International Journal of
Science and Engineering Investigations vol. 2, issue 16, May 2013
ISSN: 2251-8843

Combined Memetic Algorithm in Case of Supply Chain System's Scheduling (Approach of Cost Maintenance)

Maziyar Karbalaee Shabani[1], Shermineh Majdabadi Farahani[2]
[1] MA, Department of Industrial Management, Firoozkooh Branch, Islamic Azad University, Firoozkooh, Iran
[2] MA, Economics, Islamic Azad University, Central Tehran Branches, Tehran, Iran
([1]M.K.Shabani@live.com, [2]Shermine.majd@gmail.com)

Abstract-Scheduling of supply chain systems (SSCS) is one of problems in NP-Hard optimization. The aim of scheduling of these systems is to maximize the system efficiency by finding an optimal planning for a better cooperation among various processes. In recent years many algorithms proposed to solve this problem, and most of them are based on heuristic methods. In This paper we have proposed a new algorithm namely SCMTP, a Memetic algorithm combined with Timed Petri Net, for scheduling supply chain systems considering maintenance problem. The experimental results show that our proposed algorithm, i.e. SCMTP has about %6.73 and %23.82 improvements over GADG and PN-GA algorithms respectively.

Keywords- *Cost Maintenance, Memetic algorithm,Timed Petri Net, Scheduling of supply chain systems.*

I. INTRODUCTION

Scheduling of supply chain systems (SSCS) is one of problems of NP- hard optimization. The aim of scheduling of these systems is to maximize the system efficiency by finding an optimal planning for a better cooperation among various processes. Recent years have witnessed a wide range of research on modeling, scheduling, and evaluation of these systems. The main motivation lies in the fact that such systems require higher flexibility with respect to market change so that they can raise their competency.

Many algorithms have been proposed to solve the above-mentioned problem. For example, Takahashi and Kurahashi [1] employed Tabu Search for scheduling of supply chain systems (SSCS). Kumar et al [2] presented an algorithm for scheduling using ant colony optimization. Caballero and Mejia [3] proposed a genetic algorithm combined with Petri Net, i.e. PN-GA for scheduling supply chain systems. In this algorithm, first manufacturing system is modeled with Petri Net, and then an optimized scheduling is determined using a genetic algorithm. Li and Xie [4] developed ETPN-GA, a genetic algorithm based on Timed Petri Net for scheduling manufacturing systems which are suitable for reconfiguration aiming to minimize the production time and costs of reconfiguration. Rossi and Boschi [5] presented an innovative combinational algorithm to solve scheduling of job shop with parallel machines in order to minimize the production time. In this algorithm the problem is solved through combination of genetic algorithm and ant colony.

These algorithms do not consider maintenance. However, Chan et al [6] proposed a genetic algorithm to solve scheduling in distributed SCS considering maintenance. The major idea in their paper t is presentation a genetic algorithm with dominant genes. Also Yadollahi and Rahmani[7] have used memetic algorithm to solve scheduling of distributed SCS. Which its advantages are considering maintenance factor and tradeoff between time and cost.

As mentioned earlier, the above mentioned algorithms do not consider maintenance and it decreases the system's reliability [8]. In this study, a Memetic Algorithm combined with a Timed Petri Net named SCMTP is presented for scheduling supply chain systems. Its advantage is considering maintenance.

The paper is structured as below: section 2 introduces the problem, and section 3 sketches on basic concepts. The algorithm is described in section 4, and section 5 reports on experimental results along with a comparison of the algorithm with existing ones. Section 6 is devoted to conclusions.

II. PROBLEM DESCRIPTION

The aim of scheduling supply chain systems is to present an appropriate scheduling for N jobs in M machines, as each job includes a number of operations that should be executed in order. Each operation requires one machine for execution. After some time each machine needs a time for maintenance and its duration depends on machine service's time (machine age) [8]. While maintenance the machine will be unavailable, but after completing maintenance it will be available again. After each maintenance, the machine's age will be zero. If the maximum age of a machine can be A, and in case the machine age will be A, after completion of current execution, the machine turns to maintenance state. Figure 1 shows the required time for machine maintenance with respect to machine age.

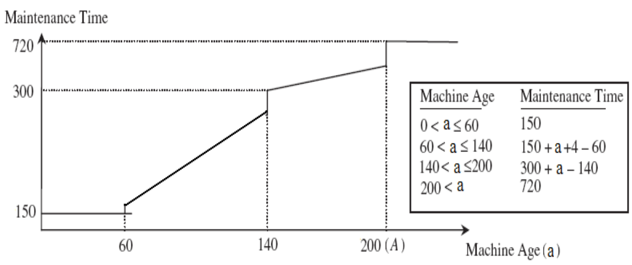

Figure 1. Maintenance time Depending on machine age.

