ISSN No. 0976-5697

Volume 4, No. 3, March 2013 (Special Issue)

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

Jobshop Scheduling Domain Through Cuckoo Search

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Abstract: Scheduling can be defined as a problem of finding an optimal sequence to execute a finite set of operations satisfying most of the constraints. Job shop scheduling is a constrained optimization problem and is the most general and complex among all shop scheduling problems. Nature is handpicked instructor to resolve combined problems within industry of computer discipline. Nature inspired algorithms and approximation algorithms are reported to be very effective in giving near optimal solutions to such complex problems. In this Paper, the concepts of the cuckoo-search discussed and guess the approach that cuckoo search optimization algorithm can perform more efficiently and there is only a single parameter apart from the population size. It can be minimizes the makespan and the scheduling can be used in computing.

Keywords: cuckoo search, job shop, scheduling.

I. INTRODAUCTION

Scheduling is the allocation of shared resources over time to competing activities. Scheduling can also be defined as a discovering an optimal sequence of operations fulfilling limitations. The problem so formulated is extremely difficult to solve, as it comprises several concurrent goals and several resources which must be allocated to lead to our goals, which are to maximize the utilization of individuals and/or machines and to minimize the time required to complete the entire process being scheduled. In recent Years the development of new universal search techniques gave reason for the hope that these methods could successfully be applied on the solving of the JSS so, we expect to find not necessarily an optimal solution, but a good one to solve the problem. New search techniques such as genetic algorithms, simulated annealing (Kirkpatrick *et al.*, 1983) or tabu search (Golver *et al.*, 1993) are able to lead to our objective i.e. to find near-optimal solutions for a wide range of combinatorial optimization problems. Nature-inspired meta-heuristic algorithms are becoming increasingly popular in optimization and applications over the last three decades. There are many reasons for this popularity and success, and one of the main reasons is that these algorithms have been developed by imitating the most successful processes in nature. Meta-heuristics can be an efficient way to produce acceptable solutions by trial and error to a complex problem in a reasonably practical time.

The complexity of the problem of interest makes it impossible to search every possible solution or combination, the aim is to find good feasible solution in an acceptable point range. Job shop scheduling is an optimization problem in which ideal jobs are assigned to resources at particular times. It is the most complex of all scheduling problems and the complexity lies in the fact that all the jobs follow different operation sequences on different machines. JSSP is the most studied and well developed model in deterministic scheduling theory. This problem is not only NP-hard it is also has the well-earned reputation of being one of the most computationally stubborn combinatorial problems considered to date. However, the meta-heuristics methods have guide to healthier results than the traditional dispatching.

II. JOB SHOP SCHDULING

Job-shop scheduling (JSS) is a difficult problem, both theoretically and practically. Each job consists of a certain number of operations. Each operation has to be performed by a dedicated machine and requires a predefined processing time. The operation sequence is prescribed for each job in a production recipe, imposing static constraints on scheduling. Thus, each job has its own machine order and no relation exists between the machine orders of any of two jobs. In the JSS problem a set 'J' of 'n' jobs J1, J2, J3, … Jn have to be processed on a set 'M' of 'm' different machines M1, M2, M3, … Mm. Job Jj consists of a sequence of mj operations Oj1, Oj2, Oj3,….., Ojmj, which have to be scheduled in this order. Moreover,

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II International Conference on
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IEEE Student Chapter Geetanjali Institute of Technical Studies, Udaipur, Rajasthan, India

each operation can be processed only by one machine among the 'm' available ones. Operation 'Ojk' has a processing time 'Pjk'. Each operation must be executed uninterrupted on a given machine for a given period of time and each machine can only handle at most one operation at a time. Some of the constraints to handle mainly are all jobs and their processing times are known prior to scheduling being carried out. This effectively transforms the dynamic problem to static one. And machines are assumed to be able to operate on only one job at a time. And most of these are single parameter objective functions, which are to be optimized. Probably, the most commonly used objective functions are minimization of makespan, minimization of cost and delays as related to problem.

In a classical JSSP, n- jobs are processed on machines,

The following notations and definitions are used to describe the job-shop scheduling problem.

n - Number of jobs

m - Number of machines

pi - Processing time of job, i (i=1,2,…n)

X_{ij}= 1, if job j is scheduled after job i

0, Otherwise for all i, j and i is not equal to j

The minimum makespan problem of job shop scheduling is a classical combinatorial optimization problem. The JSSP is not only *NP*-hard, but it is one of the worst members in the class.

An example [13] of a 3 x 3 JSSP is given in Table I.

Table 1

job	Operations routing (processing time)		
1	1 (3)	2 (3)	3 (3)
2	1 (2)	3 (3)	2 (4)
3	2 (3)	1 (2)	3 (1)

The data includes the routing of each job through each machine and the processing time for each operation (in parentheses).The Gantt-Chart is a convenient way of visually representing a classic solution of the JSSP. An example of a solution for the 3 x 3 problem in Table 1 is given in Figure 1.

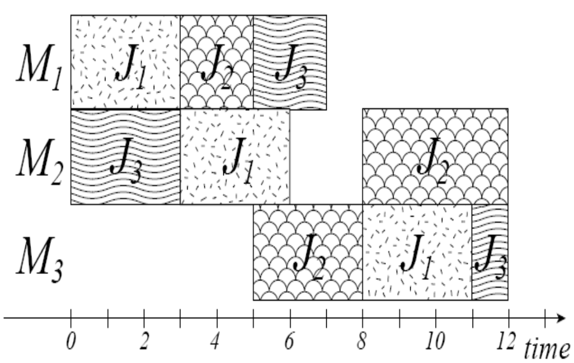

Figure 1: A Gantt-Chart representation of a solution for a 3 x 3 problem

III. CUCKOO SEARCH

Cuckoo search (CS) is an optimization algorithm developed by Xin-she Yang and Suash Deb in 2009.It is based on the brood parasitism of certain species of cuckoo. Each egg in a nest represents a solution, and a cuckoo egg represents a new solution. The aim is to use the new and potentially better solutions (cuckoos) to replace a not-so-good solution in the nests. In the simplest form, each nest has one egg. [1]The algorithm can be extended to more complicated cases in which each nest has multiple eggs representing a set of solutions.

