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Smart Manufacturing System Task Scheduling through Hadoop Scheduler

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Abstract. Extensive research has been carried out concerning the planning of flexible manufacturing systems (FMS), primarily focusing on established academic layout strategies. This research predominantly draws from fundamental principles within the intelligent system JSSE (workshop scheduling environment), with limited existing literature addressing its specific application within an FMS context. The primary objective of this article is to assess the effectiveness of scheduling models for machines and AGVs (Automated Guided Vehicles) in reducing the number of operations within the FMS, using an approach based on the Hadoop Scheduler (HS). The research methodology is subject to evaluation across a range of experimental conditions, utilizing an FMS simulation model that encompasses 40 distinct scenarios.

Keywords: Hadoop Scheduler, Task scheduling, Artificial intelligence and Makespan

1. Introduction

A Flexible Manufacturing System (FMS) can be envisioned as a computerized workshop. However, due to its tightly integrated nature, scheduling within an FMS necessitates additional considerations, such as tools, fixtures, Automated Guided Vehicles (AGVs), pallets, and more. The flexibility of machines and materials handling systems introduces a multitude of alternative task sequences and material handling routes into the planning process. Furthermore, the dynamic nature of an FMS exacerbates these challenges. This paper is primarily focused on conducting simulation-based experiments to investigate the scheduling problem within FMS. This problem can be seen as a subset of the broader dynamic job shop scheduling issue, with a specific emphasis on scheduling rules tailored to FMS. The metric employed to evaluate performance is the mean flow time. In contemporary practices, decision-making rules find widespread application, ranging from real-time scheduling of machines and material handling devices in operational settings to offline scheduling algorithms with integrated components. Panwalkar and Iskander (1977) have documented over 100 rules, categorizing them into scheduling rules, dispatching rules, and priority rules. Further literature on these rules can be explored in the works of Conway et al. (1967), Blackstone et al. (1982), and Kiran and Smith (1984a, b). Scheduling rules serve the purpose of prioritizing machines and AGVs based on factors like completion times, including travel times. In the realm of AGV scheduling, Egbelu and Tanchoco (1984) proposed specific scheduling rules, while Acree and Smith (1985) delved into the selection rules applicable in FMS. Recent research trends have shifted towards the implementation of intelligent systems in scheduling problems, as opposed to the traditional job shop scheduling, in contrast to the earlier experimental studies within FMS.

2. Hadoop Scheduler Design

The input data for this study is derived from the research conducted by Bilge and Ulusoy in 1995. This dataset includes information on a series of machines, their respective processing times, and a matrix representing the travel times between these machines. The configuration, as depicted in Figure 1, involves four CNC machines that are equipped with pallet changers and a set of tools.

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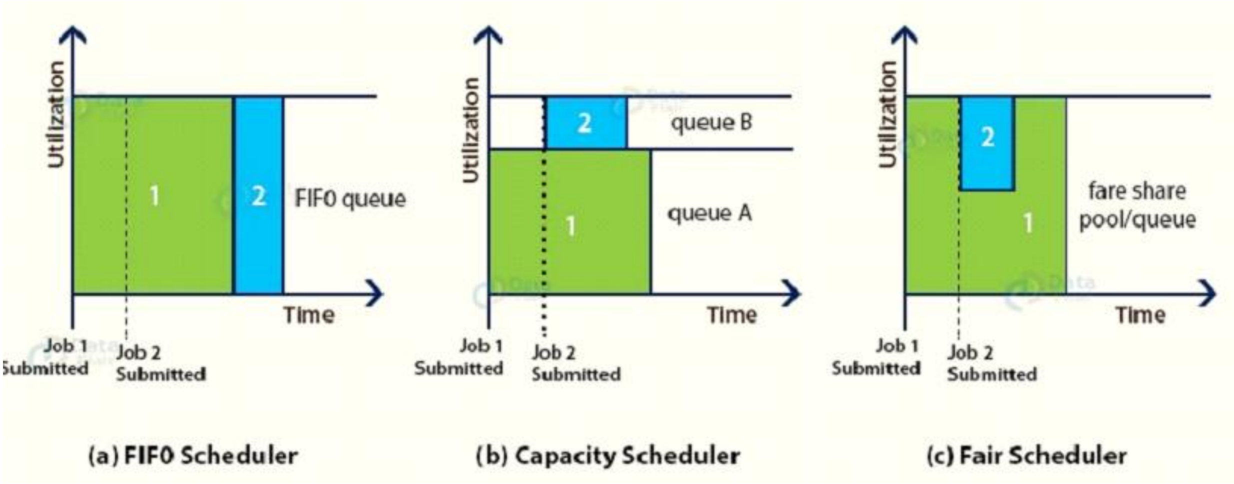

