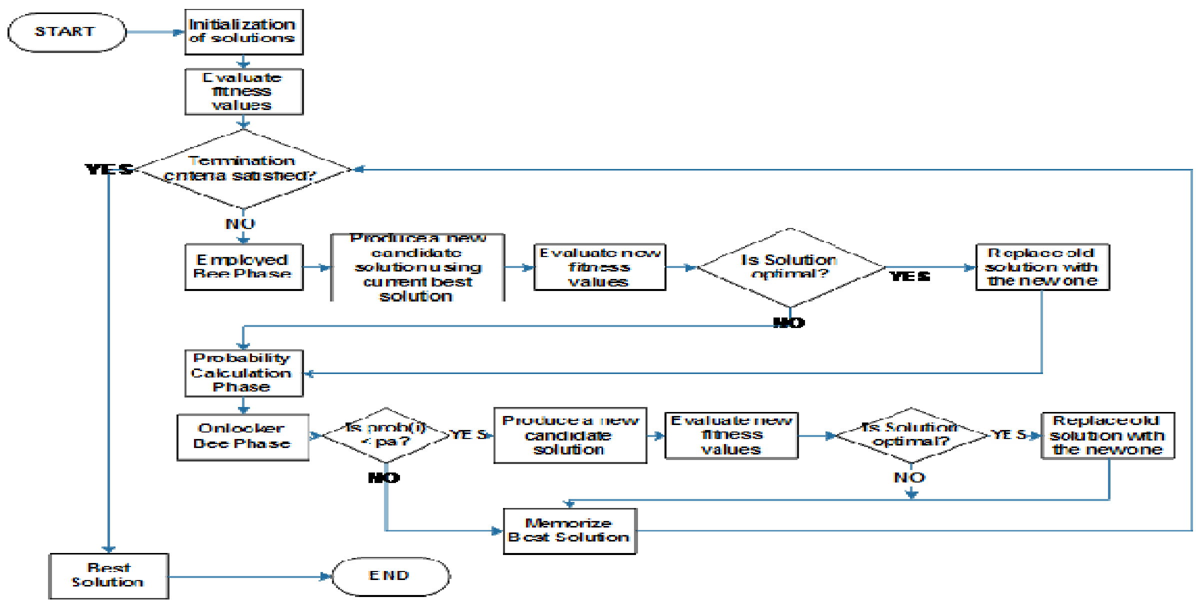

Figure 2: Flowchart of Timetable Generation using Bee Colony Optimization

5. RESULTS AND DISCUSSION

The timetable generation code was executed several times to get an optimal result using Bee Colony Optimization Algorithm. 10 different bees are used to produce 10 new food source positions or candidate solutions. In each iteration, best food source position or candidate solution is selected and that position is memorized. Table 2 shows the best candidate solution with their fitness function value at a specific iteration number. Here we have taken 20 test data at different iteration number. As shown in the figure Test data 1 i.e., the best candidate solution after iteration number 1 produces fitness function value of 23.8333. Then Test Data 2 i.e., the best candidate solution after iteration number 5 produces fitness function value of 27.1667. So there was an overall increase in 13.98% in fitness function value. Similarly after running the code for several iterations, it was found that the fitness function value of the candidate solution reaches its optimum value after 250 iterations. In this case the optimal fitness function value was found to be 45.1667.

Table 1 gives the information about preference values for each subject given by each teacher. T1 to T10 represents teachers whereas S1 to S20 represents subjects.

Table 1 :- Preference Table given by each teacher for a particular subject

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
S1	1	2	6	1	1	1	1	1	1	1
S2	1	1	1	1	1	4	1	6	1	1
S3	1	3	3	1	1	1	1	1	1	6
S4	4	1	1	1	1	1	2	1	2	1
S5	3	1	1	1	1	6	1	5	1	1
S6	1	1	5	1	4	1	1	4	3	1
S7	6	1	1	1	1	1	1	1	1	5
S8	1	1	1	1	1	1	3	1	4	1
S9	1	4	4	1	3	1	1	2	1	1
S10	1	1	1	1	1	5	1	1	1	1
S11	5	1	1	2	2	1	1	3	1	4
S12	1	1	1	1	1	1	5	1	1	3
S13	1	1	1	3	1	3	1	1	5	1
S14	1	5	1	1	1	1	1	1	1	2
S15	1	1	2	4	1	1	1	1	1	1
S16	2	1	1	6	1	1	1	1	1	1
S17	1	6	1	1	1	1	4	1	1	1
S18	1	1	1	5	1	1	1	1	6	1
S19	1	1	1	1	5	2	1	1	1	1
S20	1	1	1	6	1	1	6	1	1	1

Higher the preference value greater is their desire to take that subject.