Table 1 displays characteristics of a sample SCS with three machines and two jobs. In this system there are varying numbers of jobs operations. For example, it shows that second operation of first job in second machine needs four seconds, and that by the third machine requires seven seconds.

TABLE 1. CHARACTERISTICS OF A SAMPLE SCS

Job1 oper.	Machine	Process time	Job2 oper.	Machine	Process time
O_1	1	4	O_1	1	12
O_1	2	3	O_1	2	6
O_2	2	4	O_2	2	4
O_2	3	7	O_3	2	6
O_3	2	6	O_4	3	7
O_3	3	4	O_4	2	3
O_4	3	6	O_5	3	6

III. BASIC CONCEPTS

In this section Petri Net and Memetic algorithm are outlined.

A. Memetic Algorithm

Genetic algorithm is a heuristic algorithm used for solving optimization problems [9]. One of the disadvantages of this algorithm is its slow movement towards global optimization. Through combination of genetic algorithm with one of local search techniques such as tabu search, defects of genetic algorithm can be removed. Such combinational strategy is often called Memetic Algorithm [10].

B. Petri Net

Petri Net is a mathematical, graphic modeling tool including four components, i.e. place, transition, arc, and token. It can be used for modeling, scheduling, simulation and evaluation of system efficiency. In addition to the above advantages, modeling by Petri Net frees us from problem development by mathematical formula.

Timed Petri Net is a type of Petri Net in which one transition fires token after some given time.

IV. PROPOSED ALGORITHM

In our proposed method a Memetic algorithm is combined with timed Petri Net for scheduling supply chain systems. This algorithm has two steps. In the first step, system is modeled with Timed Petri Net, and in the second step an approximately optimized scheduling is created for the modeled system. Then, simulation is done using Petri Net model, to determine the value of appropriateness of scheduling. These steps are described in sections A, and B.

A. Modeling with Timed Petri Net

The first step is the modeling of SCS with Timed Petri Net. This step frees us from expressing mathematical problem, and it makes simulation and evaluation of system's efficiency possible. Figure 2 illustrates a sample system modeling described in Table 1 by Timed Petri Net.

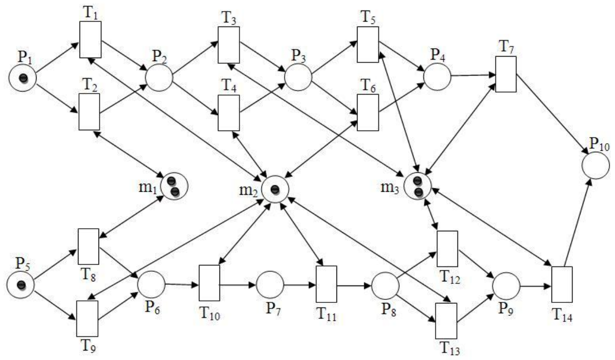

Figure 2. Modeling a sample supply chain system with Timed Petri Net.

B. Scheduling with Memetic Algorithm

In the second step, system is scheduled by a memetic algorithm.

Chromosome Display

The number of genes in each chromosome is equal to the total job operations, so each chromosome displays scheduling of job operation from left to right. The structure of each gene is jms which modified from [1]. In this display, parameter j stands for job number, m for machine number, and s for maintenance state. If parameter s be equal 1, it means that the related machine goes to maintenance state after doing operation. Otherwise, the quantity of this parameter is zero. On the other hand, the number of repetition of one job in chromosome shows the operation number of that job. Figure 3 illustrates a sample chromosome for supply chain system in Table 1.

1120	1221	2120	1330	2220	2320	1431	2430	2530

Figure 3. Structure of a sample chromosome

In displayed chromosome Figure 3, the second gene is 1221, that means the second operation of first job is done in the second machine and after doing this operation, machine turns to maintenance state.

Fitness Function

Using generated chromosome, the sequence of transition fires in Petri Net is specified. Therefore, duration of scheduling (production time) would be determined through system simulation and it is termed as chromosome fitness function.

Selection and Crossover Operator

In algorithm SCMTP, ranking method is employed for selecting chromosomes as parent. Likewise, a job-oriented crossover operator is used for generating new chromosomes. In job-oriented crossover operator, once two chromosomes are selected as parents and one job is selected randomly. Next, all genes related to that job in the first parent is transmitted to the similar place in the first child. Then, all genes present in the second parent which are related to the selected job are deleted, and the remained genes are orderly placed in the first child. This is repeated for generating second child. One of the advantages of this crossover operator is that no invalid chromosomes are generated. Figure 4 shows job-oriented crossover operator in which the first job is selected randomly.

