International Journal of Advance Engineering and Research Development (IJAERD)
Volume 1,Issue 6,June 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Optimum Timetable Algorithm Using Discrete Mathematics

Rasik R. Shah[1], Bhavika M. Tailor[2], Dr. Devbhadra V. Shah[3], Dr. Jayesh M. Dhodiya[4]

[1]*Department of Mathematics, S.N.P.I.T. & R.C., Umrakh, Bardoli, shah.rasik.15@gmail.com*
[2]*Department of Mathematics, C.G.P.I.T, Maliba Campus ,Bardoli, b.r.shah1511@gmail.com*
[3]*Department of Mathematics ,Sir P. T. Sarvajanik College of Science, Surat , drdvshah@yahoo.com*
[4]*Departmant of ASH, S.V.N.I.T, Surat , jdhodiya2002@yahoo.com*

Abstract - The construction of a timetable that assured all official rules and needs in an organization, while at the parallel time fulfills as many of the requirements and essentials of the organization workers. Time-table is the problem of assigning workers to tasks in set of shifts, during a preset period of time, normally a week. It generally consists of arranging works in a considered time table according to available times and scheduling refer to master planning and programming for all workings and activities. This construction is a considerable but actually inflexible task for the management staff involved. In the majority organization this duty is gone to managing and HRM staff. The present observation is to repeat the timetables of earlier years with minor changes to accommodate newly developed situations. However, in current years changes happen more repeatedly and patching of what has been developed in the past is not always the supreme policy. Under these situations and in radiance of the development achieved both in the hardware and software technologies, the technical society continues to effort on the problem in order to develop recognized and computerized procedures for constructing well-organized and useful timetables. This paper discussed discrete mathematics based time table algorithm to improve scheduling and load of worker of organization. This algorithm also plays a significant role for cost optimization of organization.

Key-words: Time-table Construction, Constraints, Discrete model, Algorithm.

I. INTRODUCTION

Timetabling is the allocation of a set of activities in time and space subject to some constraints to achieve a set of desirable objectives. Timetabling problems can be found in worker allocation, transport networks, educational institutions and many industrial and sports activities. Specifically in organization, industries, banks, hospitality, hotels, etc the problem of managing the works to the worker can be solved by using constraints that fulfills optimization problems by using timetables, which needs to be solved regularly. Worker timetabling is the problem of assigning workers to tasks and locations in a set of shifts, during a fixed period of time, typically a week and involves flexible workloads for workers and long-term fair distribution for undesired working shifts like day shifts, night shifts, weekends, etc. In this paper random as well as probabilistic optimization algorithms of timetabling are discussed. In order for users to utilize the timetable system optimally instead of just as a place for storing, retrieving and printing information, it needs to have the qualities of flexibility, adaptability, portability and timeliness.

II. IMPORTANCE OF TIME TABLE

The timetable is a necessary tool for the efficient working of an organization. It is the timetable that supplies the framework within which the work of the workers proceeds. It is the instrument through which it eliminates wastage of time and energy. It informs the workers as well as the organization about each and every activity of the work. Time table helps worker to complete the work at proper time which is allocated to them. It prevents duplication of efforts and enables allotment of each work with the rules.

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Timetable includes the habits of regularity, punctuality and systemized work among workers work. A good timetable clearly indicates the efficient working of the program to have the following types of timetable like consolidate timetable, work wise timetable, individual workers timetable, vacant period of worker, break time and co-curricular activities as well as game timetable. The aim of this paper is to give a brief introduction to some recent approaches to timetabling problems that have been developed or are under development in the automated scheduling, optimization and planning research group at the organizations[1].

III. CONSTRAINTS OF TIMETABLE

The classification and importance of the constraints depend on each institution. In general timetabling constraints are often divided into two categories: hard constraints and soft constraints. The hard constraints have to be obeyed or could not be violated. These constraints are embodied as constraints in the mathematical formulation. A feasible schedule is one that satisfies all the hard constraints. Features like no worker has more than one work at a given time, single worker work should not assign to two or more workers, time given for particular work should not exceed, etc. have costs associated with them, and the aim is to find, of all feasible schedules. Some examples of the soft constraint are certain workers are pre-assigned to specific work for some period, each workers should have a breakfast, lunch, dinner break. Identical work assign to workers should be given uniformly as possible throughout the days of the week[2].

