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Some Common Machine Environment in Scheduling Problems

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ABSTRACT

In this study, we discussed extensively 10 different machine environments commonly encountered in scheduling problems. We incorporated each of these environments into three parameter notation and four parameter notations of representation of scheduling problem. This will assist researchers to have a comprehensive knowledge of each of the machine environment and select the one to explore to provide solution method for a given criteria or set of criteria based on the need of the decision maker.

Keyword: Machine, scheduling, solution methods, environment.

INTRODUCTION

Scheduling in production systems is associated with allocation of a set of job on a set of machine in order to achieve some objectives. It is a decision making process that concerns with the allocation of limited resources to a set of job for optimizing one or more objectives [1]. The resources are modelled as machines and the requests for resources are modelled as jobs. Generally, the vital elements of scheduling are jobs, machines, objectives and set of constraints [2]. Scheduling problems involve processing a set of jobs on machine(s) subject to certain constraints to optimize one or more objective functions. The goal is to determine a schedule that specified when and on which machine each job is to be executed [3].

Literatures on the extensive study of scheduling objectives are numerous. For instance, Conway et al., [4] cited four criteria while Gere [5] listed about seven scheduling criteria. Also, Beenhakker [6] made an attempt by coming out with an extensive list of about 27 distinct scheduling goals (objectives) [7]. Oyetunji [8] also discussed 29 different scheduling criteria and developed mathematical expressions for all the criteria considered. Each of the criteria was expressed as a function of either the completion time of job or the given parameters. Akande etal [9] also developed some mathematical expression to reduced multicriteria scheduling problem to bicriteria problem. However, having found numerous works by researchers discussing scheduling objectives or criteria, it is necessary to discuss different machine environment under which the objectives is optimized. However, to the best of researcher knowledge little work has been found that extensively discussed numerous machine environments usually encountered in scheduling problems. Nevertheless, Brucker [10] characterized machine environment by a string $\alpha = \alpha_1 \alpha_2$ of two parameters. However, Brucker fails to extensively explain machine environments for new researcher benefit before exploring them for solution method for a given criteria. This is the basis of this paper.

Furthermore, numerous researches was found in which solution method has been provided for a given criteria (s) under one of these machine environments but extensive review of some of the environments are very sparse. There is a need to fill this gap to enable the new researchers to have a comprehensive knowledge of different machine environment in scheduling. The machine environment discussed in this paper were also incorporated into the three parameter notation [11,12] and four parameter notation [13] of representing scheduling problem.

Representation of Scheduling Problems

Scheduling problems are represented by symbolic notation. The notation can be classified into:

The four parameters notation (n/m/A/B)

The three parameters notation ($\alpha|\beta|\gamma$)

The Four Parameter Notation (n/m/A/B)

Scheduling problems can be classified by using the four symbolic notations: n/m/A/B where

n is the number of job, m is the number of machine, A is the machine environment.

B: is the performance measure the schedule is intended to optimize.

The Three Parameters Notation ($\alpha|\beta|\gamma$)

According to Lenstra etal [11], Rinnooy kan etal [12], a scheduling problem can be represented by three parameter notation given by:$\alpha|\beta|\gamma$ Where α is the machine environment, β is Job characteristics, γ is Objective function the schedule is intended to optimize.

Machine Environment (α)

The machine environment is characterized by a string $\alpha = \alpha_1 \alpha_2$ of two parameters [10]. Possible values of α_1 are ∘, P, Q, R,

PMPM, QMPM, G, X,O, J, F. Where
◦ denotes a specified dedicated machine or single machine with single processor
P denotes identical parallel machine
Q denotes uniform parallel machine
R denotes unrelated parallel machine
PMPM denotes parallel multi-purpose machine with identical speed
QMPM denotes parallel multi-purpose machine with uniform speed
G denotes the general shop model
O denotes an open shop
J denotes job shop
X denotes a combination of job shop and open shop (Mixed shop)
F denotes a flow shop.

