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Real time operating system in Flexible manufacturing Environment for task scheduling

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Abstract. Considerable research has been dedicated to the field of Flexible Manufacturing Systems (FMS) planning, with a predominant focus on established academic scheduling systems. Nevertheless, when it pertains to the selection process, which often hinges on fundamental principles within the intelligent system known as JSSE (Workshop Planning Environment), there is a noticeable dearth of literature concerning their effectiveness within an FMS. This article endeavours to bridge this void by scrutinizing the performance model of machine and Automated Guided Vehicle (AGV) scheduling, specifically in terms of mean flow time, using the Embedded System (ES) strategy. The research employs an FMS simulation model to conduct experiments, encompassing 40 scenarios designed to evaluate these concepts.

Keywords: Embedded system, Task scheduling, Artificial intelligence and makespan

1. Introduction

Decision-making rules are commonly employed in contemporary contexts, and their applications encompass various areas: Real-time Planning: Decision rules are used for online planning of machines and material handling equipment in real operational scenarios. Scheduling Algorithms: They are also used for scheduling algorithms in offline mode, often as integral components of the process. Panwalkar and Iskander (1977) have extensively discussed these rules, identifying, and distinguishing between scheduling rules, dispatching rules, and priority rules. A wealth of literature is available on these topics from authors such as Conway et al. (1967), Blackstone et al. (1982), and Kiran and Smith (1984a, b).Scheduling rules play a vital role in prioritizing machines and Automated Guided Vehicles (AGVs) for completion times, which includes the time required for travel. It is worth noting that machine scheduling in a job shop environment is a different domain. Egbelu and Tanchoco (1984) introduced scheduling rules specifically for dispatching AGVs, while Acree and Smith (1985) delved into the topic of selection rules in Flexible Manufacturing Systems (FMS).The current trend in research leans towards the implementation of intelligent systems in scheduling problems, as opposed to traditional job shop scheduling, alongside experimental studies in FMS (Sabuncuoglu and Hommertzheim 1989b). Stecke and Solberg (1981) examined heuristic rules applied in FMS settings involving ten machines and two AGVs, while Denzler and Boe (1987) addressed AGV routing, considering operational time data and conducting experimental investigations in FMS.

2. Embedded System 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.

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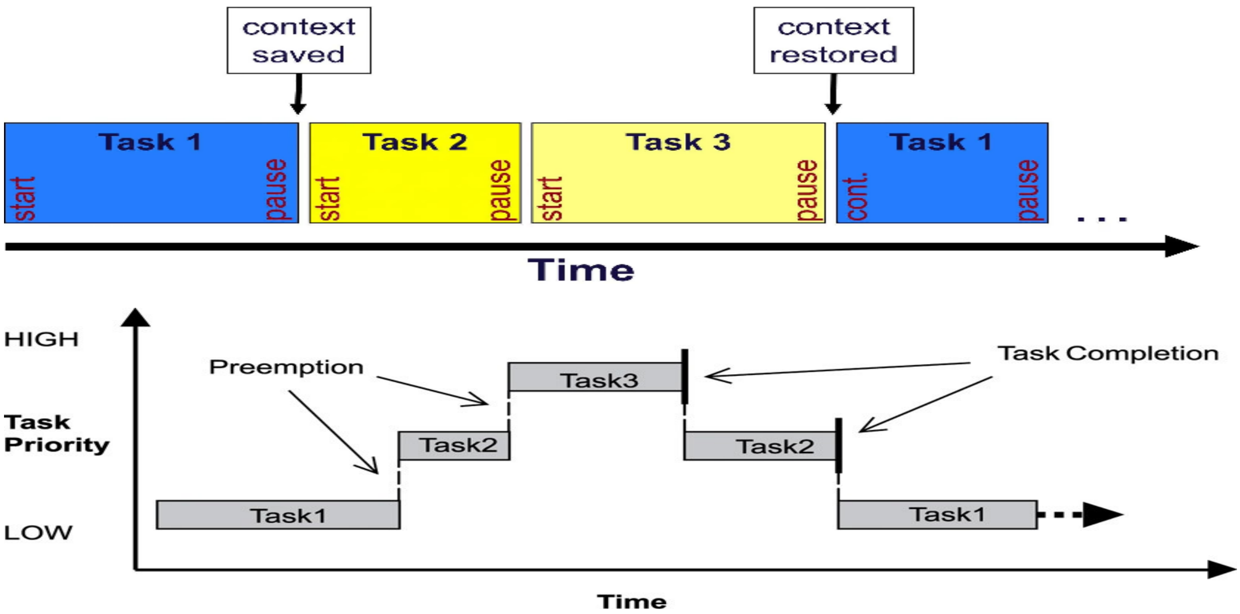

Figure 1: Scheduling in Embedded System

2.1. Methodology

Layout 2 and Job set 5 are specifically employed to demonstrate the application of the Embedded System (ES) rule, considering travel time as half and process time as triple. The following steps outline the ES 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 ES Rule

O.No	M.No	V.No	TT	Ready	Reach	PT	MS
1	1	1	0	3	2	6	14
2	2	2	27	30	15	12	39
3	4	1	78	82	41	9	59
4	1	2	35	38	21	18	57
5	3	2	98	102	59	6	71
6	2	1	132	135	77	15	107
7	3	2	106	111	71	9	89
8	4	2	168	171	90	3	96
9	1	1	195	200	100	12	124
10	4	2	174	180	96	6	108
11	2	2	237	241	113	15	143
12	3	1	103	107	107	3	113
13	1	1	113	118	124	9	142

Table 1 displays the activity sequence planned to use the ES rule for Job set 5 designs, resulting in an operational completion time (makespan) of 142.