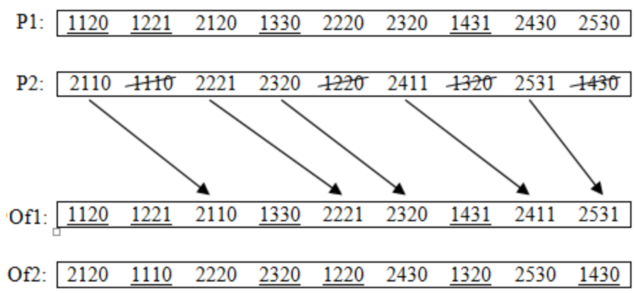

Figure 4. Job-oriented crossover operator with first job

Mutation Operator

In SCMTP there are two mutations from which by random one of them is selected and operated. In the first type mutation, two genes are randomly selected, and then the places of two genes are exchanged. In the second type mutation, one gene is selected randomly, and its maintenance state is changed.

Tabu Search

After doing crossover operator, tabu search as a local search technique is employed to improve chromosome. The aim behind tabu search is to assign better machines to operation through a change in the machine number in chromosome genes.

Tabu search uses two tabu lists: the first list is used for storing L1 last selected chromosomes to prevent selecting repeated neighbors, and the second list is used to store the best chromosomes in each generation so that these chromosomes can be used as elite for holding population diversity.

V. Experimental Results

For algorithm implementation, C#.Net 2008 programming language is used. The programs have been run on a computer with 2.4 GHz Pentium-IV processor and 1 GB RAM.

The proposed algorithm, i.e. SCMTP is compared with algorithms GADG [6], and PN-GA [3]. To compare the algorithms, five test datasets are designed to cover small, average and large systems. These test datasets are named as probX_M_J_O, where X is the test data number, M is the number of machines, j stands for the number of jobs, and O represents the number of operations for each job. For example, prob2_10_20_5 indicates that the second test dataset has 10 machines, 20 jobs, and 5 operations for each job. In other words, in such test data, there are 20*5=100 operations that represent an average system. Each algorithm is executed 50 times independently, and the mutation rate is considered 0.1 and the crossover rate is assumed 0.8.

Table 2 illustrates results from comparing three algorithms SCMTP, GADG, and PN-GA. The table indicates that success quantity for our proposed algorithm is higher than those of other algorithms. The quantity of success shows that the algorithm has reached the best answer in 50 executions. Therefore, it can be concluded that SCMTP has higher stability compared with both other algorithms since it employs tabu search as a local search technique.

TABLE 2. COMPARISON SCMTP, PN_GA AND GADG

Problem	PN_GA			GADG			SCMTP		
	Time	Ave.	success	Time	Ave.	success	Time	Ave.	success
Prob1_10_10_5	15	762	13	8	634	19	31	611	34
Prob2 _10_20_5	39	1879	16	23	1531	22	89	1502	33
Prob3_10_30_5	78	2730	12	41	2295	21	155	2201	33
Prob4_20_30_10	212	3624	14	143	2871	18	1169	2596	29
Prob5_20_30_20	1036	7211	7	391	5906	14	3817	5435	21

Success: number of times that algorithm arrives at the best answer in 50 times execution.
Ave : average of production time in 50 times execution (production time equals the maximum time required for execution of jobs)
Time : time required for algorithm execution

Figure 5 shows comparison of three algorithms SCMTP, GADG and PN-GA based on Production Time. The figure shows in comparison with two other algorithms, SCMTP finds better answer in most cases. The results related to SCMTP algorithm shows %6.73 and % 23.82 improvement over GADG and PN-GA respectively. The present of this improvement would be more significant as the system get larger.

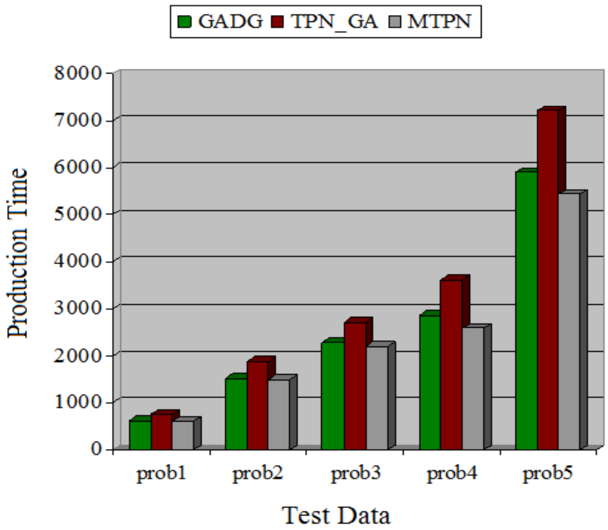

Figure 5. Comparison SCMTP, PN-GA and GADG based on Production Time.

