CHAPTER-VII

COMPARATIVE STUDY OF DISPATCHING RULE FOR JOB SHOP SCHEDULING PROBLEM

The main results of this chapter have been presented as detailed below:

Comparative Study of Dispatching Rule for Job Shop Scheduling Problem.
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7.1 INTRODUCTION

Much interest has been committed by researchers in investigating the interactions between order review and release (ORR) techniques and other important scheduling activities such as dispatching**. Nicholson** and **Pullen** [1] concentrated on the effects that the adoption of an ORR procedure can trigger on real time shop floor dispatching rules. Their research results suggested that, if job release is carefully controlled, sophisticated priority rules for dispatching on the shop might be replaced by a simple FCFS dispatching rule without remarkable deterioration in shop performances. This claim is also supported by the work of **Bechte** [2]. Nevertheless, other authors, such as **Bertrand [**3, 4] and **Portioli** [5] have shown that even with an effective order release procedure, such dispatching rules as `truncated shortest processing time' (tSPT, see **Blackstone *et al.*** [6]) can yield better shop performances than FCFS. Research performed by **Ragatz** and **Mabert** [7] also investigated this topic by comparing five order release techniques in combination with four dispatching rules. The study concluded that the greatest advantage from the use of controlled order release appears to be achieved with sequencing rules that do not incorporate due date information. A recent study by **Ahmed** and **Fisher** [8] went further in studying the connections of ORR with other scheduling activities. Their research has shown that, in determining the performance of a job shop, an interaction does exist among three activities of a job scheduling policy: due-date assignment, order review and release and dispatching. As a consequence, the impact of an ORR procedure should be evaluated while considering all the relevant scheduling decisions; this is also a conclusion of another study developed by **Perona** and **Portioli** [9].

The most preferred approach to job shop scheduling in the industry is using dispatching rules **McKay *et al.*** [10]. Dispatching rules were first proposed in the 1950s, and were attractive in terms of their simplicity and ease of application. However, there are some shortcomings to using dispatching rules. First, dispatching rules do not consider all of the available resources at the same time.

The common practice is to employ an additional rule to first select a resource and then apply the dispatching rule. This contaminates the effectiveness of the dispatching rule, and the cumulative effect of these two types of rules (resource selection and dispatching) can only be determined through extensive simulation. Second, dispatching rules do not allow for the use of multiple criteria in the scheduling process. Dispatching rules often influence only one performance measure, whereas scheduling in the industry usually requires the meeting of several objectives simultaneously. Third, the rigid structure of the dispatching rules excludes the use of other useful information that may be available for scheduling. Fourth, there is no single universal dispatching rule. The literature reports hundreds of such rules, and the choice of a suitable dispatching rule depends on the nature of the scheduling problem and the performance measure of interest. Because the scheduling environment itself is dynamic, the nature of the scheduling problem will change over time and therefore, the dispatching rule will also need to change over time **Subramaniam** [11].

The problem of scheduling in dynamic shops is an important operational problem in view of its complexity and significance in terms of associated costs of scheduling. While a number of research studies have investigated the problem of scheduling in flow shops and job shops, only some attempts have been done to study the problem of scheduling in assembly job shops that manufacture multilevel jobs. The problem of scheduling in dynamic assembly job shops with jobs having weights for holding and tardiness of jobs deserves due attention. In this study an attempt has been made to propose new priority dispatching rules that minimize the performance measures related to weighted flow time and weighted tardiness of jobs. The existing unweight dispatching rules have been modified in view of the consideration of weights for flow time and tardiness of jobs. The performances of the (modified) existing dispatching rules and the proposed dispatching rules are compared through exhaustive simulation experiments with the consideration of a number of different experimental settings involving due-date setting, utilization levels and types of job structures. The proposed dispatching rules are found to perform better than the existing ones in most experimental settings and with respect to a number of measures of performance.

