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Recent Approaches for Solving Scheduling Problems: A Review

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Abstract—*Scheduling is one of the most complex optimization problem in any industry, mostly because of the large solution space (number of possible solutions, which is equal to n! ^m for a combination of n jobs and m machines) available. For solving scheduling problems in the manufacturing industry, a number of conventional approaches are widely used. But these approaches are very time consuming and ineffective in actual situations. So to overcome this challenging situation of solving scheduling problems, Recently a number of non-conventional approaches have been developed which give better results as compared to the traditional techniques, such as Genetic algorithm, Ant colony algorithm, Fuzzy Logic etc. The main aim of the Present study is to review the recent approaches proposed by various researchers around the globe for solving scheduling problems.*

1. INTRODUCTION

Scheduling may be defined as allocation of tasks of the available resources (material, labour or equipment) over a period of time. The objective of scheduling is to satisfy various production constraints and maximize / minimize a desired objective function. Effective scheduling plays a very important role in today's competitive manufacturing world. Performance criteria such as machine utilization, manufacturing lead times, inventory costs, meeting due dates, customer satisfaction & quality of products are all dependent on how efficiently the jobs are scheduled in the system. Operation scheduling can be defined as, "the processing of a set of jobs, in a given amount of time, on the already allocated corresponding set of machines, in a workshop consisting of several machines or production facilities including operative workers."[Hitomi, (1996)] [Jain, (1998)] classified the available operations scheduling models as job sequencing, flow-shop scheduling, mixed-shop scheduling, job-shop scheduling & open shop scheduling.

Job Shop Scheduling problem (JSSP) is one of the well-known hardest combinatorial optimization problems. There is still a lot of room for improvement in the existing techniques because of its large solution space. If there are 'n' jobs and 'm' machines, the number of theoretically possible solutions is equal to (n!)^m. Among these solutions, an optimal solution, for a certain measure of performance, can be found after checking all the possible alternatives (possible only in small size problems). JSSP is one of the most well-known problems in both fields of production management & combinatorial optimization. It is a method of resource allocation for single – objective or multi – objective optimization scheduling with constraints. Scheduling derives its importance from two different considerations:

1. Ineffective scheduling results in deprived utilization of available resources. A noticeable symptom is the idleness of facilities, human resources & apparatus waiting for orders to be processed. Thus, cost of production increases.
2. Poor scheduling normally creates delay in flow of some orders through the systems. Thus, it calls for special measures that further increase cost of production.

Fig. 1 shows an example of job shop scheduling with six machines and some of the job sequences (see Fig. 1) that the job can follow. If we want to process 2 jobs on these six machines the number of theoretically possible solutions is equal to 2! ^ 6, which is equal to 64. Among these solutions, an optimal solution, for a certain measure of performance, can be found after checking all the possible alternatives (possible only in small size problems). Hence comes the need to develop better and better optimization techniques, so that we can reach to the optimal solution.

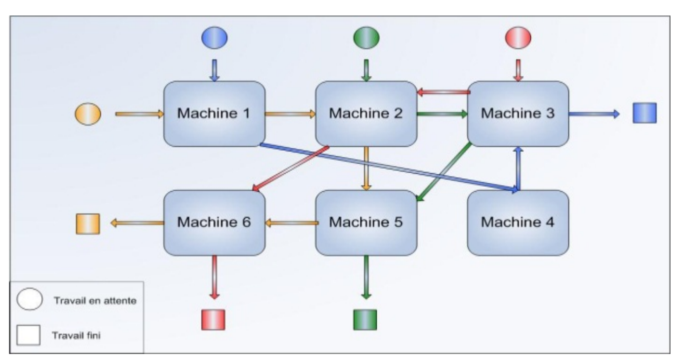

Fig. 1: Job shop scheduling

Current need

It is fairly obvious that optimal production process is important to today's commercial industry. This importance stems from the desire to lower production costs & increase profits. It is often said that time is money. Thus it is in the best interest of both the company and the individual to use time efficiently. This is why, it is important to study scheduling problems like the JSSP.

