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# A Note on Multi Objective scheduling and It's Applications

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## ABSTRACT

*Multi objective scheduling has been playing a vital role in literature from past decades now. Single objective scheduling is very rare in business now a day, hence for any researcher is opportunity to research on multi objective scheduling. The scheduling problems are classified as single machine scheduling problem multi-level machine problems like flow shop, job shop and open shop scheduling problems. The multi objective problems includes minimize the makespan that is minimize the total completion time of all jobs is the primary objective along with minimization of weighted tardiness of job and minimization of sum of weighted completion time etc.. The aim of the study is to find the optimal solution using local and global search techniques. This study is also on application of heuristic algorithms that is designed for solving the problems in a more efficient fashion than traditional methods. The best algorithm will be simulated and tested on the Bench Mark problem and the results will be studied based on optimality of the schedule and speed of the algorithm.*

***Keywords:*** *Scheduling, Multi Objective Optimization, Pareto optimality, Job Shop Scheduling, Stochastic Search and Evolutionary Algorithms.*

## 1. INTRODUCTION

In the real world most of the decision makers face a problem which are identified as multi objective problems. Where there does not exist a single objective by which one can measure a success of the required solution, instead there exist a multi objectives which has to be achieved. In such cases there does not exist **a** single scheduling solution which simultaneouslysatisfies all the objectives hence compromise solution must be obtained in order with the performance of the decision maker [1] Obviously, Multi objective scheduling problems are complex compare to single scheduling problems and it is difficult to find a compromise solution which states all the objectives simultaneously. Because of this the objectives are more often inconsistent, contradictory and conflicting [2]. Multi objective scheduling with conflicting objectives give rise to a set of optimal solutions instead of a single optimal solution. In general the optimal solution is called Pareto Optimal Solution. In this article, we have reviewed the important results which have been obtained and finally discussed future work in it and technologies that have been proposed to solve Multi objective scheduling problems.

## 2. MULTI OBJECTIVE OPTIMIZATION AND APPROACHES:

**2.1:Basic Concepts:** Multi objective optimization finds applications in various fields and it is the subject of study for researches from 1970.Multi objective optimization comes into picture whenever someone has to deal one or more criterion simultaneously, then this will be refereed as multi objective optimization problem[3].This kind of problem will not have one solution which is best w.r.t all other objectives instead there exist multiple solutions, which are better w.r.t other solutions in the search space. When considered all the objectives and there solutions are called non- dominated solutions [4].

**2.2 Approaches:** From the literature survey it is found that there are 5 different approaches to solve multi objective optimization problems [6] namely

(i) Scalar Methods

(ii) Interactive Methods

(iii) Fuzzy Methods

(iv) Meta Heuristic Methods

(v) Decision Aid Methods

However the selection of the Approaches completely depends on the goal of the study and the content of the application used. The most used approach is Meta heuristic methods which are suitable for solving production based scheduling with more than one criteria[6][7].

[11] Proposed Applied "Evolutionary Algorithm" based approaches to solve multi objective optimization problems where "Evolutionary Algorithms (EA)" are stochastic search algorithms and the aim of EA is to search global near optimal solution using Exploration and Exploitation methods. Compare to Mathematical programming, Evolutionary Algorithms are best suitable to solve Multi objective optimization problems because they find a set of Pareto optimal solutions [8]. In the present time Multi Objective Evolutionary Algorithms (MOEA) has attracted most of the researches .MOEA's are classified into three categories as follows

(1) Aggregating Functions: These methods aggregate all the Sub- Objectives into one combinatorial objective then converting the Multi objective optimization problem into a single- objective problem [9] this Model is defined as - If a multi objective problem as 'n' sub- objectives then lets define the objective as f(x) = min $\sum_{i=1}^{n} W_i f_i(x)$ (i= 1, 2…., n) and $W_i \geq 0$ wherw $W_i$ is the weight of the i$^{th}$ sub objective and$\sum W_{i\,=}$ 1.

The function can be linear or non-linear when it is linear hard to search the solution but it is non linear then can be solved easily.

(2) Population based Approaches: "VEGA is the most common used approach in this method. A population was divided into disjoint sub populations where each sub population consists of its own Optimized objective".

(3) Pareto- Based Approaches: These methods are merged with pareto optimality in the choosing mechanism currently many researches are going on this kind of approaches. The representative Algorithms are "Multi Objective genetic Algorithm(MOGA)"[10] "Niched Pareto Genetic Algorithm(NPGA)"[11] "Non-Dominated Sorting Genetic Algorithm-II(NSGA-II)"[12] "Strength Pareto Evolutionary Algorithm(SPEA)"[13] "Multi Objective Messy Genetic Algorithm (MOMGA)" [14] "Orthogonal Multi Objective Evolutionary Algorithm(OMOEA)"[14] "Density Based multi objective Evolutionary Algorithm(DMOEA)"[16].

## 3. MULTI OBJECTIVE SCHEDULING:

**3.1 Scheduling Concepts:** In most of the scheduling problems minimizing the makespan is considered as major objective that is single objective but in general Makespan is not only the important objective in scheduling there are multiple objectives depending on the requirements of the production, customer needs and so on. In such cases scheduler can choose the best schedule among the generated solutions because of different nature of objective functions obtaining an optimal schedule solutions by optimizing all the objective functions is not possible hence it is required to obtain as many as "Pareto optimal Schedule" such that it should be non- dominating.