For example, let us consider the first column of the preference table described above. It shows preferences given by Teacher number 1 for each subjects starting from 1 to 20.The preference value for Subject Number 7 given by Teacher Number 1 is 6 (which is the maximum value in this case).So T1 desires to take subject number 7 than any other subjects . Preference value '1' indicates that the particular teacher is least interested in taking that subject.

Table 2 shows possible solutions and their corresponding fitness function values at different iteration number

Table 2:- Possible Solutions at different iterations with their fitness function value

Iteration Number	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11	S 12	S 13	S 14	S 15	S 16	S 17	S 18	S 19	S 20	Fitness Function Value
1	4	4	10	8	6	9	1	4	3	1	7	6	7	2	2	3	2	5	5	5	23.8333
5	4	3	10	8	6	9	1	4	3	1	7	6	4	2	8	3	2	9	5	5	27.1667
10	4	3	10	8	6	9	1	4	3	1	7	6	4	2	8	7	2	9	5	5	27.3333
20	4	3	10	8	6	9	1	4	3	7	1	6	4	2	8	7	2	9	5	5	28.6667
30	4	3	10	8	6	9	1	4	3	7	1	6	4	2	8	5	2	9	5	5	30.1667
50	4	8	10	8	6	9	1	4	3	7	1	7	4	2	3	1	2	9	5	5	33.6667
75	4	8	10	1	6	9	1	6	3	7	1	7	4	2	4	5	2	9	5	5	36.6667
100	3	8	10	1	6	8	1	4	3	7	1	7	6	2	4	5	2	9	5	4	40.8333
120	3	8	10	1	6	8	1	4	3	7	1	7	6	2	4	5	2	9	5	4	40.8333

150	3	8	10	1	6	8	1	9	3	7	1	7	6	2	4	5	2	9	5	4	42.5000
175	3	8	10	8	6	3	1	9	2	6	1	7	9	2	4	5	2	9	5	7	44.0000
200	3	8	10	8	6	3	1	9	2	6	1	7	9	2	4	5	2	9	5	7	44.0000
225	3	8	10	1	6	3	1	9	2	6	1	7	9	2	4	5	2	9	5	7	44.8333
250	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667
275	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667
300	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667
325	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667
350	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667
400	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667
500	3	8	10	1	6	8	1	9	2	6	1	7	9	2	4	5	2	4	5	7	45.1667

Let us consider the first row

4 4 10 8 6 9 1 4 3 1 7 6 7 2 2 3 2 5 5 5 5

It tells you that Subject Number 1 i.e., S1 is allocated to teacher number 4 i.e., T4, S2 is allocated again to T4, S3 is allocated to T10 and so on. The fitness function of above-given example is 23.8333.

Table 3:- Subjects allocations

Teacher Number	Subjects allocated to each teacher
T1	S4,S7,S11
T2	S14,S17
T3	S1,S9
T4	S15,S18
T5	S16,S19
T6	S5,S10
T7	S12,S20
T8	S2,S6
T9	S8,S13
T10	S3

This table shows the final allocation of each subject to the corresponding teachers. According to the table, Subject number 4, 7 and 11 are assigned to Teacher number 1 .Then Subjects number 14 and 17 are assigned to teacher number 2 and so on. The optimized fitness function value is found to be 45.1667. The implementation of timetable management system through Bee Colony Optimization is done using Matlab 7.0 and the result is depicted in the form of a graph in figure 3.