The JSSP is simply a helpful model to help aid in the eventual development of scheduling software for industrial, personal or commercial use. This study focusses on the recent trends in scheduling of various operations in industries as proposed by various researchers.

Objectives of JSSP

1. Solving disruption problems on the shop floor, such as rush orders, machine overloads and breakdowns.

2. Reduction of in- process inventory.

3. Increasing equipment utilization

4. Minimize make-span

5. Minimize Tardiness

Flow shop scheduling

Flow shop consists of a conversion process in which successive units of output undergo the same sequence of operations, using specialized equipment usually positioned along a production line; for example auto assembly, assembly of television sets, etc. In flow shop scheduling problem, there are *n* jobs; each requires processing on *m* different machines. The order in which the machines are required to process a job is called process sequence of that job. The main difference of the flow shop scheduling from the basic single machine scheduling is that the inserted idle time may be advantageous. Though the current machine is free, if the job from the previous machine is not released to the current machine, we cannot start processing on that job. So, the current machine has to be idle for some time.

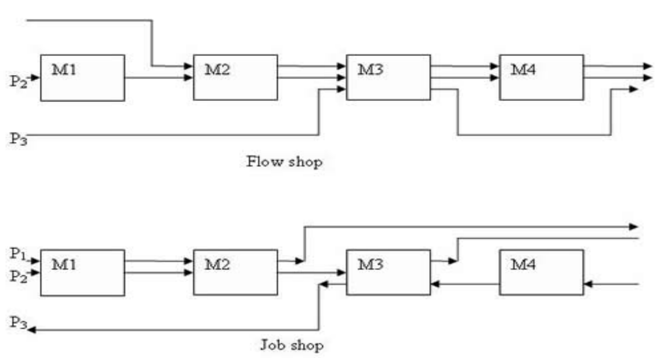

Fig. 2: Job Shop & Flow Shop

Hence, inserted idle time on some machine would lead to optimality. Various conventional approaches to solve FSSP are already present such as Johnson's algorithm, Branch & bound technique, Palmer's heuristic, etc. [R. Panneerselvam]. Fig. 2 shows the job shop & flow shop through a diagram. (see Fig. 2)

Open Shop Scheduling Process

Open shop schedules differ from flow shop and job shop schedules in that in an open shop no restrictions are placed on the order in which the tasks for any job are to be processed. It is easy to conceive of situations where the tasks making up a job can be performed m any order, even though it is not possible to carry out more than one task at any particular time.

Review of various recent approaches for solving scheduling problems

Category 1: According to the type of scheduling problem

a. JSSP

Thi-Kien Dao et. Al. (2015), proposed an optimization algorithm based on parallel versions of the bat algorithm (BA), random-key encoding scheme, communication strategy scheme and makespan scheme to solve the NP-hard job shop scheduling problem. In the experiment, forty three instances of the benchmark in job shop scheduling data set with various sizes are used to test the behavior of the convergence, and accuracy of the proposed method. The results compared with the other methods in the literature show that the proposed scheme increases more the convergence and the accuracy than BA and particle swarm optimization. [1]

Karthikeyan, S. et. Al. (2015), proposed to solve the multi-objective flexible job shop scheduling problem (FJSP). Three minimization objectives - the maximum completion time, the workload of the critical machine and the total workload of all machines are considered simultaneously. In the proposed algorithm discrete firefly algorithm (DFA) is combined with local search (LS) method to enhance the searching accuracy and information sharing among fireflies. The experimental results on the well-known benchmark instances and comparison with other recently published algorithms shows that the proposed algorithm is feasible and an effective approach for the multi-objective flexible job shop scheduling problems. [2]

b. FSSP

Baskar, A (2015), conducted a study on minimization of makespan in permutation flow shop scheduling problems. They developed an algorithm to improve the makespan and proposed to find more than one sequence having optimal/ near optimal makespan. They also developed model for the optimization of the makespan with a few constraints. The new algorithm based on the dummy machine concept improved the makespan up to 18.8% and produced many new sequences.