Single Machine Scheduling with Single Processor (α_1 = ◦)

The single machine scheduling problem with single processor (machine) consists of single machine to process n jobs. The objective of this problem is to schedule these n jobs on the single machine such that a given measure of performance is optimized. The jobs may be independent or dependent. If the set-up times of the jobs are independent of the process sequence of the jobs in the schedule, then the problem is termed as the single machine scheduling problem with independent jobs; otherwise it is termed as single machine scheduling problem with dependent jobs [14]. The different measures of performance of the single machine scheduling problem with independent jobs are:

- Minimizing the mean flow time
- Minimizing the maximum lateness
- Minimizing the total tardiness
- Minimizing the number of tardy jobs

In this scheduling problem, the makespan will be the same for all the sequences. Hence, it is not a part of the list of measures of performance.

Single machine with single Processor is encountered in many manufacturing and servicing industries. Some common real life examples include;

- Aircraft queuing up to land
- Treatment of patients in a hospital by a consultant surgeon
- The scheduling of different programs on a computer

Apply the three parameter notation given by: α|β|γ

Where α is the machine environment. For Single Machine Scheduling with Single Processor α = 1. Thus, the three parameter notation for single machine scheduling with single processor is given by: 1|β|γ

Apply the four symbolic notations: n/m/A/B

where A is the machine environment. A is usually left blank in a single machine with Single Processor scheduling problem. Thus, the four parameter notation for single machine scheduling with single processor is given by: n/m/ /B.

Flow Shop (α_1 = F)

The flow shop scheduling problem consists of n jobs which require processing on m different machines. All the jobs have the same processing order on the machines [8]. Thus, with this technological constraint in flow shop, the number of different sequences reduces to (n!). This reduced number is quite large for even temperate size problems and recognized to be NP hard problems [2, 15, 16, 17]. Some of the measures of performance of this problem include;

- Minimizing the mean flow time
- Minimizing the maximum lateness
- Minimizing the total tardiness
- Minimizing the number of tardy jobs
- Minimizing the makespan

In a flow shop, the work in a job is broken down into separate tasks called operations, and each operation is performed at a different machine. Thus, a job is a collection of operations with a special precedence structure. In particular, each operation after the first has exactly one direct predecessor and each operation before the last has exactly one direct successor, as shown in Figure 1.0. Thus, each job requires a specific sequence of operations to be carried out for the job to be completed.

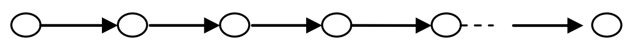

Figure 1.0: The Precedence structure of a job in a flow shop

The two common models of flow shops are:

i. Pure flow shop model: The shop contains m different machines, n jobs and each job consists of m operations, each of which requires a different machine. The machines in a flow shop can thus be numbered 1, 2, . . . ,m; and the operations of job j numbered (1, j), (2, j), . . . , (m, j), so that they correspond to the machine required. For example, P53 denotes the operation time on machine 5 for job 3. Figure1.2 represents the flow of work in a “pure” flow shop, in which all jobs require one operation on each machine.

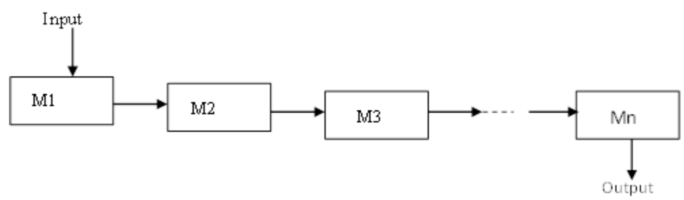

Figure 1.2: The flow of work in a “pure” flow shop

ii. General flow shop model: In this case, jobs may require fewer than m operations, their operations may not always require adjacent machines, and the initial and final operations may not always occur at machines 1 and m. Nevertheless, the flow of work is still unidirectional, and we can represent the general case as a pure flow shop in which some of the operation times are zero. With machines in series, the conditions that characterize the flow shop model are similar to the conditions of the basic single-machine model. Figure 1.3 represents the flow of work in a more flow shop.

