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Task Scheduling in Grid Computing Environment with mean flowtime criterion

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Abstract. Extensive research has been conducted in the field of Flexible Manufacturing Systems (FMSs) planning, most of it has primarily concentrated on well-established academic scheduling systems. When it comes to the selection process, which often relies on fundamental principles within the intelligent system JSSE (Workshop Planning Environment), there is a notable scarcity of literature concerning their performance within an FMS. This article aims to address this gap by examining the performance model of machine and Automated Guided Vehicle (AGV) scheduling in terms of mean flow time using the Grid Computing Environment (GCE) strategy. The study conducts experiments through an FMS simulation model, involving 40 scenarios to assess these concepts.

Keywords: Grid computing, Task scheduling, Artificial intelligence and Makespan

1. Introduction

While there is no universally accepted definition for Flexible Manufacturing Systems (FMS), Groover (1987) characterizes FMSs as assembly systems that comprise a group of numerically controlled (NC) machines connected by Automated Guided Vehicles (AGVs), all under the control of a computer. These systems are designed to handle a wide variety of components with low to medium demand volumes. Depending on the number of NC machines and their integration with a material handling system, FMSs can be categorized into several types, some of which have been discussed by Dupont (1982), Browne et al. (1984), and Kusiak (1985).

Throughout the lifecycle of an FMS, various challenges are encountered. Some of these challenges and an evaluation of the solutions proposed in works like Buzacott and Yao (1985), Suri (1985), and Kusiak (1986a) have been considered. These issues can be classified into operational, strategic, and tactical categories. A FMS can also be viewed as a highly automated workshop. However, due to its integrated nature, scheduling for an FMS requires additional considerations, including tools, equipment, Automated Guided Vehicles (AGVs), pallets, and so forth. The increased flexibility of machines and material handling systems in an FMS leads to a multitude of scheduling options and material handling paths that must be considered in the decision-making process. Furthermore, the dynamic nature of an FMS exacerbates these challenges. This paper focuses on conducting simulation-based experiments to address the scheduling problem in FMS. The problem can be primarily seen as a type of dynamic job shop scheduling problem. The study involves the analysis of scheduling rules applicable to FMS, with the mean flow time used as the performance metric.

2. Grid Computing Design

The input data has been sourced from Bilge and Ulusoy's work in 1995. This data comprises a sequence of machines, their associated processing times, and the matrix indicating travel times between the machines. Figure 1 illustrates the setup, which consists of four CNC machines equipped with pallet changers and tools.

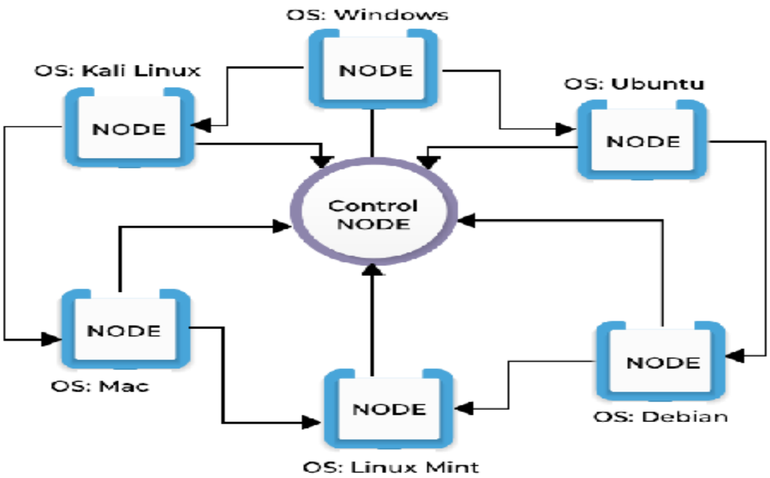

Figure 1: Topology in Grid Computing

2.1. Methodology

Layout 1 and Job set 1 are specifically employed to demonstrate the application of the Greatest Completion Time (GCE) rule, considering travel time as half and process time as triple. The following steps outline the GCE approach for Job set 1:

Step 1: Job set 1 is taken into consideration. Step 2: Initial placement at position '1' in the primary line results in the sequence: 1 – 2 - 3 - 4-5 - 6 - 7 – 8 – 9 – 10 - 11-12 - 13. Step 3: The maximum operational finish time is identified. It represents the potential completion time (makespan) for the given job set.

The determined values of various constraints for all activities are presented in Table 1.

Table 1. Completion Times with the GCE Rule

Order	Machine	Vehicle	Travel Time	Job Ready	Job Reach	Process Time	Makespan
1	1	1	0	2	3	8	27
2	2	2	14	15	30	16	78
3	4	1	39	41	82	12	118
4	1	2	19	21	38	20	98
5	3	2	57	59	102	10	132
6	2	1	71	77	135	18	189
7	3	2	62	66	132	12	168
8	4	2	89	90	171	8	195
9	1	1	96	100	200	15	245
10	4	2	92	95	195	14	237
11	2	2	108	113	241	18	295
12	3	1	103	107	211	10	241
13	1	1	113	118	245	15	290

Table 1 displays the activity sequence planned using the GCE rule for Job set 2 designs, resulting in an operational completion time (makespan) of 290.

Total completion time = 27+78+118+98+132+189+168+195+245+237+295+241+290 = 2313

Average flow time = Total completion time / Total number of operations = 2313 / 13 = 177.92"

3. Results and Discussion

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Results should be clear and concise. Show only the most significant or main findings of the research. Discussion must explore the significance of the results of the work.
The workshop scenario for Flexible Manufacturing Systems (FMS) presented here features Job Set Model 8 and Layout 4.

