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(Review Article)

Dispatching Rules for the Job shop scheduling

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Abstract

Dispatching rules are widely accepted in the industry because of the ease of implementation, satisfactory performance, Low computation requirement, and flexibility to incorporate domain knowledge and expertise. Dispatching Rules have been reviewed and Case study Problem is solved using different Dispatching Rules in this paper.

Keywords: Dispatching rule;Job shop; Flow shope; Tardiness; Makespan

1. Introduction

Dispatching rules are a very common means of scheduling due to their simplicity and speed, Expert systems can choose between dispatching rules, but if none of the rules are very good, then the expert system can only do so much. Dispatching rules are also often implemented without an expert system. In a few cases with special problem structure, dispatching rules can give a rigorous optimum, but for most problems they are a heuristic. The biggest drawback of many dispatching rules is the quality of the solution. There is no guarantee of even a local optimum, much less a global optimum. A second drawback is that there is no straightforward means to tell how far the solution is from the global optimum. Of course, the second drawback can make it easy to overlook the first drawback. In a broad sense, every sequencing algorithm can be considered a dispatching rule, where the rule is to use a particular algorithm. However, dispatching rules here means simple rules, such as earliest due date or shortest processing time. Dispatching Rules can be classified as Process Time based rules, Due date based Rules, Combination based Rules and Rules that are neither PT based nor DD based.

2. DISPATCHING RULES

FCFS rule selects the next job from the queue based on their arrival time at the current machine. That is, Zij = rij, where rij is the arrival time of job i at machine j. SPT rule selects the next job from the queue based on their processing times at the current machine. That is, Zij = pij, where pij is the processing time of job i at machine Mj.

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EDD rule selects the next job from the queue based on their due date. That is, Zij = di, where di is the due date of job i.

AT-RPT rule, provided by Rajendran and Holthaus, selects the next job from the queue based on their arrival time into the system with respect to the total remaining processing time. The formula is, Zij = - [t - ri] - RPTi, where t is the current time and RPTi is the total remaining process time of job i.

MST rule selects the next job from the queue based on their slack times. Slack time of any job is computed by deducting the current time and the total remaining process time from the due date of the job. That is $Z_{ij} = s_i = d_i - RPT_i – t$.
MDD rule selects the next job from the queue based on their due dates with respect to the current time and the total remaining processing time of the job. That is, $Z_{ij} = Max \{d_i, t + RPT_i\}$.

Critical Ratio [CR] rule selects the next job from the queue based on their relatively available time divided by the total remaining process time of the job. That is, Zij = [di – t] / RPTi.

S/PMOP rule selects the next job from the queue based on their slack time divided by the number of remaining operations of the job. That is, Zij = [di – RPTi - t] / ROi, where ROi is the total remaining operations of job i. RR rule, provided by Raghu and Rajendran, can improve the average delay time and the average flow time performance. The formula takes into account the total work content of job. PT+WINQ rule, provided by Holthaus and Rajendran, can improve the average flow time. The formula is Z ij = p ij + w i.

PT+WINQ+AT rule, provided by Holthaus and Rajendran, can improve the maximum flow time and the flow time variance. The formula is Z ij = p ij + w i + ri. PT+WINQ+SL rule, provided by Holthaus and Rajendran , can improve the maximum delay time and its variance. The formula is Z ij = p ij + w i + s i.

3 Literature Review on dispatching rules for job shop scheduling:

S.S.panwalkar [1] tells that Combination of priority rules work better than single priority rule. They classified over scheduling rules and made an attempt to explain the general idea behind different rules. They point out that most research in scheduling including simulation is based on hypothetical problems. While there is a definite need for such an effort to have more research based on real problems.

R.Haupt [2] has explained 26 rules... EDD is the most important rule. They present a classification, a characterization and an evaluation of elementary priority rules. They conclude that the experimental design of successive simulation runs became an integral part of process of priority rule formulation and application. They pointed that more sophisticated cases of global shop information and evaluation of performance criteria would be future criterion.

Ling-Huey su and pei-chann chang [3] have prepared two heuristics the problem is divided into many stages. This can be used for Dynamic arrivals, machine breakdown and rescheduling.