IV. TIMETABLE ALGORITHMS

A number of algorithms and methodologies have been implemented to solve the complexity of timetabling programmatically. Among these are Integer Linear programming methods, the Heuristic Search method and Constraint Based Reasoning methods, Neural Networking, Graph Coloring, Genetic Algorithms and Knowledge based methods. All these approaches attempt to find the most optimized solution for a timetable, taking into account a number of constraints like time slots, available rooms, number of subjects and the number of lecturers or teachers. All timetables are checked for validity: If any hard-constraint is violated, the solution is infeasible and invalid. Soft-constraint violations result in a penalty, the penalty of a solution is the sum of all those penalties. The advantage of these systems is to reduced amount of time it takes to produce a timetable automatically versus creating a timetable manually. The draw-back of most of them is that they tend to be inflexible once a timetable has been scheduled. The automatic system therefore performs better than the manual system.

A. Job Sequence Algorithm

The problem consists in scheduling jobs, each job being a set of elementary operations to be processed on different machines. The objective pursued is to minimize the completion time of the set of operations. Dynamic and stochastic job problems which incorporates attributes such as non-zero ready times, intertravel time, multiple scheduling time, multiple job routes simultaneously, assign weights to jobs and uncertain processing times can also be solved using the computational intelligence techniques. Due dates can be set, can get smaller jobs by splitting larger ones, Single machine results imply small jobs clear out more quickly than larger jobs, algorithm start with a small job and end with a small job, small jobs make small move and can be combined to form larger job as they arrive at a machine. These features increase the search space of solutions and make the task of scheduling very complicated. It cannot hope to find optimal solutions of realistic sized scheduling problems, polynomial approaches, like dispatching, may not work well. There are always more than two machines, process times are not deterministic[3] [4]. All jobs are not ready at the beginning of the problem and process time are sequence dependent. The algorithm can be extended to n numerous jobs or any other performance measures too. This extension makes the problem much harder and it is beyond the framework of this paper.

B. Assignment Algorithm

A mathematical model has been established to discuss about multi-objective assignment problem which is characterized by non-linear membership function. The approach emphasizes on optimal solution of each objective function by minimizing the worst upper bound, which is close to the best lower bound. This algorithm proposes for solving multi-objective assignment problem through interactive fuzzy goal programming approach. Consider an internship assignment system, where at the end of each academic year, interested university students search and apply for available positions, based on their preferences e.g., nature of the job, salary, office location, etc. Algorithm iteratively finds stable query-object pairs and removes them from the problem. In the decremented assignment problem a pair of vertices, not necessarily connected with a matching edge and their incident edges are removed from a weighted bipartite graph with a given assignment. This application provides theoretical framework but difficult to implement in hardware[3] [4].

V. LIMITATIONS

The draw-back of most of algorithms is that they tend to be inflexible once a timetable has been scheduled. A further complication with timetables is that most of the organization or industries have already allocated the pre-requisites, which further complicates the construction of a timetable. Usually a limited time in which a timetable must be generated taking into account the limitations on availability of workers, work assign at particular place and period. Many timetabling systems ignore constraints like the size of the place versus the size of the work to carried out, the various types, or the flexibility required by workers. The constraints touched upon highlight various aspects, that would make the difference between a good and usable timetable, and a bad one. Constraints are requirements that a solution has to hard-constraints or should soft-constraints[3] [4].

VI. OBJECTIVES

The problem is based on worker, shift, task type or simply task and location. Locations correspond to working places, such as production lines in an industrial plant or departments in a hospital. This research paper investigates the process of solving such time table problem at industries, institute or organization. It includes a detailed study of the system, data collection, and identification of problematic areas as well as system constraints and restrictions. So the objective of this paper is to develop Random Mathematical Algorithm (RMA) and Probabilistic Mathematical Timetabling Algorithm (PMTA) for better scheduling. The main purpose is to demonstrate the possibility of building them, automatically, by using computers[5].

VII. RANDOM MATHEMATICAL ALGORITHM (RMA)

Step-1: Define your Time Table problem.

Step-2: Identify the decision variable

S_s: work for Assign, s = 1,2,3,…..,p.

T_{Ss} = Total number of work for assign = p

P_i: Period’s of work, i=1,2,3,……,q.