Figure 6 compares SCMTP, PN-GA and GADG in terms of required time for execution. The figure indicates that SCMTP needs more time for execution since it uses tabu search as a local search technique.

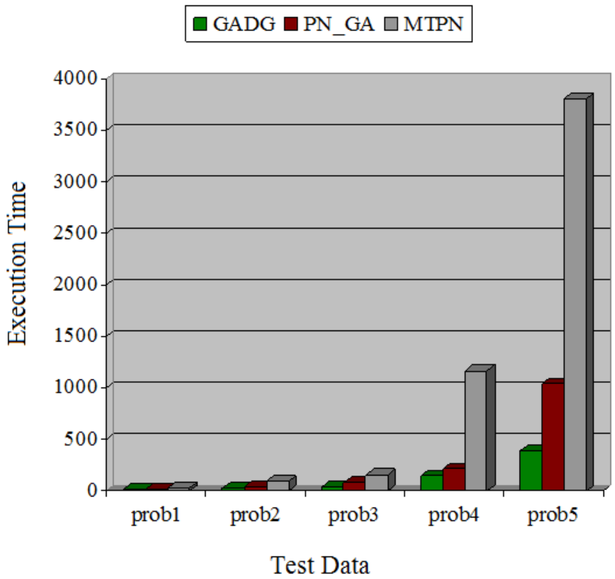

Figure 6. Comparison of SCMTP, GADG and PN-GA based on Execution Time

VI. Conclusion

In this paper a Memetic algorithm combined with Timed Petri Net, i.e. SCMTP is proposed for scheduling supply chain systems. One of its advantages is that it considers maintenance problem. The aim of this algorithm is to minimize production time. Performance of this algorithm is compared with GADG and PN-GA as well. The results show that SCMTP has %6.73 and %23.82 improvements over GADG and PN-GA respectively. The present of this improvement would be more significant as the system get larger. Although SCMTP requires more execution time since it uses tabu search as a local search technique.

References

[1] Takahashi, Masakazu, and Setsuya Kurahashi. "Tabu Search Algorithms for Multimodal and Multi-Objective Function Optimizations." International Journal of Computer Science and Network Security 7, no. 10, 257 – 264, 2007.

[2] Kumar, R, M K Tiwari, and R Shankar. "Scheduling of supply chain systems: an ant colony optimization approach." IMechE, 1443–1453, 2003.

[3] Caballero, J, and G. Mejia, "A Hybrid Approach that Combines Petri Net Models And Genetic Algorithms for Scheduling of Supply chain Systems" .III Congreso Colombiano y I Conferencia Andina Internacional de Investigación de Operaciones. Cartagena, Colombia. Electronic Proceedings, 2004.

[4] Li, Aiping, and Nan Xie. "A Robust Scheduling for Reconfigurable Manufacturing System Using Petri Nets and Genetic Algorithm." Proceedings of the 6th World Congress on Intelligent Control and Automation, 7302-7306, 2006.

[5] Rossi, Andrea, and Elena Boschi. "A hybrid heuristic to solve the parallel machines job-shop scheduling problem." Advances in Engineering Software (Elsevier Ltd), 2008.

[6] Chan, Felix, S H Chung, L Y Chan, G Finke, and M K Tiwari. "Solving distributed SCS scheduling problems subject to maintenance: Genetic algorithms approach." Robotics and Computer-Integrated Manufacturing (Elsevier Ltd) 22, 493–504, 2006.

[7] M Yadollahi and A M Rahmani, "Solving distributed supply chain systems scheduling problems subject to maintenance: Memetic algorithms approach", The 9th IEEE International Conference on Computer and Information Technology(CIT2009), Xiamen , China, 36-41, 2009.

[8] Peres, F, and D Noyes. "Evaluation of a maintenance strategy by the analysis of the rate of repair." Qual Reliab Eng Int 19, 129 – 148, 2003.

[9] Dreo, J, A Petrowski, P Siarry, and E Taillard. Metaheuristics for Hard Optimization. New York: Springer Berlin Heidelberg, 2003.

[10] Moscato P. "Memetic algorithms: A short introduction", In Corne, D., Glover, F., Dorigo, M., editors, New Ideas in Optimizations, McGraw-Hill, Londres, 219 – 235, 1999.