SHIFT JOB NEIGHBOURHOOD HEURISTICS FOR SINGLE MACHINE FAMILY SCHEDULING PROBLEMS

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Abstract

In this study, we consider a single machine scheduling problem in minimizing the maximum lateness L_{max} of N jobs in the presence of sequence independent family setup time ,S_f .The problem is to schedule the arrival job in the system with setup time and the job will divided into families .Our objective is to minimize the maximum of lateness,L_{max} of N jobs .The setup time is required at time zero when family condition is same and a new batch of family is obtained .We also apply EDD rule in the heuristics method to get maximum lateness and improve this rule by using shift job forward and backward method .Every job within family each family will be arranged according to the due date of its job. We propose two neighborhood, local search method forward and backward algorithm .Furthermore, we compare the neighbourhood heuristics solutions obtained with lower bound and discuss whether the backward or forward shift will improved the solution quality. We perform a computational for both algorithm and compare the results .From the comparison, backward shift algorithm is better compared to the forward shift algorithm in minimizing the maximum lateness .

Keyword: shift job neighbourhood heuristics, single machine, minimizing maximum lateness

Introduction

Nowadays, the manufacturing and service industries have complex setting, with multiple types of products, each involving a lot of different steps and machines for completion. The one who is responsible for the manufacturing plant must find a way to manage resources successfully in order to supply products in the most efficient possible way. The decision maker needs to create a production schedule that contribute to on-time completion, delivery, and minimizes objectives such as the flow time of a product. Based on these concerns, grew an area of studies known as the scheduling problems. Scheduling problems are a part of decision making; act as an important role in manufacturing and service industries. This problem, making a few plans on how to finish a complex job by completing its constituent tasks on different processors which can be considered as machines, people, robots, etc.. All of these situations have numerous kinds of jobs to schedule, many kinds of processors to schedule the jobs, and frequently uncertainties about the amount of time the various jobs require on the distinctive processors.

In general, scheduling is an allocation of resources, for example, machines to tasks, so as to optimize a given objective function. This general statement could be interpreted in a few ways. Based on an approach presented in Baker (1974), we can recognize two different meanings of the term scheduling. On the macro level, scheduling signifies a decision making function, i.e., a process that answers questions such as "What sort of item is to be manufactured (made)?", "On what scale?", and "What resources will be utilized?". The second meaning of the term refers to scheduling theory, which supplies tools for the efficient solution of scheduling problems. In this way, it can be seen as a collection of principles, models and techniques that provide insight into the scheduling function. A solution to a scheduling problem generally requires two sub problems to be solved. The allocation problem determines which resources should be distributed to perform the given tasks. The sequencing problem decides when each task will be performed. It is this second meaning of the term scheduling, the scheduling theory on the micro level, that we are concerned with.

Objective of Study

The objectives of this study are:

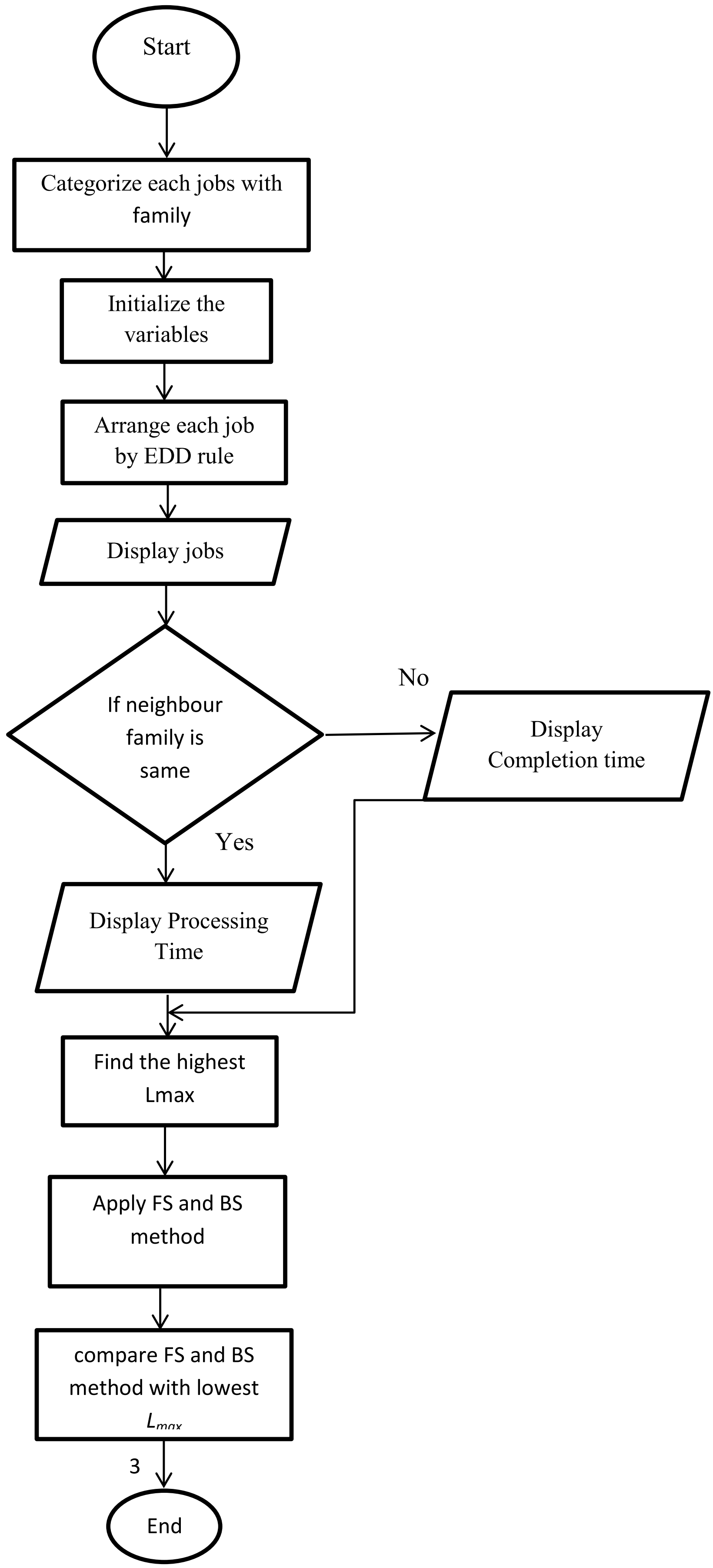
1. To find a feasible schedule for a single machine family scheduling problems using the shift job neighborhood heuristics to minimize the maximum lateness L_{max}, of the jobs in the presence of the of the independent family setup times s_f
2. To develop and solve the mathematical model for single machine family scheduling problems by using Code Blocks C++ Programming.
3. To compare the shift job neighborhood heuristics between forward shift and backward shift.

Litereture Review

Applications of models that involve batching and scheduling are varied. Potts and Van Wassenhove (1992) give an example involving a production line for colour plastics. Customer orders can be divided into major colour groups, such as reds, blues, etc. Setup time between colour from the same group are negligible. Besides that, based on the standard classification of Graham et al. (1979) . Then , The SMFSP for arbitrary family f can be represented as $1 \mid s_f / L_{\max}$ based on the standard classification of Graham et al. (1979).Then, Hariri and Potts (1997) have independently proposed a branch and bound algorithm. They obtained an initial lower bound by ignoring setups, except for those associated with the first job in each family, and solved the resulting problem with EDD rule. Webster and Baker (1995) have defined the EDD-for-batches as a heuristic by which, given a set of batches with jobs inside the batch ordered in EDD fashion, the minimum L_{max} is attained by sequencing all batches in non-decreasing order of their due dates. Based on the paper Tariq Saleh Abdul-Razaq (2010), tested a set of generic local search to minimize total weight completion time.

Methodology

General flow chart of forward and Backward Method


Start
Categorize each jobs with family
Initialize the variables
Arrange each job by EDD rule
Display jobs
If neighbour family is same
No
Display Completion time
Yes
Display Processing Time
Find the highest Lmax
Apply FS and BS method
compare FS and BS method with lowest L_{max}
3
End

The heuristics use in this study uses a constructive procedure, which is referring to the observations of Gupta (1988), to find initial schedule. Descent procedures are then applied with the objective to minimize the maximum lateness of the jobs. A descent method attempts to improve on a current solution by searching, in some suitably defined neighbourhood, for a new solution which has a lower objective function value. If such an improved solution is found, it becomes the current solution from which further improvement is sought. If no improvement is possible, then the method terminates and the solution is a local optimum.

Algorithm of forward and backward shift method:
Step 1: Declare the jobs according to their own family where N jobs (30 or 50) are partitioned into F families (4, 8, or 12).
Step 2: Sequencing the jobs in non-decreasing order of their due dates using EDD rule. Thus, from this step, maximum lateness L_{max} is calculated. The value of the lateness is declared as initial solution.
Step 3: Apply shift job: forward or backward shift job. After that L_{max} is calculated. If the value in this step is lower than the initial solution then the value in this step will be consider as an improved solution.
Step 4: Repeat shift job again until we find the lowest value of the improved solution as an optimum solution of L_{max}.