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T_{Pi} = Total number of period's = q
Cj: work places, j = 1,2,3,….,r. T_{Cj} = Total number of work place = r
D_k: working days per week, k = 1,2,3,….,t.
T_{Dk} = Total number of working day per week = t (Maximum 7)
W_d: workers, d = 1,2,……..,u
T_{Wds} = Total number of workers, work period work wise = B_z
TT_{Wd} = Total number of work load of workers = A_z

Step-3: Identify the worker for each work by optimization as well as according to the capacity and capability of worker.

Workers	Capable for work		Work place	Works to be carried out
W_1	S_1, S_2, S_3		C_1	S_1, S_2, S_3, S_4, S_5, S_6
W_2	S_4, S_5,S_6		C_2	S_7, S_8, S_9, S_{10}, S_{11}, S_{12}
W_3	S_7, S_8, S_9		C_3	S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18}
W_4	S_{10}, S_{11}, S_{12}		.	.
.	.		.	.
.	.		.	.
.	.		.	.
.	.		.	.
W_u	S_{p-2}, S_{p-1}, S_p		C_r	S_{p-5}, S_{p-4}, S_{p-3}, S_{p-2}, S_{p-1}, S_p

Table 1. Identify the workers work for capable load and work place availability

Step-4: Assign the work to worker as per their step-3 wise allocation described in this flow chart
Step-5: Verify all work and their load allocation, workers load, check total load is equal to total workers load
Step-6: Print necessary document
Step-7: End

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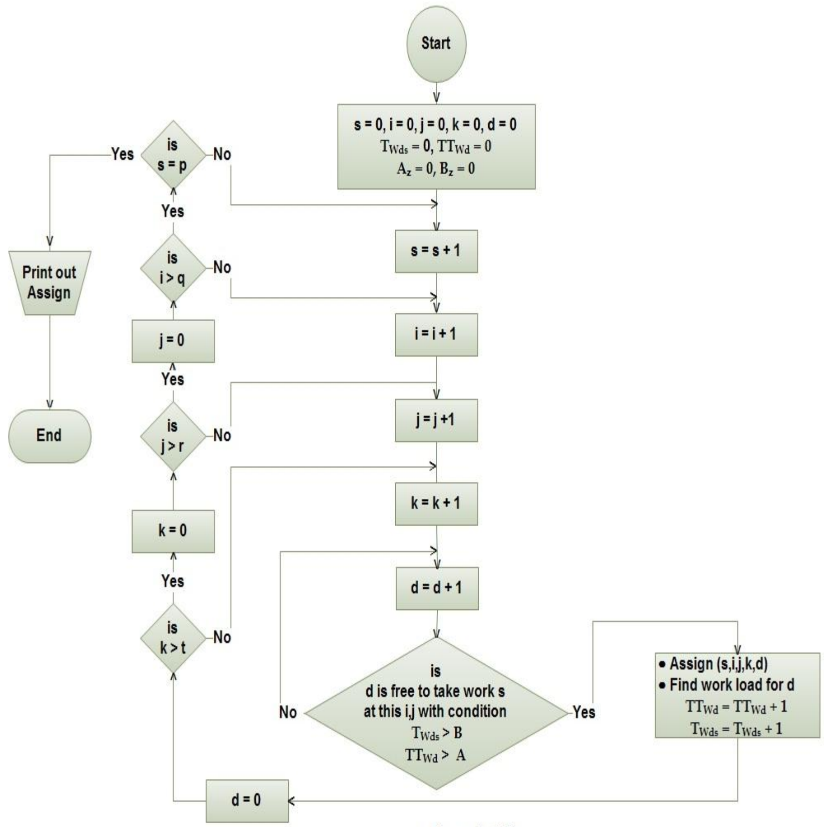

Figure 1: RMA

VIII. PROBABILISTIC MATHEMATICAL TIMETABLING ALGORITHM (PMTA)

Step-1: Define your Timetable problem

Step-2: Identify the decision variable

S_s: work for Assign, s = 1,2,3,…..,p. T_{Ss} = Total number of work for assign = p
Cj: work places, j = 1,2,3,….,r. T_{Cj} = Total number of work places = r
D_k: working days per week, k = 1,2,3,….,t.
T_{Dk} = Total number of working day per week = t (Maximum 7)
W_z: worker, z = 1,2,……..,d
T_{Wzs} = Total number of worker, work period work wise
TA_x = work wise load, x = 1,2,…….,p
WP_{bz} = Probability of worker, z = 1,2,……,d
P_i: Period's of works, i=1,2,3,…….,q. T_{Pi} = Total number of period's = q