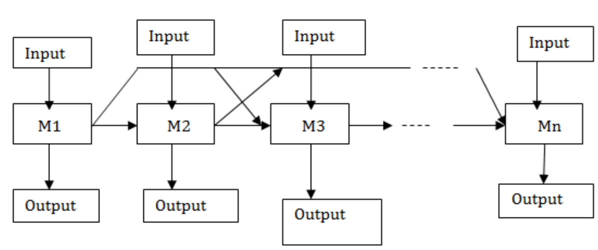

Figure 1.3: The workflow in a general flow shop

Flow shop is encountered in many manufacturing and servicing

Input

industries. An assembly line of vehicle is a classic example of flow shop in which every vehicle go through all the stations one by one in the same sequences and same tasks are performed on each vehicle.
Apply the three parameter notation given by:α|β|γ
Where α is the machine environment. For flow shop Scheduling with m, number of machine, α = m. Thus, the three parameter notation for flow shop Scheduling is given by: m|β|γ
Apply the four symbolic notations: n/m/A/B where A is the machine environment. A= P for pure flow shop. A= F for general flow shop. Thus, the four parameter notation for flow shop Scheduling is given by:
n/m/ P/B for pure flow shop.
n/m/F/B for general flow shop

Job Shop Model (α_1 = G)

The job shop scheduling problem consists of n jobs which require processing on m different machines. Each job has process sequence. Furthermore, the process sequences of the jobs are different from one another. The measures of performance of this problem are as listed under the flow shop scheduling problem. A scheduling problem is said to be a general job shop if there are no restriction upon the form of technological constraint and each job has its own processing order and bears no restriction on the processing order of any other jobs [13, 14]. For a general job shop problem, the numbers of possible sequences are〖(n!)〗^m Where n is number of jobs and m is the number of machines.
The difference between job shop scheduling and the flow shop problem is that the flow of work is not unidirectional in a job shop environment. Each job in a job shop consists of several operations with the same linear precedence structure as in the flow shop model. Although a job can have any number of operations, the most common formulation of the job shop problem specifies that each job has exactly m operations, one on each machine. It is not difficult, however, to adapt the main ideas to general cases in which a job visits the same machine more than once or skips some machines. Because the workflow in a job shop is not unidirectional, we can think of each machine in the shop as having the input and output flows of work shown in Figure 1.4.

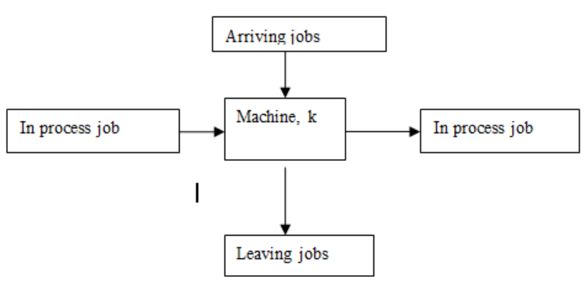

Figure 1.4 Workflow in a job shop.

Unlike the flow shop model, there is no initial machine that performs only the first operation of a job, nor is there a terminal machine that performs only the last operation of a job. Also, in the job shop, it is appropriate to describe an operation with a triplet (i, j, k) to denote that operation j of job i requires machine k. A problem setting can then be described by listing the processing times of all operations identified by such triplets.
Apply the three parameter notation given by: α|β|γ. Where α is the machine environment. For job shop Scheduling with m, number of machineα = m. Thus, the three parameter notation for job shop Scheduling is given by: m|β|γ
Apply the four symbolic notations: n/m/A/B. Where A is the machine environment. A= G for general job shop problem. Thus, the four parameter notation for flow shop Scheduling is given by: n/m/ G/B for general job shop.