Figure 1: Basic structure of Hadoop Scheduler

2.1. Methodology

Layout 2 and Job set 5 play a crucial role in the execution of the Hadoop Scheduler (HS) as an example with half the movement time and double the process time. The HS is explained in the following steps for Job Set 5:

Step 1: Consider Job Set 5. Step 2: Initially, place item '1' at the beginning of the primary line, arranged as follows: 1 – 2 - 3 - 4 - 5 - 6 - 7 – 8 – 9 – 10 - 11 - 12 - 13. Step 3: Determine the maximum completion time, representing the possible completion time (makespan) for the given job set.

Table 1 displays the specific constraints for all the activities involved in the HS:

Table 1. Completion Time Using HS

Order	Machine	Operation	TT	JRT	Job Reach Time	Process Time	Makespan
1	1	1	0	2	2	6	14
2	2	2	14	15	15	12	39
3	4	1	39	41	41	9	59
4	1	2	19	21	21	18	57
5	3	2	57	59	59	6	71
6	2	1	71	77	77	15	107
7	3	2	62	66	71	9	89
8	4	2	89	90	90	3	96
9	1	1	96	100	100	12	125
10	4	2	92	95	96	6	108
11	2	2	108	113	113	15	143
12	3	1	103	107	107	3	114
13	1	1	113	118	124	9	142

Table 1 illustrates the activity scheduling through the HS algorithm for Job Set 5, resulting in a total completion time (makespan) of 143.

Total completion time = 1165

Average flow time = Total completion time / Total number of operations = 1165 / 13 = 89.61 Average number of operations in the FMS = Total Flow Time / Makespan = 1165 / 143 = 9

3. Results and Discussion

The results must be presented in a clear and concise manner, focusing on the most significant or primary findings of the research. In the discussion section, it is essential to delve into the importance of the research outcomes.

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The workshop scenario described for Flexible Manufacturing Systems (FMS) involves the utilization of Job Set Model 5 and Layout 2

Model. No	Lay out	No of Operations in Hadoop System
MD 10	11	12
MD 10	22	12
MD 10	33	12
MD 10	44	12
MD 8	11	11
MD 8	22	11
MD 8	33	11
MD 8	44	11
MD 4	11	10
MD 6	11	10
MD 4	22	10
MD 6	22	10
MD 7	22	10
MD 4	33	10
MD 6	33	10
MD 7	33	10
MD 4	44	10
MD 6	44	10
MD 7	44	10
MD 7	11	9
MD 9	44	9
MD1	11	8
MD 2	11	8
MD 3	11	8
MD 5	11	8
MD 9	11	8
MD1	22	8
MD 2	22	8
MD 3	22	8
MD 5	22	8
MD 9	22	8
MD1	33	8
MD 2	33	8
MD 3	33	8
MD 5	33	8
MD 9	33	8
MD1	44	8
MD 2	44	8
MD 3	44	8
MD 5	44	8

Within the context of optimizing the configuration of Automated Guided Vehicles (AGVs) and machines, priority rules are utilized to handle three distinct processing time values. These rules are detailed in two separate tables. An examination of the make span and mean flow time for various job sets and layouts is visually depicted in Figures 2.