Step-3: Identify the worker for work by optimization that is according to the capacity of workers

Workers	Assign work	Work wise load set	Probability	Total load of workers TL_z

W_1	S_1, S_2, S_3	$\{TW_{1(1)}, TW_{1(2)}, TW_{1(3)}\}:\{TA_1, TA_2, TA_3\}$	$P_{b1} = 0$	TL_1
W_2	S_4, S_5, S_6	$\{TW_{2(4)}, TW_{2(5)}, TW_{2(6)}\}:\{TA_4, TA_5, TA_6\}$	$P_{b2} = 0$	TL_2
W_3	S_7, S_8, S_9	$\{TW_{3(7)}, TW_{3(8)}, TW_{3(9)}\}:\{TA_7, TA_8, TA_9\}$	$P_{b3} = 0$	TL_3
W_4	S_{10}, S_{11}, S_{12}	$\{TW_{4(10)}, TW_{4(11)}, TW_{4(12)}\}:\{TA_{10}, TA_{11}, TA_{12}\}$	$P_{b4} = 0$	TL_4
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
W_d	S_{p-2}, S_{p-1}, S_p	$\{TW_{d(p-2)}, TW_{d(p-1)}, TW_{d(p)}\}:\{TA_{p-2}, TA_{p-1}, TA_p\}$	$P_{bp} = 0$	TL_p

Table 2. Identify the Professor for subject wise load

Work places	Work to done	Load set of worker
C_1	$S_1, S_2, S_3, S_4, S_5, S_6$	W_1, W_2
C_2	$S_7, S_8, S_9, S_{10}, S_{11}, S_{12}$	W_3, W_4
.	.	.
.	.	.
.	.	.
.	.	.
C_r	$S_{p-5}, S_{p-4}, S_{p-3}, S_{p-2}, S_{p-1}, S_p$	W_{d-1}, W_d

Table 3. Identify workers work availability

Step-4: Assign the work to the workers as follows
Step-5: Verify all work and their work load allocation and check total load is equal to total worker work load.

Step-6: Print necessary document
Step-7: End

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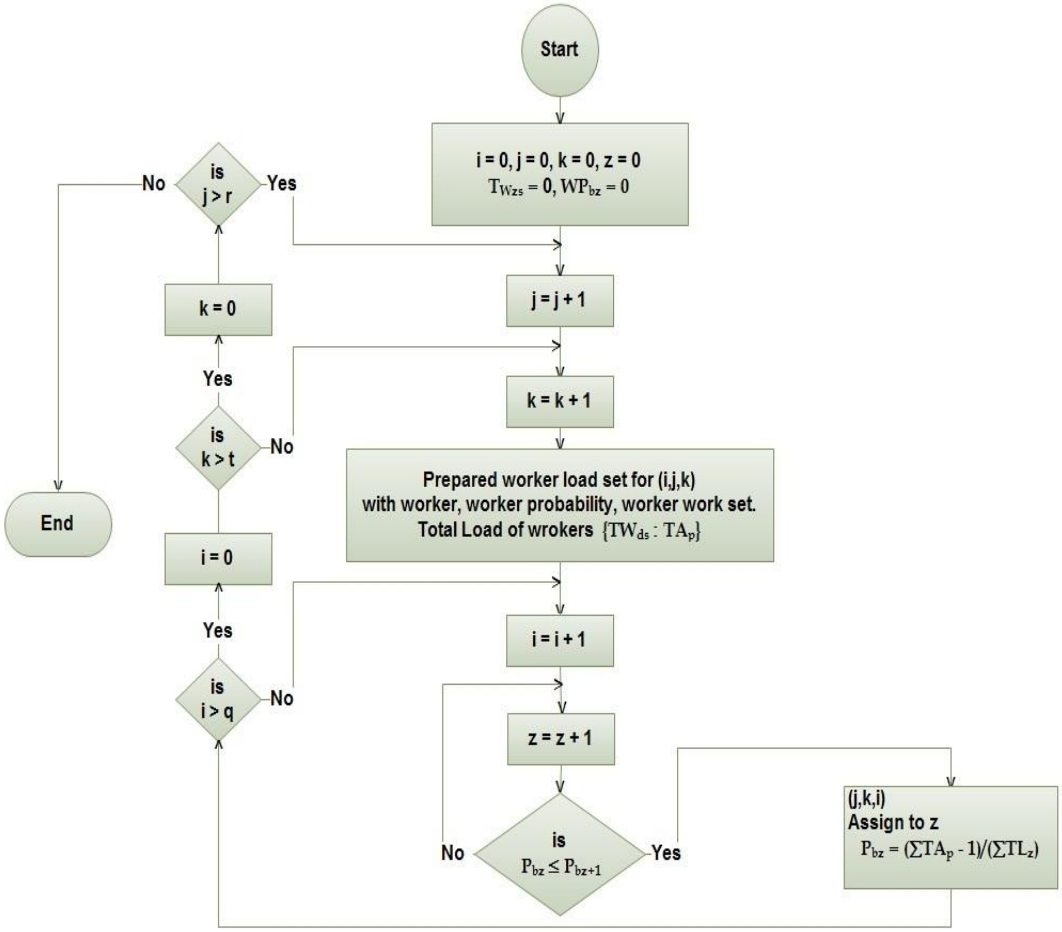