The most frequently used approach is to schedule heuristically according to predetermined ‘‘rules of thumb’’. In certain cases, scientifically derived scheduling procedures can be used to optimize the scheduling objectives.

Measures considered in this paper include [12]:

Mean flow time: $$\overline{F} = \frac{1}{n}\sum_{j=1}^{n} F_j$$

Mean tardiness: $$\overline{T} = \frac{1}{n}\sum_{j=1}^{n} T_j$$

Maximum flow time: $$F_{\max} = \max_{1 \le j \le n} \{F_j\}$$

Number of tardy jobs: $$N_T = \sum_{j=1}^{n} \delta(T_j)$$

Tardiness variance: $$\frac{1}{n}\sum\left(T_j - \overline{T}\right)^2$$

7.2 PROBLEM IN DISPATCHING RULE

Until now there has been no single dispatching rule [6] that minimizes most of the regular and non-regular performance measures, particularly in the dynamic environment of job shop scheduling. A study has therefore been carried out to find new dispatching rules using a combination of rules that minimize most of the regular performance measures.

The dispatching rules

SPT (Shortest Processing Time): Highest priority is given to the waiting operation with the shortest imminent operation time.

LPT (Longest Processing Time): Highest priority is given to the waiting operation with the longest imminent operation time.

MWKR (Most Work Remaining): Highest priority is given to the waiting operation associated with the job having the most total processing time remaining to be done.

LWKR (Least Work Remaining): Highest priority is given to the waiting operation associated with the job having the least amount of total processing time remaining to be done.

TWORK (Total Work): Highest priority is given to the job with the least total processing requirement on all operations.

FIFO (First In First Out): Highest priority is given to the waiting operation that arrived at the queue first.

LIFO (Last In First Out): Highest priority is given to the waiting operation that arrived at the queue last.

7.3 JOB BASED ASSUMPTIONS

Standard assumptions are used [6, 12, and 13].

1. A job arriving in the system goes directly to a machine center for its first operation.
2. The characteristics of each job are statistically independent from those of all other jobs.
3. Each job has a specified sequence of machine centers that it should visit.
4. Each job requires a finite processing time for each of its operations. The processing time of all jobs of a specific type at any machine center has a known distribution function.

5. Each job may have to wait between processing at different machine centers, and thus in-process inventory is allowed.

7.4 MACHINE BASED ASSUMPTIONS

1. Each machine center consists of a single or several identical machines.
2. Each machine in the shop operates independently of other machines and is capable of operation at its own maximum output rate.
3. Each machine is continuously available for processing jobs, and there are no interruptions owing to breakdowns, maintenance, or other such causes.

7.5 DYNAMIC JOB SHOP

A job shop will be treated mainly as dynamic, when conditions such as continuously arriving new jobs and deviations from the current schedule need to be accommodated. A job shop should be treated as an integrated part of a manufacturing system. Within the subset of dynamic/stochastic models we deal with experimental, simulation-based approaches, while ignoring the analytical procedures by means of queuing theory systems. The vast majority of simulation- based dynamic job shop scheduling literature assumes a Poisson distribution of job arrivals and, correspondingly, exponentially distributed interarrival times. As far as the processing time is considered as random variable, exponential as well as normal distributions occur. The evident advantage of a dynamic scheduling approach is due to the fact that it allows for an up-to date decision with respect to meanwhile entering (possibly rush) jobs, by loading a machine at the latest possible moment, namely as that machine gets idle [10].

Operating policies

- Each job is considered as an indivisible entity even though it may be composed of several individual units.
- Each job, once accepted, is processed to completion, that is, no cancellation or interruption of jobs is permitted.
- Each job (operation), once started on a machine, is completed before another job is started on that machine.
- Each job is processed on no more than one machine at a time.
- Each machine canter is provided with adequate waiting space for allowing jobs to wait before starting their processing.
- Each machine canter is provided with adequate output space for allowing completed jobs to wait until they are moved out of the machine center.