Total completion time = 1162

Average flow time = Total completion time / Total number of operations = 1162 / 13 = 89.38

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 5 and Lay 2.

Model Number	Embedded No	Flow Time
M 5	20	89.38
M 5	30	89.61
M 5	10	96.92
M 5	40	98.92
M 2	20	101.33
M 2	30	103.13
M 7	20	105.84
M 7	30	107.78
M 2	10	112.2
M 2	40	114.46
M 7	10	117.15
M1	20	118
M1	30	118.23
M 7	40	122.57
M 3	20	123.62
M 3	30	123.87
M1	10	125.3
M1	40	126.76
M 3	10	132.62
M 3	40	133.56
M 4	20	150.15
M 4	30	154.63
M 4	10	160.65
M 4	40	167.52
M 6	20	170.22
M 6	30	170.33
M 8	20	172.15
M 8	30	172.35
M 6	10	178.88
M 6	40	181.44
M 8	10	182.56
M 8	40	185.3
M 9	20	191.64
M 9	30	191.7
M 9	10	196.47
M 9	40	201.23
M 10	20	248.66
M 10	30	249.85
M 10	10	251.09
M 10	40	255.28

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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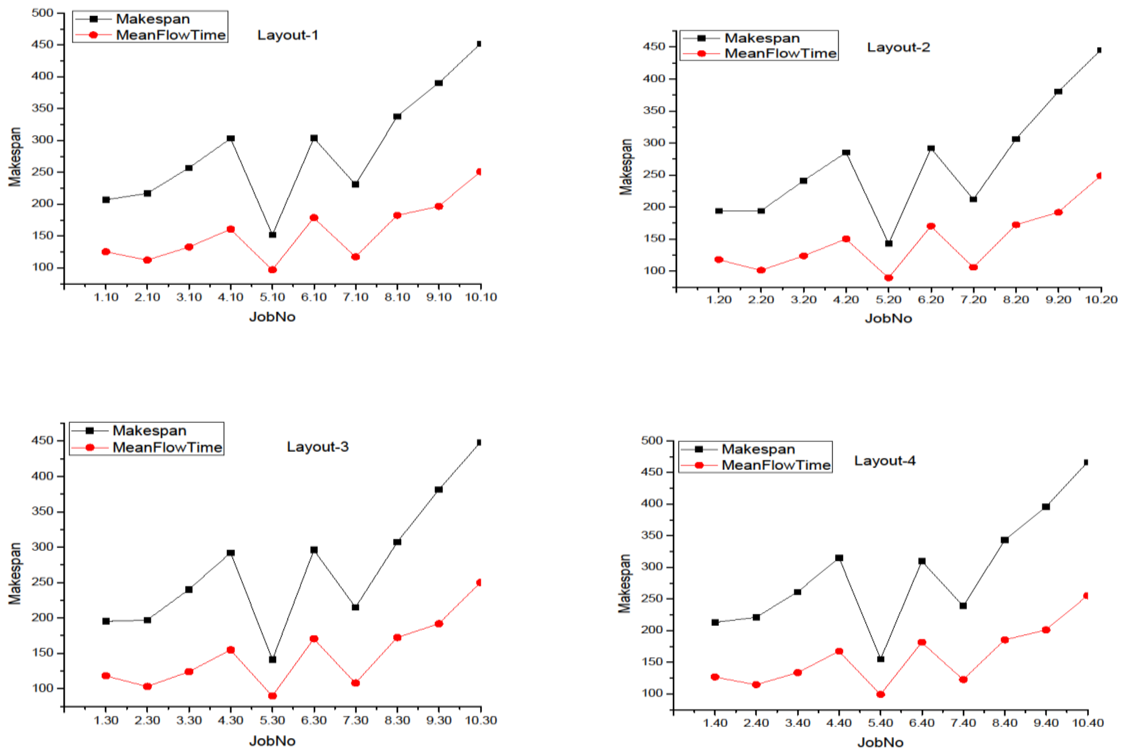

Figure 2: Make span Vs Mean flow time (t/p>0.25)

4. Conclusions.

FMS challenges are tackled through the Embedded System (ES) approach, employing the mean flow time as the evaluation criterion. Four different layouts are examined, each consisting of four identical machines and two material handling systems. This investigation delves into not just machine scheduling but also AGV scheduling, yielding the following key findings:

The study reveals a direct relationship between increased machine and AGV utilization and a rise in mean flow time.

Mean flow time significantly influences the distribution of completion times within the FMS.

When scheduling strategies impose heavier workloads on AGVs and machines, mean flow time becomes of paramount importance. This is due to the heightened utilization of the FMS system, which results in a higher number of job delays.

Across 40 problem scenarios, the ES rule consistently proves to be the most effective choice when evaluated based on the mean flow time criterion, particularly when combined with AGV rules.

The research underscores the necessity of formulating and implementing new rules tailored to the FMS environment and subjecting them to ongoing testing under various objective functions.

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