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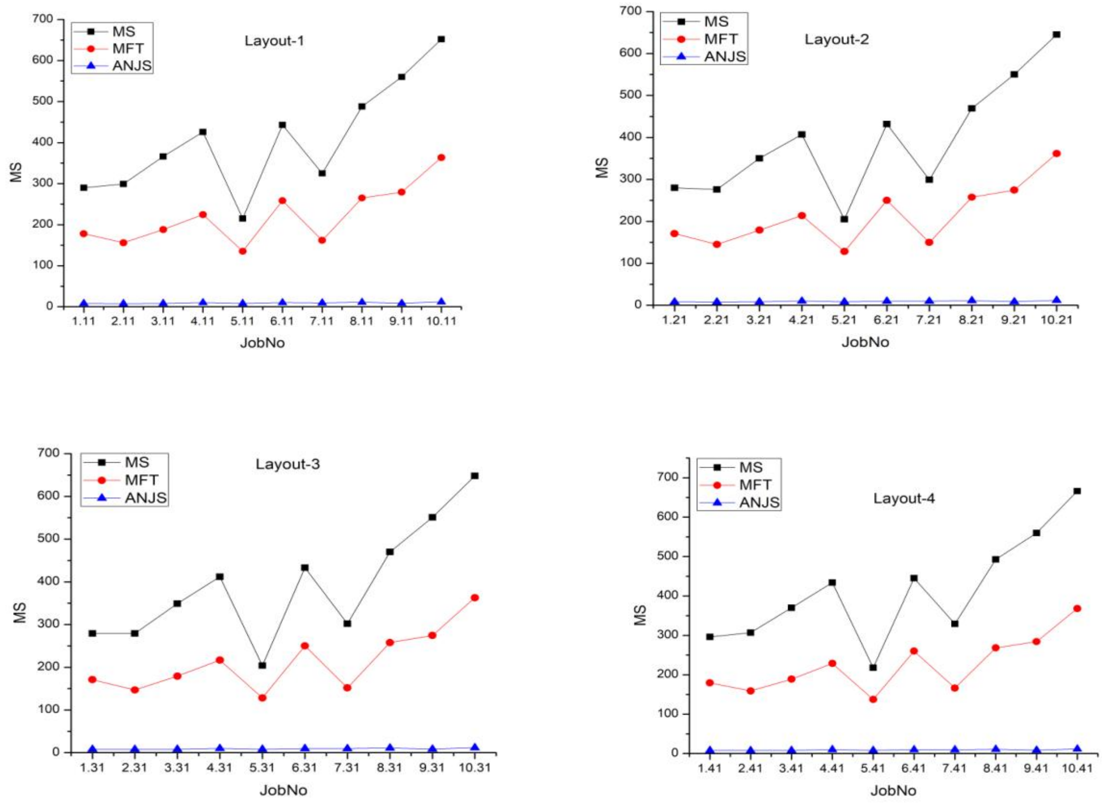

Figure 2: No of Operations in Hadoop System

4. Conclusions.

To address challenges in Flexible Manufacturing Systems (FMS), a Hadoop Scheduler (HS) was employed with the goal of minimizing the number of operations within a system that consists of four layouts, each featuring four identical machines and two material handling systems. This comprehensive study encompasses not only machine scheduling but also the scheduling of Automated Guided Vehicles (AGVs), yielding the following findings: The research reveals that an increase in the number of jobs within the system leads to a corresponding increase in the utilization of both machines and AGVs. Significantly, the distribution of completion times in the FMS is greatly influenced by the number of operations in the system. When both AGV and machine workloads increase due to scheduling rules, the number of operations in the system becomes a critical factor as it directly impacts the overall utilization of the FMS. Consequently, this results in a higher degree of job tardiness. The HS rule was put to the test in a system involving 40 operations, consistently outperforming other approaches, including those based on AGV rules. Future efforts should be directed towards the development and implementation of new rules within the FMS environment, enabling continuous testing with various objective functions.

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