Result and Discussion

Table 4.31 : Summary of Computational Results

	N	F	LB	FS	BS
A	30	4	1341.60	2896.76	2848.84
		8	1562.56	3144.20	3059.04
		12	1766.80	3356.64	3316.24
	50	4	2285.84	5266.00	5221.92
		8	2486.12	5382.88	5334.36
		12	2693.72	5442.12	5398.68
	Average		2022.77	4248.10	4196.51
B	30	4	1156.32	2003.28	1940.16
		8	1206.44	2452.64	2372.44
		12	1240.60	2971.88	2096.32
	50	4	2164.68	4109.40	4037.84
		8	2208.52	4613.32	4533.96
		12	2246.80	4774.60	4705.92
	Average		1703.89	3487.52	3281.11
		4	1793.92	5693.68	5656.84

C	30	8	2399.92	6608.28	6571.08
		12	2990.20	6906.04	6871.68
	50	4	2766.40	10373.68	10318.96
		8	3331.76	10896.72	10843.92
		12	3931.96	11062.68	11005.40
	Average		2869.03	8590.18	8544.65
AVERAGE			2198.56	5441.93	5340.76

Table 4.32: Gap (%) between FS and BS algorithms

Number of jobs,*N*	Number of family,*F*	**FS**	**BS**
30	4	59.49	58.91
	8	57.64	56.93
	12	54.68	51.18
50	4	63.14	63.13
	8	61.58	61.24
	12	58.30	57.97

Table 4.31 is showed about the average value og jobs 30 and 50 for families 4,8,12 .from we observed, our solutions is quite effective when there are small families compared to large families. As expected the relative size of setup times is affects problem hardness and results. In the case of setup time class C with large setup time, jobs tend to form a large batch size with more jobs in a batch to reduce the need of setup time between batches from different families. Therefore, more jobs will miss their assigned due dates. However with a small setup time similar to setup time class B, more jobs will meet their respective due dates. Hence when the setup time is small, more batches are formed which means fewer jobs are to be processed per batch. The average value of BS is lower than FS and the value of Bs is nearest to LB. So, BS is the good result compare to FS.

Table 4.32 is shown is described the gap (%) between the list forward and backward algorithm with optimal solution that is MILP model. The result of gap has been calculated by using formulae percentage of gap. The highest gap FS algorithms is 63.14% and BS is 63.13% for N=50 and F=3. Thus, the difference gap between FS and BS is ±0.5% . So, BS is producing good results compare to the FS because BS has a minimum gap compare to FS.

Conclusion

This project considers the problem of single machine family scheduling problem (SMFSP) to minimize the maximum lateness, where a setup time is incurred whenever the machine switches from processing a job in one family to a job in another family. The coding from the software is able to solve the problems in the project but the average gap between the upper bound and the lower bound is quite large. Shift job neighbourhood heuristics were proposed as possible methods for finding good solutions to the stated problem. The results presented clearly imply that shift job neighbourhood heuristics is the possible method for finding a schedule for SMFSP which minimize the maximum lateness of the jobs in the presence of the independent family setup times. Good solutions, though not always optimal, were found in most instances for minimizing the maximum lateness.

The exchange of jobs through the sequence of family setup problem using backward and forward shift can be an improvement method. From the computational experiment, it provides further evidence to support view that backward shift turn out to be a better neighbourhood local search compared to the forward shift. We suggest to give priority to the backward shift heuristic rather than the forward shift heuristic in order to minimize the maximum lateness in the future proposition of local search heuristics.

References

Graham, R. L., Lawler, E. L., Lenstra, J. K. & Rinnooy Kan, A. H. G. 1979. Optimization and approximation in deterministic machine scheduling diseases: a survey. *Annals of Discrete Mathematics*, 5: 287-326.

Gupta, J.N.D., 1988. Two stage, hybrid flowshop scheduling problem. *Journal of Operational Research Society*, 3: 359-364.

Hariri, A. M. A & Potts, C. N. 1997. Single machine scheduling with batch setup time to minimize maximum lateness. *Annals of Operations Research*, 70: 75-92.

Ahn, B. & Hyun, J.(1990). Single facility multi-class job scheduling. Computers and Operations Research, 17: 265-272.

Tariq Saleh Abdul-Razaq (2010). Local Search Heuristics for Single Machine Schedulling. *AL-Mustansiriya J. Sci,* Vol. 21, No 7, 2010