The developed two models were useful in practical applications also, which was verified through a case study. [3]

Deming lei et. Al. 2015, considered multi-agent scheduling in flow shop environment. In this paper flow shop scheduling problem with two agents is studied and its feasibility model is considered, in which the goal is to minimize the makespan of the first agent and the total tardiness of the second agent simultaneously under the given upper bounds. A simple variable neighborhood search (VNS) algorithm is proposed, in which a learning neighborhood structure is constructed to produce new solutions and a new principle is applied to decide if the current solution can be replaced with the new one. VNS is tested on a number of instances and the computational results show the promising advantage of VNS when compared to other algorithms of the problem. [4]

c. OSSP

Guillermo campos ciro et. Al. (2015) proposed a fuzzy ant colony optimization to solve an open shop scheduling problem with multi-skills resource constraints. An open shop scheduling problem based on a mechanical workshop is described here. The main objective is to find the sequence of jobs which minimizes the total flow time. A mathematical model is described and solved optimally. A fuzzy ant colony optimization method is proposed due to the difficulty to fix the different parameters of an ACO and improve the quality of the solution. Finally, some computational experiments are defined using the references of the literature to get efficiency of ant colony optimization. A first kind of tests are related to the small-sized instances allowing to evaluate the general performance of the model and the algorithm while a second one involves the large-size instances showing a further evaluation of the algorithm.[5]

Cateogery-2 According to the various parameters in scheduling

a. Makespan

Wenwen Lin et.al. (2015), developed an integrated model for processing parameter optimization and flow-shop scheduling. In this study, Objectives to minimize both makespan and carbon footprint were considered simultaneously, which was solved by a multi-objective teaching–learning-based optimization algorithm. In the theoretical aspect, the strategies greatly improved the performance of the optimization results through reducing machine idle time and cutting down the search space. From the perspective of practical applications, these strategies greatly help elevate production efficiency and reduce environmental impacts. [6]

Chang, H. et.al. (2015), aimed to minimize the total order completion time (makespan). They developed a novel method that involved encoding feasible solutions in the genes of the initial chromosomes of a genetic algorithm (GA) and embedding the Taguchi method behind mating to increase the effectiveness of the GA. Two numerical experiments were conducted for evaluating the performance of the proposed algorithm. The first experiment involved comparing the proposed algorithm and the traditional GA. The second experiment entailed comparing the proposed algorithm with those presented in previous studies. The results demonstrate that the proposed algorithm is superior to those reported in previous studies and effectively overcome the encoding problem that occurs when a GA is used to solve the Flexible Job Shop Scheduling Problem.[7]

b. Tardiness

J. kuhpfahl et.al (2015), feels that the job shop scheduling problem with total weighted tardiness objective (JSPTWT). This objective reflects the goal to achieve a high service level which is of increasing importance in many branches of industry. The paper concentrates on a class of baseline heuristics for this problem, known as neighborhood search techniques. An approach based on disjunctive graphs is developed to capture the general structure of neighborhoods for the JSPTWT. Existing as well as newly designed neighborhoods are formulated and analyzed. The performance and search ability of the operators (as well as combinations thereof) are compared in a computational study. Although no dominant operator is identified, a transpose-based perturbation on multiple machines turns out as a promising choice if applied as the only operator. Combining operators improves the schedule quality only slightly. But, the implementation of operators within a meta-heuristic enables to produce a higher schedule quality. A structural classification of neighborhood operators and some new analytical results are presented as well. [8]

Ame Mensendiek et.al. (2015), Shows that the problem of minimizing the total tardiness of a set of jobs to be scheduled on identical parallel machines where jobs can only be delivered at certain fixed delivery dates. Scheduling problems with fixed delivery dates are frequent in industry, for example when a manufacturer has to rely on the timetable of a logistics provider to ship its products to customers. They developed and empirically evaluated both optimal and heuristic solution procedures to solve the problem. As the problem is NP-hard, only relatively small instances can be optimally solved in reasonable computational time using either an efficient mathematical programming formulation or a branch-and-bound algorithm. Consequently, they developed a tabu search and a hybrid genetic algorithm to quickly find good approximate solutions for larger instances. [9]

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