Open Shop (α_1= O)

The open shop scheduling problem consists of n jobs which are to be scheduled on m different machines. There is no process sequence for each job, which means that the operations of that job can be performed in any order. The measures of performance of this problem areas listed under the flow shop scheduling problem. The open shop is defined as the flow shop, with the exception that there are no precedence relations between the operations.
Apply the three parameter notation given by: α|β|γ. Where α is the machine environment. For open shop Scheduling with m, number of machineα = m. Thus, the three parameter notation for open shop Scheduling is given by: m|β|γ
Apply the four symbolic notations: n/m/A/B. Where A is the machine environment. A= O for open shop problem. Thus, the four parameter notation is given by: n/m/ O/B

Closed shop ((α_1= C)

This is a modified job shop in which the productions order are generated as a result of inventory replenishment decision. Thus, the scheduling is not affected by customer order but by the inventory availability and scarcity. The inventory decision making is very important in closed shop scheduling. The closed shop environment is note present in Brucker [10] notation. For this environment, α_1 in Brucker [10] notation can be represented by C.
Apply the three parameter notation given by: α|β|γ. Where α is the machine environment. For closed shop Scheduling with m, number of machineα = m. Thus, the three parameter notation for job shop Scheduling is given by: m|β|γ
Apply the four symbolic notations: n/m/A/B. Where A is the machine environment. A= C for closed shop problem. Thus, the four parameter notation for flow shop Scheduling is given by: n/m/ C/B for closed shop.

The mixed shop, α_1 = X,

This is a combination of a job shop and an open shop. This implies that the scheduling problem consists of n jobs which require processing on m different machines. Some jobs has process sequence (as in job shop) while others has no process sequence (as in open shop)
Apply the three parameter notation given by: α|β|γ. Where α is the machine environment. For mixed shop Scheduling with m, number of machineα = m. Thus, the three parameter notation for job shop Scheduling is given by: |β|γ . Apply the four symbolic notations: n/m/A/B where A is the machine environment. A= X for mixed shop problem. Thus, the four parameter notation for flow shop Scheduling is given by: n/m/ X/B for mixed shop.

Parallel Machine

In parallel machine environment, there are n jobs J_i (i =1,2,3--------n) that have to be processed on m machines, M_i, (i=1,2,3-----m) such that each machines can process at most one job at a time and that each job can be processed on one machine at a time. Parallel machine environment can be classified into identical parallel machine, uniform parallel machine and unrelated parallel machine.

Identical parallel machines (α_1= P)

These are multiprocessors system in which all the processors are identical, in the sense that they have the same computing power. In other word, for the processing time P_{ij} of job J_i on machine M_j we have $p_{ij} = p_i$, for all machines M_J. That is Pi1 = Pi2 = P_i3= ------ =P_{nm}.

Some real life examples of identical parallel machines includes

A plastic manufacturing firm using four different injection moulding machines with each machine producing the same product at the same rate depending on the parameter setting by the operator.

Examination hall centre in which all the candidate is writing the same questions and are expected to commenced and stopped at the same time.

Uniform parallel machines (α_1= Q)

A uniform parallel machine is a natural generalization of identical machines in which the machines run at different speeds but do so uniformly, that is they differ by some constant speed factors. Thus, for each machine i there is a speed factor, S_i, and $p_{ij} = p_i/S_i$ where p_i is the inherent processing requirement of job j.

Some real life examples of uniform parallel machines problem are:

An hospital that has four doctors with all the doctors having varying capacities of handling/treating patients. The time a patient spends with a doctor does not only depend on the patient but also on the particular doctor.

An automobile firm with many brand service advisor: The time spent in receiving (taking inventories of the car, advise customers on other detected fault but not inclusive in customer complaint,) a customer vehicle depends both on the customer and the service advisor.

Unrelated Parallel machines(α_1= R)

In unrelated parallel machines, the processing time of jobs j1 varies between the machines in a completely arbitrary fashion. The processing time of each job on any of the machines is different and bears no relation with each other. Though there is no relationship between machines speed in an unrelated parallel machine, there may exist hierarchy between the machines. Thus, the machines can be ranked from the highest to the lowest speed. An automobile servicing firm situation in which different technician is working on different lift is an example of unrelated parallel machine.

Multi-purpose machine (MPM) problem

There is a special case of parallel machine called the multi-purpose machine (MPM) problem. This is a situation when the processing time of a job depends on the machines, i.e. the job j has processing time of length p_{ij} if it is scheduled on machine M_i [18]. In such a case, a job can be processed by any machine of an associated, pre specified subset of the machine set.