CS is based on following idealized rules[1]

a. Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest;
b. The best nests with high quality of eggs will carry over to the next generation;
c. The number of available host's nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability P $\in$ (0, 1). Discovering operates on some set of worst nests, and discovered solutions dumped from farther calculations.
d. Levy Flight is used when new solution is derived from the old one to attain realistic approach.

These species lay their eggs in other host bird's nests and remove other eggs to increase the hatching probability of their own eggs. If host birds discover that the eggs are not their own, they will either throw these alien eggs away or simply abandon their nest and build a new nest elsewhere. Some female parasitic cuckoos are often specialized in the impressions of color and pattern of the eggs of a few chosen host species. This reduces the probability of their eggs being abandoned and thus increases their reproductively. This algorithm has been applied in several optimization problems, upper forming the results achieved with the well-known meta-heuristic algorithm. Yang and Deb discovered that the performance of the cuckoo search can be improved by using Lévy flight instead of simple random walk as the random walk via Lévy flight is more efficient in exploring the search space as its step length is much longer in the long run.

A. Lévy Flight:

A Lévy flight is a random walk in which the step-lengths have a probability distribution that is heavy-tailed. When defined as a walk in a space of dimension greater than one, the steps made are in isotropic random directions. The name "Lévy flight" refers to the French mathematician Paul Pierre Lévy. [1] The term "Lévy flight" was coined by Benoît Mandelbrot, who used this for one specific definition of the distribution of step sizes. Lévy flight is the typical characteristic of flight behavior demonstrated by many animals and insects. Generally, the foraging path of an animal is effectively a random walk because the next move is based on both the current location/state and the transition probability to the next location. The chosen direction implicitly depends on a probability, which can be modeled mathematically. So, Lévy flight essentially provides a random walk while the random step length is drawn from a Lévy distribution [1]

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$$\text{Lévy} \sim u = t^{-\lambda},\ 1 < \lambda < 3 \quad (1)$$

This has an infinite variance with an infinite mean. The distribution of step length in this is according to the probability distribution which is heavily tailed. The distance of the random walk from the origin tends to a stable distribution after a large number of steps. The Lévy flight has been applied to diverse range of fields, describing animal foraging patterns, the distribution of human travel and even some aspects of earthquake behavior and light. The behavior of Lévy flight showed promising results when applied to optimization and optimal search problems. Lévy flights are, by construction, for general distributions of the step-size, the distance from the origin of the random walk tends, after large number of steps, to a stable distribution.

B. Cuckoo Search Algorithm:

The pseudo code Defined algorithm by Xin-she Yang and Suash Deb,

Begin
Generate initial population of n host nests xi (i = 1, 2... n)
While (t <MaxGeneration) or (stop criterion)
Get a cuckoo randomly or generate solution by L´evy flights and evaluate its quality/Fitness Fi
Choose a nest among n (say, j) randomly
If (Fi > Fj)
Replace j by the new solution;
End
Fractions (pa) of worse nests are abandoned and new ones are built;
Keep the best solutions or nests with quality solutions; Rank the solutions and find the current best
End while
Post process results and visualization
End

A fitness function is a particular type of objective function that is used to summarize, as a single figure of merit, how close a given design solution is to achieving the set aims. Moreover, the fitness function must not only correlate closely with the designer's goal, it must also be computed quickly.

IV. EXPLORATION OF CUCKOO SEARCH ALGORITHM WITH PARTICLE SWARM OPTIMIZATION

a. The space complexity of the cuckoo search algorithm is more than the particle swarm optimization. As the number of parameters in the cuckoo search is less than that of the particle swarm. Therefore the space required in memory by the particle swarm optimization is more than that of the cuckoo search optimization algorithm.
b. Cuckoo search is simple to understand compared to the particle swarm optimization. Cuckoo search algorithm can be easily implemented.
c. Both algorithms can solve the optimization problems. Both are population based algorithms.
d. The run time complication of the cuckoo search algorithm is better then particle swarm algorithm. As in the cuckoo search algorithm the cuckoo once generates the egg and calculates its fitness value. After calculating its fitness value it compares the current solution with the previous best solution. So the solution is less complex. It has only one loop to check. It can work on large number of population. In particle swarm, it has been inspired with the bird flocking behavior. Each particle to find out whether the current best solution among the neighbors and after that the global best solution among the swarm.
e. The randomization concept comes in the cuckoo search as compared to the particle swarm optimization. As there exists the concept of levy flight which supports large step length.

So as if consider rules of cuckoo search, a new approach will be apply on job shop scheduling, it's may be like, consider cuckoos egg as new job and hosts egg as a job. If new appear job satisfied the limitation in given environment more or less. If consider one job at a time on one machine and will plan the job as per the requirements. After calculating its value it compares the current solution with the previous best solution. The best result which satisfies necessities in the direction of draw nearer to grab selected and others are discarded.

V. CONCLUSION

Jobshop scheduling is a type of combinatorial optimization problem. The scope of this area is really huge in next generation computing, modeling and algorithm engineering. In this paper, presented a cuckoo search algorithm, can be apply on combinatorial problem. This is now a day a new approach to solve scheduling problem, in scientific and high power computing to minimize the completion time and resource consumed. There still remain considerably demanding tasks for the research community to address for the recognition of many open areas in technology.

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