The following are the most common Multi objective criteria that appears in the literature

Make span $C_{max}(\sigma)$ ; Minimum

Completion Time $\sum_{j=1}^{n} W_j C_j (\sigma)$ ; Maximum

Lateness $L_{max} (\sigma)$ ; Maximum

Tardiness $T_{max}(\sigma)$ ; Maximum

Earliness $E_{max} (\sigma)$ ; Total (weighted)

**3.2 Parallel machine Scheduling:** In this schedule there will be 'n' independent jobs on 'm' identical parallel machines with some objectives to be optimizes. Parallel machine schedule is a "NP- Hard" problem no methods are available to generate optimal solutions from literature survey it shows that there are many multi objective problems on parallel machine scheduling one such is earliness and tardiness penalties[15] these models are single machine models which involves common due date for all jobs . The results shown that when the due date is same for all the jobs the optimal schedule will be "V-shaped". The jobs that complete before the due date are in LPT sequence and jobs that complete after the due date are in SPT sequence. [16] Developed a decision theory based model for earliness and tardiness in which jobs have different arrival and processing times.[17] joined GA with dispatching rules to solve the multi objective parallel machine scheduling problems.

**3.3 The Shop scheduling:** In shop scheduling each machine performance one of the operations that the job consists of .Shop scheduling problems are mainly classified into four

(i) Single Machine Scheduling
(ii) Flow Shop Scheduling
(iii) Job- Shop Scheduling
(iv) Open- Shop Scheduling

**3.3.1 Single Machine Scheduling:** which is the simplest shop scheduling problem where there will be one machine available and jobs arriving requires services from this machine.

**3.3.2 Flow Shop Scheduling:** In this scheduling jobs are processed on multiple machines in an identical sequence. "Flow Shop Scheduling Problems (FSSP)" is NP- hard problems because of its wide applications to industrial areas FSSP are well studied problems in "Combinatorial Optimization". The well known criteria considered in FSSP is minimizing the makespan($C_{max}$) “Ho&Chang [18]”conducted first research on multi- objective FSP where they proposed heuristic procedure to solve multi objectives like Makespan, total flow time and total machine idle time. “Sridhar &Rajendran [19]” proposes Heuristic based “Genetic Algorithm” for the same objectives”Ponnambalan [20]”developed multi objective evolutionary search algorithm using travelling salesman Algorithm and Genetic Algorithm. “B.Yagrhaham [21]” proposed “Ant Colony Optimization Algorithm” to solve FSSP with multi objectives like Makespan,- total flow time - total machine idle time.

**3.3.3 Job Shop Scheduling:** This kind of scheduling finds application in Industrial Production and multi process computer systems .The multi objectives in most of the job shop scheduling problems are minimizing the makespan and total tardiness. “Sakawa& Kubota [22]” developed a “Genetic Algorithm” using “Gantt Charts” for JSSP with ‘fuzzy processing time and Fuzzy due dates’ and the objective is to maximize the minimum Agreement index to maximum. “Xia & WV [23]” proposed a hybrid Algorithm of “Particle Swarm Optimization (PSO)” And “Simulated Annealing” to multi objective FJSSP. “Kazi [24"]” proposed an Evolutionary approach for solving multi objective JSSP using “Jumping Genes Genetic Algorithm(JGGA)” which searches near- optimal optimizing multiple criteria simultaneously.

**3.3.4 Flexible Job Shop Scheduling:** This scheduling is an Extension of JSP in which each operation can be processed on any machine out of given set of machines .FJSSP are more complex than JSP as there is an additional need to determine assignment of operations to machines. Generally FJSP consists of rating sub problem which assigns each operation to a machine out of a set of capable machines and Scheduling sub- problem consists of sequencing the assigned operations on all the machines to achieve some criteria. “ImedKacem [25]” propose a Pareto approach based on hybridization of ‘fuzzy logic & evolutionary Algorithms’ to solve. “Chinyao Low [26]” used global criterion approach to develop a multi objective model for solving FMSSP which consists of three performances that is Min mean job machines idle time, flow time and job tardiness “JieGao [27]” proposed “hybrid genetic algorithm’ for FJSP which consists of three criterions namely min.Makespan, Min Maximal machine workload and min. total workload. “Tay [28]” proposed multi objective FJSP by using dispatching rules discovered through genetic programming.

**4. Conclusions and Future Research:** Through this survey we noticed that multi objective problem gives rise to set of optimal solutions rather than a single optimal solution including ‘Pareto-Optimal solution’ cannot said to be best than the rest. This requires finding many ‘Pareto- optimal solutions’ as possible. A classical optimization method transforms multi objective problems to a single objective optimization problem. Since from survey it is noticed that many multi objective approaches have been proposed out of which Hybrid Algorithm, the integration of two methodologies for multi objective optimization has become an interest topic for the research. Classical scheduling approaches solve the problem with optimal & sub optimal schedule but they can easily become infeasible in reality. Manufacturing systems are dynamic, complex & stochastic systems hence dynamic manufacturing systems require dynamic scheduling hence more research studies are planning in the dynamic Evolutionary [29].

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