Using the α|β|γ notation, we can denote open shop with multipurpose machine by: ├ O(MPM)┤ ‖β|γ

Also, job shop problems with multi-purpose machines is denoted by : ├ J(MPM)┤ ‖β|γ.

Modification of Brucker Notation

Brucker notation of machine environment did not take into consideration the situation of parallel multi-purpose machines with unrelated machine speed and the situation of closed shop machine environment. A multi-purpose machine (MPM) problem with unrelated machine speed is a special case of the problem of unrelated parallel machine problem when the processing time of a job depends on the machines, i.e. the job j has processing time of length p_{ij} if it is scheduled on machine Mi. In such a case, set α_1 = RMPM. Also, in a closed shop environment, we can set α_1 = C Extend this into brucker notation then we have: Possible values of α_1 are ∘, P, Q, R, PMPM, QMPM, RMPM, C G, X,O, J, F.

CONCLUSION

About 10 distinct machine environments have been discussed and incorporated into the four parameter and three parameter notations. The closed shop machine environment and the multi-purpose machine (MPM) problem with unrelated machine speed are also incorporated into the Brucker Notation of machine environment in scheduling.

REFERENCES

1. V.T Kindt and J.C Billiant. Multicriteriascheduling , theory, model and algorithm, 2nd edition. 2005
2. Michael P.. Scheduling Theory, Algorithms, and Systems. Prentice Hall, New Jersey, second edition. 2005
3. D. Karger, C. Stein, and J. Wein Scheduling algorithms :CRC handbook of theoretical computer science. 1999
4. Conway, R.W ., B.M . Johnson and W .L. Maxwell, 1960. An experimental investigation of priority dispatching. J. Ind. Eng., 11: 221-230
5. Gere, W.S. A heuristic approach to job shop scheduling. PhD. Thesis, Carnegie Institute of Technology. 1962
6. H.L Beenhakker,. Development of alternate criteria for optimality in the machine sequencing problem, PhD. Thesis, Purdue University. 1963
7. P. Mellor. Review of Job Shop Scheduling,Operations (1966). 161-171.
8. E.O Oyetunji. Some Common Performance Measures in Scheduling Problems;Research Journal of Applied Sciences, Engineering and Technology 1(2): 6-9, (2009) ISSN: 2040-7467
9. S. Akande, E.O Oyetunji, A.E Oluleye : Reducibility of Some Multi Criteria Scheduling Problems to Bicriteria Scheduling Problems. Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management Bali, Indonesia, January 7 – 9, 2014
10. Brucker, P. Scheduling Algorithm. Springer Berlin Heidelberg Newyork. 2006
11. J.Lenstra, E. Lawler, A. Kan, and D. Shmoys.: Sequencing and scheduling: algorithms and complexity. In Logistics of Production and Inventory: Handbooks in Operations Research and Management Science, volume 4, (1993). pages 445–522. North-Holland
12. R.L., Graham, E.L., Lawler, J.K., Lenstra, A.H.G Rinnooy Kan,., Optimization and approximation in deterministic sequencing and scheduling: a survey. Ann. Discrete Math. vol. 5, pp. 287-326, 1979.
13. S. French. Sequencing and Scheduling. Ellis Horwood Limited. 1982
14. I.M Al-harkan. Algorithm for sequencing and scheduling.2008
15. Gonzalez T and Sahni. S. Flowshop and Jobshop Schedule; Complexity and approximation. Ops Res,26, 36-52.1978
16. Garey MR., Johnson DS, Sethi R. The complexity of flow shop and job shop scheduling. Mathematics of Operations Research 1 (1976). 117- 129.

17. Sayin S. and Karabati S. “A bicriteria approach to the two-machine flow shop scheduling problem”. European Journal of Operation Research 113 (1999) Pp 435–449,

18. Zsuzsanna V ‘On scheduling problems with parallel multi-purpose Machines’ Egrerv´ary Research Group, Budapest, Hungary. Page–1117 (2005). ISSN 1587–4451

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