Figure 2: PMTA

IX. DISCUSSION

The RMA and PMTA models are effective algorithms and more efficient optimization modules that can apply to any educational institutions or organizations. It can be used for industrial as well as hospital timetabling if the workload has to be arrranged hourly or working period has to be changed by hourly. Timetabling problems in practice are never fixed, because the input data continuously change.So workers working in industries having more complicated timetable than in educational institutions or organizations. In below sample calculation it is shown how PMTA model works by considering random data of educational institutions or organizations as follow:

A. Sample Calculation

Day = k; k = 1,2,3,4 and 5

Class=j; j=1 and 2

Period=i; i=1,2,3,4,5 and 6

Professor=d; d=1,2,3 and 4

Subjects=s; s=1,2,3,4,5,6,7,8,9,10,11 and 12

Professor	Subjects
d_1	{1,5,9}
d_2	{2,6,10}
d_3	{3,7,11}
d_4	{4,8,12}

Class	Subjects
1	1,2,3,4,5,6
2	7,8,9,10,11,12

Table 4. Random data of Professor subject class wise load

The sample calculation based on probability is as follows

CLASS 1				CLASS 2			
Day	Allocated set {k,j,i}	Probability	Subject wise period remaining	Day	Allocated set {k,j,i}	Probability	Subject wise period remaining
1	(1,1,1)	W_1=14/15	{1,5,9}:{4,5,5}	1	(1,2,1)	W_3=7/15	{3,7,11}:{0,2,5}
	(1,1,2)	W_2=14/15	{2,6,10}:{4,5,5}		(1,2,2)	W_4=7/15	{4,8,12}:{0,2,5}
	(1,1,3)	W_3=14/15	{3,7,11}:{4,5,5}		(1,2,3)	W_1=6/15	{1,5,9}:{0,2,4}
	(1,1,4)	W_4=14/15	{4,8,12}:{4,5,5}		(1,2,4)	W_2=6/15	{2,6,10}:{0,2,4}
	(1,1,5)	W_1=13/15	{1,5,9}:{4,4,5}		(1,2,5)	W_3=6/15	{3,7,11}:{0,2,4}
	(1,1,6)	W_2=13/15	{2,6,10}:{4,4,5}		(1,2,6)	W_4=6/15	{4,8,12}:{0,2,4}
2	(2,1,1)	W_3=13/15	{3,7,11}:{3,5,5}	2	(2,2,1)	W_1=5/15	{1,5,9}:{0,1,4}
	(2,1,2)	W_4=13/15	{4,8,12}:{3,5,5}		(2,2,2)	W_2=5/15	{2,6,10}:{0,1,4}
	(2,1,3)	W_1=12/15	{1,5,9}:{3,4,5}		(2,2,3)	W_3=5/15	{3,7,11}:{0,2,3}
	(2,1,4)	W_2=12/15	{2,6,10}:{3,4,5}		(2,2,4)	W_4=5/15	{4,8,12}:{0,2,3}
	(2,1,5)	W_3=12/15	{3,7,11}:{3,4,5}		(2,2,5)	W_1=4/15	{1,5,9}:{0,1,3}
	(2,1,6)	W_4=12/15	{4,8,12}:{3,4,5}		(2,2,6)	W_2=4/15	{2,6,10}:{0,1,3}
3	(3,1,1)	W_1=11/15	{1,5,9}:{2,4,5}	3	(3,2,1)	W_3=4/15	{3,7,11}:{0,1,3}
	(3,1,2)	W_2=11/15	{2,6,10}:{2,4,5}		(3,2,2)	W_4=4/15	{4,8,12}:{0,1,3}
	(3,1,3)	W3=11/15	{3,7,11}:{2,4,5}		(3,2,3)	W_1=3/15	{1,5,9}:{0,1,2}
	(3,1,4)	W_4=11/15	{4,8,12}:{2,4,5}		(3,2,4)	W_2=3/15	{2,6,10}:{0,1,2}
	(3,1,5)	W_1=10/15	{1,5,9}:{2,3,5}		(3,2,5)	W_3=3/15	{3,7,11}:{0,1,2}
	(3,1,6)	W_2=10/15	{2,6,10}:{2,3,5}		(3,2,6)	W_4=3/15	{4,8,12}:{0,1,2}
