ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

REVIEW ON DEVELOPMENT OF META-HEURISTIC BASED SOLUTION FOR JOB SHOP SCHEDULING PROBLEM

Shruti Rishi Raj [*],Rajiv Goel

[*]M.Tech. Scholar in Computer Science & Engineering, Ambala College of Engineering and Applied Research, Ambala, India

Assistant Professor, Department of Computer Science & Engineering, Ambala College of Engineering and Applied Research, Ambala, India

ABSTRACT

The job shop scheduling problem is one of the classical NP-Hard scheduling problem. Very simple special cases of the job-shop problem are already strongly NP-hard. An instance with ten jobs to be processed on ten machines formulated in 1963 was open for more than 25 years. In this paper we discuss a prominent approach to solve job shop scheduling problem based on Ant Colony Optimization. The ACO algorithm is developed using artificial ants. The Ant System in ACO takes its cue from the nature inspired insect that is the working scenario of ants and the quality of attractions towards the pheromone trails excreted by the ants of the previous iteration. Moreover the pheromone (hormone) excreted by the ants gets evaporated progressively by the passage of time, so the path with the highest pheromone deposition till the end of iteration will be the best solution for the ants to follow to reach for the target.

KEYWORDS: Job shop scheduling problem, Heuristics, Makespan, Ant Colony Optimization.

INTRODUCTION

The Job shop scheduling problem is the one of the most prominent problem in operation research. It can be stated as a finite number of jobs needed to be assigned to a finite number of machines with no preemption of operation while taxing to minimizing the makespan. The Job Shop Scheduling Problem is known to be a strong NP-hard problem. As this problem is now applied as online problem in dynamic scheduling in which the order of processing of jobs depend upon the task in hand and algorithm needs to take the decision before arrival of new job.The objective is to schedule the recent jobs so as to minimize the maximum of their completion times. Many extension to this problem are available like flexible job shop scheduling problem,flow shop problem etc.

More variation of the problem is also executable like Machines can be related, independent, sequence dependent, require the same sort of idle time between the jobs or no idle time, fixed processing time or constraints like certain jobs can be scheduled on some machines only, set of jobs can relate to different set of machines, etc. These constraints make the Job Shop Scheduling into different versions of the same problem.

This problem is not only NP-hard but it is also one of the most computationally stubborn combinatorial problems considered to date. This unmangebility is one of the reasons the problem has been so widely explored. Indeed, some of the excitement in working on the problem arose from the fact that a specific instance, with 10 machines and 10 jobs, dealt in a book by Muth and Thompson[1] remained unsolved for over 20 years. This particular instance was finally settled in 1985 by Carlier [2] as stated by Ivan[3].

PROBLEM FORMULATION

Classic job-shop scheduling problem systems contain 'n' independent job on 'i' machines. Each job includes one or more operations that must be implemented sequentially. Each operation needs specific process time.

A mathematical representation of the problem can be stated as follows: Let M and J be the finite number of machines and jobs in the system respectively, where M & J can be represented as M={M1,M2....Mi} and

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

J={j1,j2....jn]. The folowing table represents the jobs to machines such that each job is processed with each machine only once.

*Table 1. Illustration of 3 * 3 problem.*

Job(J)	**Machine (Processing time)**		
Operation	O_1	O_2	O_3
J_1	1(3)	2(3)	3(3)
J_2	1(2)	3(4)	2(3)
J_3	2(2)	1(3)	3(1)

DISJUNCTIVE GRAPH

The most prominent model for representing the job shop scheduling problem is the disjunctive graphs. The disjunctive graphs are kind of mixed graph which contain the vertices and edges. The edges in disjunctive graph are of two types i.e conjunctive edges and disjunctive edges. The vertices represent the task to be performed where as the edges represent the connection between the vertices both the directed and undirected edges. The disjunctive graph is represented by:

$$G=(V,C \cup D)$$

Where V is the set of vertices representing to operations of jobs together with the two special nodes called source(representing the begning of the schdule) and sink(representing the end of the schdule), C is the set of conjunctive arcs representing technological sequences of the operations which initially connect every two consecutive task of the same job, D is the set of disjunctive arcs which connect mutually unordered operations which require the same machine for their execution.