7.6 EXPERIMENTAL CONDITIONS

A simulation experiment has been conducted for an open shop configuration consisting of six machines. It has been observed by many researchers that job shop size variations do not significantly affect the relative performance of dispatching rules. The number of operations for each job is uniformly distributed with an exponential distribution. Two process-time distributions are used:

1. Expo (16)
2. Expo (18)

An externally determined due date occurs when either the due date is set for a specific time in the future or is established by the customer. An internally determined due date is based either on the total work content (or sum of the processing time) of a job or on the number of operations to be performed on the job. Most researchers assign due dates by the total work content method [1, 2, 3, 4, 5]. In the present study, the due date of an arriving job is set at multiples 4, of its total work content (TWK_i) from the time of its arrival. The due date assignment [6] is presented as follows:

$DD = T_i + c^* \, TWK_i$, where $C = 4$.

Job arrivals are generated using an exponential distribution. Two machine utilization levels are tested in the experiments, viz. 85% and 95%. Thus, in all, two types of process time distributions, four different due date settings and two different utilization levels make a total number of eight simulation experiment sets for every dispatching rule.

7.7 RUN LENGTH AND NUMBER OF REPLICATIONS

Typically, the total sample size in simulation studies of job shop scheduling is on the order of thousands of job completions [1, 2, 3, 4, and 5]. For a given total sample size, it is preferable to have a smaller number of replications and a larger run length, and the recommended number of replications is about ten. The method suggested by Fishman [9] has been taken as a guideline in the present study to fix the total sample size required in simulation studies.

7.8 COMPARISON OF RESULTS

The results of the simulation study are presented in Tables 1. All performance criteria are given relative to the best performing rule. To explain further, the mean tardiness values, here the computed relative percentage error (or relative percentage increase), are written as *Tk* which denotes the mean tardiness of jobs due to the application of rule k where;

$k = 1$ indicates the FIFO rule

$k = 2$ indicate the LIFO rule

$k = 3$ indicate the LPT rule

$k = 4$ indicate the SPT rule

$k = 5$ indicate the TEKR rule

Table 1. Allowance factor C=4

% UP	Rules	TJ	MAX FL	MAX TY	MEAN FL	MEAN TY	σ_t^2
85%	FIFO	87.245	1007.55	645.12	2.7616	2.0021	512.17
	LIFO	16.618	804.09	541.58	6.1657	3.3841	1124.67
	LPT	24.167	1098.39	756.95	10.843	8.573	3849.29
	SPT	88.051	1068.87	598.64	1.093	0.6228	389.18
	TWKR	15.356	995.49	606.52	3.2914	2.1131	793.92
95%	FIFO	92.254	0914.2	712.58	1.495	1.024	58.245
	LIFO	34.668	804.54	588.24	5.5426	4.3546	1309.19
	LPT	50.690	1092.96	892.69	11.1246	9.9486	4054.29
	SPT	92.985	1008.8	695.6	2.09	1.986	59.456
	TWKR	33.981	1005.9	786.5	2.982	2.4698	979.89

TJ = Tardy jobs

TY = Tardiness

UT = Utilization factor

FL = Flow time

σ_t^2 = Tardiness variance

This chapter presents only the mean and maximum tardiness because the performances of the rules are similar for that of maximum and variance of flow times, as for maximum and variance of tardiness.

The combination exploits the benefits of both rules which not only seek to maximize the throughput at the current machine, but also seek to minimize the waiting time of a job for the subsequent operation. It is also quite interesting to observe that the rules based on the random choice between the two rules fare better than the rules considered individually. Such rules seek to combine the advantages of both rules.

It appears that for the objective of minimizing the maximum tardiness, only the LPT rule emerges as effective. When the utilization of the shop floor is high, it was found that the LIFO rule works well. It is well known that the SPT rule is quite effective for minimizing the mean flow time of jobs and that SPT yields a larger flow time of jobs with large process times [12]. Thus, it implies that the SPT rule's performance is not so good with respect to minimizing the maximum and variance of flow times.