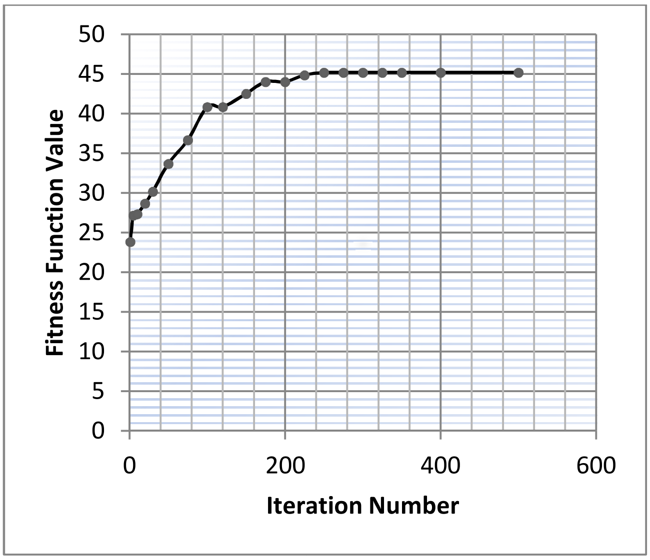

Figure 3: Graphical representation of Fitness Function Value v/s Iteration Number

6. CONCLUSIONS AND FUTURE SCOPE

Generally BCO leads the way to generate an optimal solution. The honey bee movement found the optimal solution even faster. BCO is an optimization technique which is used for solving complex problems like course timetable problem. This work discusses Bee Colony Optimization (BCO) to find the optimal solutions for designing the course time table. Honey bees are designed on the basis of timeslots in a course timetable which reduces the computational complexity. The solution is found with the characteristics of the proposed problem and also is able to improve the satisfaction of the teachers and classes toward the schedule in time table. Any conflicts between the teachers schedule, the class schedules, or the classroom schedules are also in this work. The future scope is to optimize the course time table by using Firefly algorithm and Particle swarm optimization along with comparison.

7. REFERENCES

[1] Adrianto Dennise, "Comparison Using Particle Swarm Optimization and Genetic Algorithm for Timetable

Scheduling", Journal of Computer Science 10 (2),2014 pp- 341-346.

[2] AI.Betar,M.A. and A.T.Khader,A hybrid harmony search for university course timetabling. Proceedings of the Multidisciplinary International Conference on Scheduling: Theory and Applications, 2009, pp.157-179.

[3] Bhaduri,A.,University time table scheduling using genetic artificial immune network. Proceedings of the international Conference on Advances in Recent Technologies in Communication and Computing,IEEE Xplore Press,2009,pp.289-292.

[4] Campana Emilio Fortunato, Diez Matteo, Fasano Giovanni, and Peri Daniele, "Initial Particles Position for PSO, in Bound Constrained Optimization", 2013, ICSI, Part I, LNCS 7928, Springer-Verlag Berlin Heidelberg.

[5] Chu Shu-Chuan, Chen Yi-Tin, Ho Jiun-Huei, "Timetable Scheduling Using Particle Swarm Optimization", Proceedings of the First International Conference on Innovation Computing, Information and Control 2006, ICICIC.

[6] D. Dervis Karaboga, An Idea Based On Honey Bee Swarm for Numerical Optimization 2005, Technical Report-TR06,Erciyes University, Engineering Faculty, Computer Engineering Department.

[7] Daskalaki Sophia, Birbas Theodore, Housos Efthymios, "An Integer Programming Formulation for a Case Study in University Timetabling", European Journal of Operating Research: Elsevier, 2004.

[8] Ho Sheau Fen Irene, Safaai Deris, Hashim Zaiton Siti Mohd, "University Course Timetable Planning using Hybrid Particle Swarm Optimization", Proceedings of the first ACM/SIGEVO Summit on Genetic and Evolutionary Computation 2009, ISBN: 978-1-60558-326-6.

[9] Ioannis X. Tassopoulos, Grigorios N. Beligiannis, "A hybrid particle swarm optimization based algorithm for high school timetabling problems", in applied soft computing 12(2012),pp- 3472-3489.

[10] Lai,L.F.,C.C. Wu.,N.L.Hsueh,l.t.Huang and S.F Hwang,An Artificial intelligence approach to course timetabling. International Journal Artificial Intelligence Tools, 2008,17:223-240.

[11] Montero Elizabeth, Riff Maria-Christina, Altamirano Leopoldo, "A PSO Algorithm to Solve a Real Course+Exam Timetabling Problem",2011 ICSI: International Conference on Swarm Intelligence, France.

[12] Mudjihartono Paulus, Triadi Gunawan Wahyu, Jin AI The, "University Timetabling Problems With Customizable Constraints Using Particle Swarm Optimization Method", International Proceeding: International Conference on Soft Computing, Intelligent System and Information Technology (ICSIIT), Petra University, Indonesia. 2010, ISBN: 978-602-97124-0-7.