Oliver Holthaus and Chandrasekharan Rajendran [4] have proposed two rules by combining SPT and WINQ. Extensive simulation experimentation has been carried out to evaluate the performance of various dispatching rules. He found that no single rule is effective in minimizing all measure of performance. On the basis of the additive strategy, and is found quit significant in minimizing the mean flow time Future research could be to develop rules that include information about process time ,total work content , Jobs in the next queue and Due date.

Chandrasekharan Rajendran and Oliver Holthaus [5] investigated three new dispatching rules. They considered 13 dispatching rules for the analysis of the relative performance with respect to the objectives of the minimizing mean flow time, maximum flow time,variance of flow time, proportion of tardy jobs, mean tardiness, maximum tardiness and variance of tardiness. They proposed [PT+WINQ]/TIS rule, PT/TIS rule and AT-RPT rule. First two rules seem too often good solutions with respect to the flow time related performance measures. AT-RPT rule found to be very effective in minimizing the maximum flow time and variance of flow time of jobs.

Chandrasekharan Rajendran, Hans Ziegler [6] compared SPT, RANDOM, PT+WINQ rules and new rule 2PT+WINQ+NPT .The new rule performed better and a heuristic is compared with the new rule.

K.M.Mohanasundaram et al. [7] Proposed rule LF-ECT which perform better than TWKR-RRP for lead time based measure and LFD-JDD performs better than JDD-RAN for due date measures. They found from the simulation study that the proposed rules are quite effective in minimizing the maximum and standard deviation of flow time and staging delay and the maximum conditional tardiness and standard deviation of tardiness. LF-ECT was compared with TWKR-RRP rule for lead time based measures and LTD-JDD was compared with TWKR-RRP rule for due date measures.

Emmett Lodree Jr et al.8] Proposed new rule EADD which perform 16% better than SPT for Dynamic flow shops for minimizing number of tardy jobs. This can be utilized for Dynamic job shops.

P.D.D.Dominic et al. [9] new rule MWKR_SPT gives the best result for mean tardiness and MWKR_FIFO is best for minimizing mean flow time.

Nhu Binh HO and Joc cing TAY [10] have generated five composite dispatching rules by GP these rules are based on the combinations of parameters such as process time, Release date, due date, current time, number of operations and average processing time of each job .It perform better than single.

T.C.Chiang and L.C.FU [11] Proposed rule which outperform 14 existing rules when tardy rate and mean tardiness are simultaneously considered. The proposed rule can provide performance close to COVERT and ATC when mean tardiness and the maximum tardiness are considered at the same time they propose a rule which combines the design concepts including "Shorter processing time earlier due date and longer processing time earlier in order to generate schedules with balanced performance on all three objectives.

Horng Cyi Horng [12] compared steady state performance of Dispatching Rule-pairs in open shops. 2PT+WINQ+NPT is better than PT+WINQ in minimizing mean flow time.PT+WINQ+NPT+WSL outperform PT+WINQ+SL in minizing maximum tardiness.

H. L. Lu et al. [13] chose four ORR mechanism and the two ORR mechanisms (BILA and BILWLC) have been proposed. Six dispatching rules have been chosen and their performance with respect to the MAD and SFTT measure has been valuated.

Chandrasekharan Rajendran and Knut Alicke [14] were proposed DD/BJ rule and TPT+DD/BJ rules.

Joc cing Tay, Nhu Binh Ho [15] evolved Dispatching Rules using genetic programming. These rules are based on the combinations of parameters such as process time, Release date, due date, current time, number of operations and average processing time of each job. It performs better than simple priority rules.

Wiem mouelhi-chibani, Henri pierreval [16] used neural network to select dispatching rules. Neural network can automatically select efficient dispatching rules dynamically.

Hyo-Heon Ko et al. [17] proposed apparent tardiness cost with setup and quality (ATCSQ). It showed outstanding performance compared to ATCS and Quality rule, even with various threshold values.