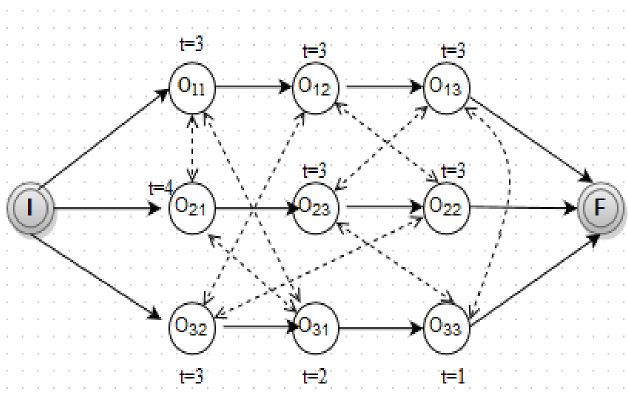

*Fig1. Graph of a 3 * 3 instance of JSSP*

Each arc is labeled with the positive processing time as its weight. The job shop scheduling requires to find the optimum length of all machines to find the minimum length schedule. The resultant schedule may be extracted by the acyclic orientation of undirected edges and the longest path from source to sink is minimized to conclude the makespan i.e. the total time until all tasks have been completed.

ANT SYSTEM

The ant colony optimization takes its cue from the ant's behavior for finding the shortest path from the hub to the food. The algorithm is bioinspired, simulates the behavior of the ant by the artificial ants. The basic idea is to keep a population of ants working for the search of food. They move in random directions in search of food. When found the food the ants excrete a hormone (more like a chemical scents or perfume) called pheromone on the way back to the hub in spots (mainly turning points) which attracts the ants of next batch towards that path and the ants follows that path and deposit more pheromone on the way back to home while carrying the food. In this way they do not lose their path back to the home The pheromone trails evaporate gradually with increasing time.

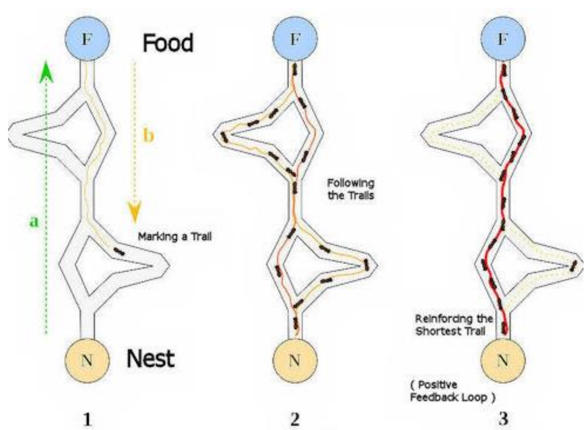

Fig2. Ant System

Now each ant of the next batch on the way back to the hub is updating the pheromone of that spot into the path. In this way the pheromone trails of the best route remain updated where the less used path gets demolished by the evaporation of the pheromone trails. In this way the ants follow the route many times and make the pheromone concentration more on the most used spots in the path. Hence, keeping only those paths that are most suited for the ant and in this way they optimize the shortest path from the hub to the food destination.

ANT COLONY OPTIMIZATION IN JSSP

Ant colonies display very interesting behavior, though one specific ant has limited capabilities, the behavior of a whole ant colony system is highly organized. They are capable of finding the shortest path from their hub to a food destination, without using visual cues, but by exploiting pheromone information deposited by the ants of the previous iteration. The probability that the ants coming later choose the path is proportional to the amount of pheromone on the path, previously deposited by other ants. This theory was the basis for forming the Ant Colony Optimization algorithm using artificial ants. The artificial ants are designed based on the behavior of real ants as artificial ants has the capacity to explore the search space. They excrete pheromone trails on the graph edges and choose their path with respect to the probabilities that depend on pheromone trails.At the end of each iteration, each ant present in the population explore a complete tour traversing all the nodes based on a probabilistic state transition rule,

$$P_{ij} = \frac{(\tau_{ij})^{\alpha} (\eta_{ij})^{\beta}}{\Sigma(\tau_{ij})^{\alpha} (\eta_{ij})^{\beta}} \qquad (1)$$