4	(4,1,1)	W_3=10/15	{3,7,11}:{1,4,5}	4	(4,2,1)	W_1=2/15	{1,5,9}:{0,0,2}
	(4,1,2)	W_4=10/15	{4,8,12}:{1,4,5}		(4,2,2)	W_2=2/15	{2,6,10}:{0,0,2}
	(4,1,3)	W_1=9/15	{1,5,9}:{1,3,5}		(4,2,3)	W_3=2/15	{3,7,11}:{0,1,1}
	(4,1,4)	W_2=9/15	{2,6,10}:{1,3,5}		(4,2,4)	W_4=2/15	{4,8,12}:{0,1,1}
	(4,1,5)	W_3=9/15	{3,7,11}:{1,3,5}		(4,2,5)	W_1=1/15	{1,5,9}:{0,0,1}
	(4,1,6)	W_4=9/15	{4,8,12}:{1,3,5}		(4,2,6)	W_2=1/15	{2,6,10}:{0,0,1}
5	(5,1,1)	W_1=8/15	{1,5,9}:{0,3,5}	5	(5,2,1)	W_3=1/15	{3,7,11}:{0,0,1}
	(5,1,2)	W_2=8/15	{2,6,10}:{0,3,5}		(5,2,2)	W_4=1/15	{4,8,12}:{0,0,1}
	(5,1,3)	W_3=8/15	{3,7,11}:{0,3,5}		(5,2,3)	W_1=0	{1,5,9}:{0,0,0}
	(5,1,4)	W_4=8/15	{4,8,12}:{0,3,5}		(5,2,4)	W_2=0	{2,6,10}:{0,0,0}
	(5,1,5)	W_1=7/15	{1,5,9}:{0,2,5}		(5,2,5)	W_3=0	{3,7,11}:{0,0,0}
	(5,1,6)	W_2=7/15	{2,6,10}:{0,2,5}		(5,2,6)	W_4=0	{4,8,12}:{0,0,0}

Table 5. Simple Calculation based on probability

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X. CONCLUSION

This paper consists of two mathematical models RMA and PMTA. The algorithm carries out all workers assign work and construct a feasible complete timetable. The first one is a RMA that allocate the work one by one to each worker and take long process to make such a huge timetable. The second algorithm is a PMTA that calculates the probability at each period before allocating work to the workers, so the workload is divided equally among all workers. The two schemes results shows that the PMTA scheme will be better, capable of solving timetable problem comparing to RMA, while its performance is determined by the work size allocated to the workers.

REFERENCES

[1] J. S. Appleby, D. V. Blake and Newman, "Techniques for Producing School Timetables on a Computer and their Application to other Scheduling Problems", The Computer Journal, 1961, Volume 3, Issue 4,pp. 237- 245.
[2] Robertus Johannes Willemen, " School timetable construction Algorithms and complexity", 2002 ,ISBN 90-386-1011-4
[3] Aldy Gunawan, Kien Ming Ng, and Kim Leng Poh, "Solving the Teacher Assignment-Course Scheduling Problem by a Hybrid Algorithm", World Academy of Science, Engineering and Technology, 33 2007
[4] José Joaquim Moreira, "A System for Automatic Construction of Exam Timetable Using Genetic Algorithms". 2008
[5] Brian Autry, University course timetabling with probability collectives, March 2008
[6] Aldy Gunawan, "Applying metaheuristics to some timetabling problems",2004

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