V. Subramanian et al. [18] proposed a scheduling method based on the analytic hierarchy process is developed and applied to two formal job shop problems. The scheduling method proposed in this paper can be easily modified to include multiple criteria scheduling. This method is also well suited for dynamic scheduling where the effects of random job arrivals, machine failure and repair are included.

Oliver Holthaus and Chandrasekharan Rajendran[19] have proposed two composite rules.

Veronique sels et al. [20] has proposed five composite rules and 2PT+LWKR+FDD outperform others for most of the criteria.

J Amitha & M. Karpagam [21] used ant colony optimization metaheuristic to job shop problem. They found that step parallel pheromone updating [SSPU] rule because local and global updating rules are that applied in parallel in SPPU rule. Hence it is clear sequential application of local and global update results in more cycles than the parallel applications of these trial updates.

Christoph W Pickardit [22] proposed a two stage hyper heuristic for the generation of a set of work centre- specific dispatching rules. They combine genetic programming [GP] algorithm and evolutionary algorithm [EA]. Results show that all hyper-heuristics are able to generate rules that achieve lower mean weighted tardiness.

R. Balasundaram et al. [23] introduces a novel methodology for generating scheduling rules using data mining based approach. The advantages of DT's are that the dispatching rule is in the form of IF-Then else rules, which is easily understandable by the shop floor people. In real time applications, more data and attributes are controlled in shop floor control system and tree constructed from these attributes will lead to better dispatching rules. This approach is easily extendable for large flow shop problems.

Bin Chao Chen and Timothy I. Matis [24] developed weighted based modified rule [WBMR] that minimizes the mean tardiness of weighted jobs in an M-machine job shop. The numerical testing of this rule reveals the good performance of jobs in comparison to other dispatching rules.

4. Case Problem on Job shop scheduling using Dispatching Rule:

Table 1. Case Problem

Jobs	Processing time (min) *			Due dates (min)
1	1 (005)	2 (010)	3 (004)	18
2	3 (004)	1 (005)	2 (006)	24
3	3 (005)	2 (003)	1 (007)	16

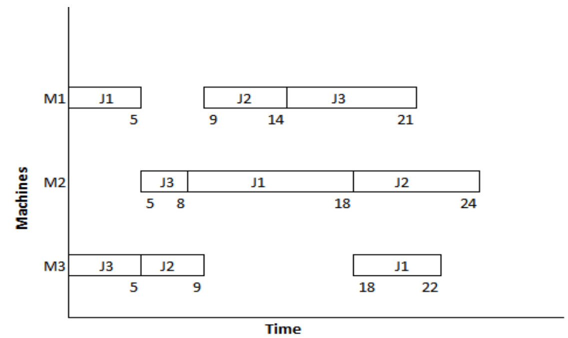

Figure 1. Gantt chart for 3 Jobs 3 Machines (SPT)

Table 2. SPT rule

Job	Due date	Comp. time	Tardiness
J1	18	22	4
J2	24	24	-
J3	16	21	5

From Gantt chart Make span=24 and Maximum Tardiness=5

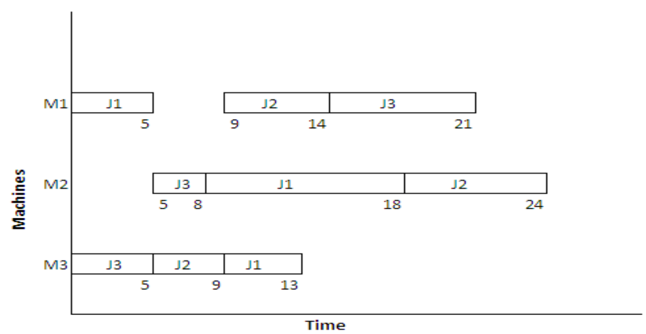

Figure 2. Gant Chart for 3 Jobs 3 Machines (EDD)

Table 3. EDD rule

Job	Due date	Comp. time	Tardiness
J1	18	13	-
J2	24	24	-
J3	16	21	5

From Gantt chart Make span=24 and Maximum Tardiness=5

Table-4 PT+WINQ+SL rule (Priority Value)