Model Number	Grid No	Mean Flow Time
Model 7	4	198.1
Model 10	4	186.9
Model 10	1	167.76
Model 4	4	166.05
Model 10	3	161.14
Model 10	2	158.76
Model 9	4	157.94
Model 8	4	155.1
Model 9	1	144.29
Model 4	1	143.2
Model 6	4	140.94
Model 8	1	139.9
Model 9	3	134.76
Model 9	2	134.64
Model 6	1	130.2
Model 4	3	128.57
Model 4	2	119.105
Model 3	4	111.18
Model 6	3	105.33
Model1	4	105.23
Model 7	1	105.15
Model 6	2	105.11
Model 3	1	104.8
Model 8	3	103.2
Model 8	2	102.8
Model1	1	98.61
Model 2	4	96.2
Model 5	4	94.69
Model 2	1	88.2
Model 5	1	87
Model 3	3	84.93
Model 3	2	83.93
Model 7	3	83.36
Model1	3	81.69
Model1	2	80.61
Model 7	2	79.47
Model 2	3	71.66
Model 5	3	70.07
Model 5	2	69
Model 2	2	68.06

In the optimal arrangement of Automated Guided Vehicles (AGVs) and machines, priority rules are used for three different processing time values, as presented in two tables. An evaluation of makespan and mean flow time across various job sets and layouts is depicted graphically in Figures 2.

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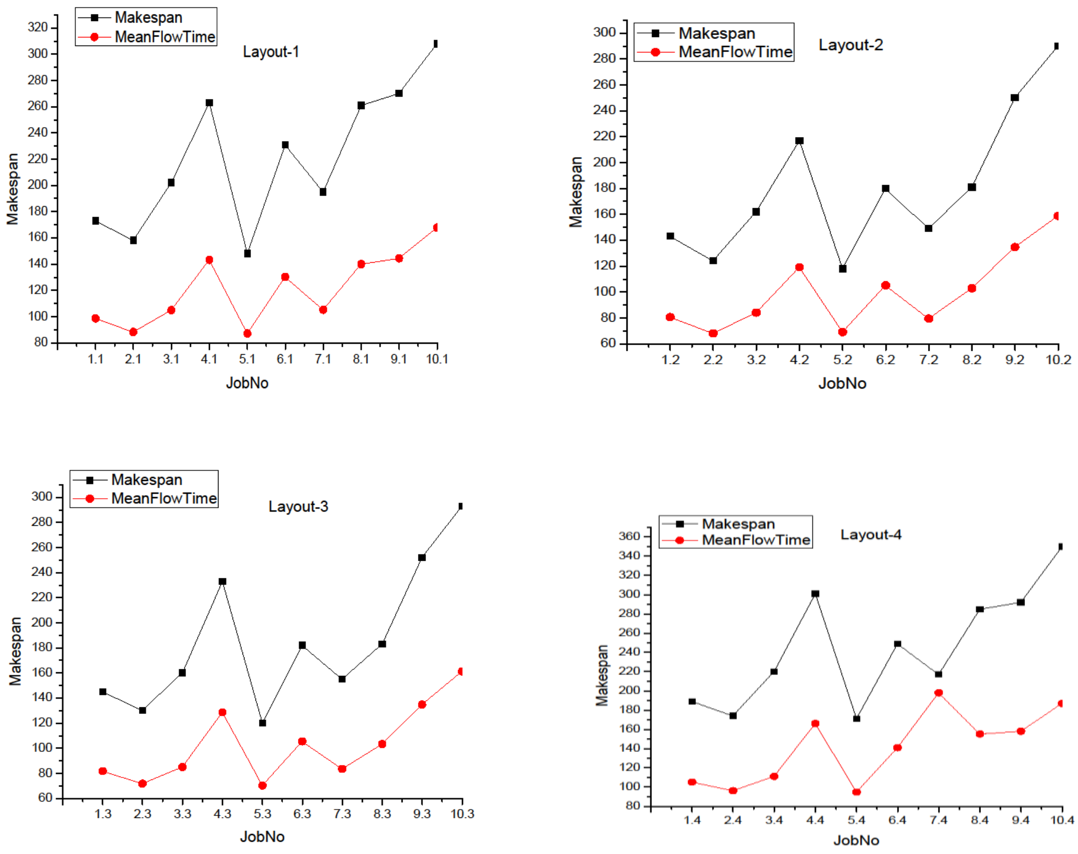

Figure 2: Make span Vs Mean flow time (t/p>0.25)

4. Conclusions.

FMS problems are addressed using the Grid Computing Environment (GCE) approach, employing the mean flow time criterion. Four layouts are considered, each featuring four identical machines and two material handling systems. This study encompasses scheduling not only for machines but also for AGVs, with the following findings:

The study indicates that an increase in mean flow time is directly correlated with heightened machine and AGV utilization.

Completion time distribution within the FMS is significantly influenced by mean flow time.

When scheduling rules lead to increased loads on AGVs and machines, mean flow time becomes paramount. This is because the utilization of the FMS system increases, and the number of delayed jobs also rises.

The GCE rule is tested across 40 problems using the mean flow time criterion, and it consistently emerges as the most effective choice, especially when combined with AGV rules.

The study suggests the need to develop and implement new rules specific to the FMS environment, and to subject them to continuous testing across various objective functions.

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