Where α and β are constants which tune the relative importance in probability of the amount of pheromone versus the heuristic distance. P_{ij} gives the transition probabilty from node i to node j. The probility depends upon the two factors one is pheromone denoted by τ_{ij} and another is heuristic factor denoted by $\eta_{ij.}$ The nodes are chosen by the ants based on the order in which they appear in the rearranging process. The artificial ant moves from one node i to another node j building step by step solution to be inserted into Tabu list until all the nodes hav been traversed. The Tabu list stored the information of all the visited nodes by the ant. After each ant fills its tabu list, the list is searched for the minimum timespan. This minimum timespan is recoreded for that ant which have least timespan among all the ants. Now only pheromone for all those nodes are updated and rest all nodes pheromone value is reset to $\Delta\ \tau_{ij} = 0$. The rule of pheromone updating is defined as equation

$$\tau_{ij}\ (t) = \Delta\ \tau^{k}_{ij} + \rho * \tau_{ij}\ (t-1) \qquad (2)$$

$$\Delta\ \tau_{ij}\ (t) = Q / L_k \qquad (3)$$

where ρ is the evaporation coefficient, τ_{ij} (t) is contribution of *k* ants in total pheromone deposition by ants of each t iteration, Q is the positive real valued constant and L_k is the length of minimum makespan of solution founded by ant k. The evaporation coefficient helps in reducing the effect of old pheromone deposition in the future decision of the ants. The important property of evaporation is that it helps in the prevention of premature convergence to a sub-optimal solution. In this way, the Ants has the capability of forgetting bad solutions, which favors the exploration of the search space.

RESULTS AND DISCUSSION

The job shop scheduling is very famous problem explored by many researchers and solved by many meta-heuristic techniques like Genetic algorithm, ACO, Max-Min ant system, PSO, tabu search, simulate annealing and many more. The following table compare few meta-heuristic approaches results with best known values.

Table 2. Comparative analysis.

Instances	Best Known	ACO [5]	GA [8]	Max-Min [4]
la01	666	666	667	666
la02	655	669	655	671
la03	597	623	617	624
la04	590	611	606	607
la05	593	593	593	593
la06	926	926	926	926
la07	890	890	890	895
la08	863	863	863	863
la09	951	951	951	951
la10	958	958	958	958
la11	1222	1222	1222	1222
la12	1039	1039	1039	1039
la13	1150	1150	1150	1150
la14	1292	1292	1292	1292
la15	1207	1212	1207	1288
la16	945	1005	994	1009
la17	784	812	794	878
la18	848	885	861	916
la19	842	875	890	975
la20	902	912	967	1001

With the overall performance, as proved by deep analysis by Surekha [7] it can be concluded that ACO is superior than genetic algorithm for solving JSSP. As the rate of convergence of Genetic algorithm is

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

slower than the rate of convergence of Ant colony optimization in optimizing JSSP.

CONCLUSION

The Job shop scheduling problem is NP-hard problem and it is very hard to solve it mathematically hence meta-heuristic approaches are needed for finding its optimal or near optimal solution. Each technique has specific mechanisms and representational components. In this paper Ant colony meta heuristic technique is studied for the optimization of job shop scheduling problem for minimum makespan time.

REFERENCES

[1] Muth, J. F. and Thompson, G. L., Industrial scheduling, (1963), Prentice-Hall, Englewood Cliffs, NJ.
[2] Carlier, J., and Pinson, E., An algorithm for solving the job shop problem, (1989), Management Science Vol. 35 2, pp. 164-176
[3] Ivan Lazár, Review on solving the job shop scheduling problem: recent development and trends,(2012), Faculty of Manufacturing Technologies,Technical University of Kosice.
[4] Mario Ventresca and Beatrice M. Ombuki, Ant Colony Optimization for Job Shop Scheduling Problem, Brock University, Department of Computer ScienceTechnical Report # CS-04-04.
[5] Edson Flórez, Wilfredo Gómez and Lola Bautista, An Ant Colony Optimization Algorithm For Job Shop Scheduling Problem(2014), Universidad Industrial de Santander, Bucaramanga, Colombia.
[6] V. Selvi & r. Umarani, An ant colony optimization for job scheduling to minimize makespan time(2012), ijcct, 0975 –7449 vol-3, iss-3.
[7] Surekha P, S.Sumathi, solving fuzzy based job shop scheduling problems using GA and ACO (2010), Journal of Emerging Trends in Computing and Information Sciences, vol-1, E- ISSN 2218-301.
[8] S. M. Kamrul Hasan, Evolutionary algorithms for solving job-shop scheduling problems in the presence of process interruptions(2009), Rajshahi University of Engineering & Technology, Bangladesh.