Job	Due date	Comp. time	Tardiness
J1	18	13	3
J2	24	20	15
J3	16	11	8

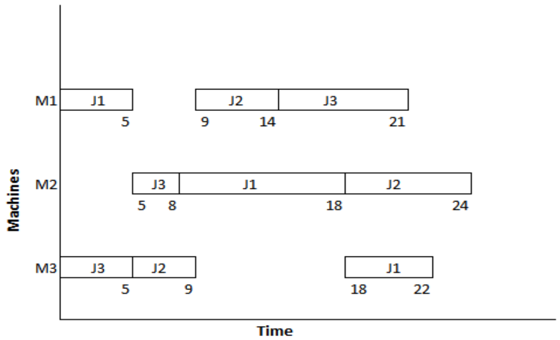

Figure-3 Gantt chart for 3 Jobs 3 Machines (PT+ WINQ+SL)

Table 5. PT + WINQ + SL (Hybrid) rule

Job	Due date	Comp. time	Tardiness
J1	18	22	4
J2	24	24	-
J3	16	21	5

Maximum Tardiness=5

3.3 Result and Discussion

Different Dispatching Rule gives different Result for different Criteria.

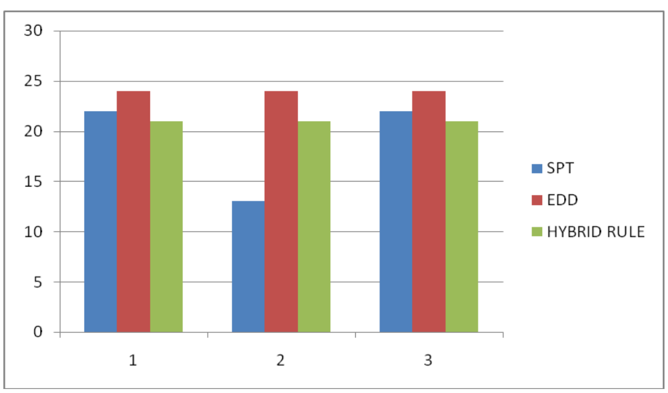

Figure 4. Comparasion of SPT, EDD and Hybrid rule for Completion time

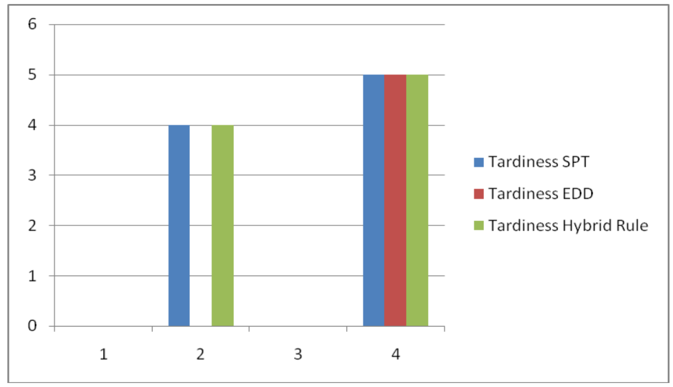

Figure 5. Comparasion of SPT, EDD and Hybrid Rule for Tardiness

Table 6. Comparasion of SPT, EDD and Hybrid Rule for Makespan and Maximum Tardiness

	SPT	EDD	HYBRIDE RULE (PT+WINQ+SL)
Make Span	24	24	24
Maximum Tardiness	5	5	5

Table 7. Completion time of different Job for different dispatching rules

Completion time	SPT	EDD	Hybrid rule (PT+WINQ+SL)
J1	22	18	22
J2	24	24	24
J3	21	21	21

EDD gives better results for Tardiness criterion and SPT gives good result for Make span criterion. Hybrid dispatching rule (PT+WINQ+SL) gives better result than individual rule.

4. Conclusions

Different Dispatching Rule gives different Result for different Criteria. Until now there has been no single dispatching rule that minimizes most of the regular and non-regular performance measures. The study has therefore been carried out to find new dispatching rules using a combination of rules. Dispatching rules gives the ease of implementation, satisfactory performance, Low computation requirement, and flexibility to incorporate.

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