

A Study on the Group Sequencing Method in Regards with Transportation in an Industrial FMS

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Introduction

Flexible Manufacturing System:
designed to combine high productivity
and production flexibility.

Job shop problem: a model used to
optimize the performance of FMS.
The job shop model is a simplified
model of FMS: differences exist between
model and reality, the uncertainties
(transportation, processing times that
may be variable, etc.).

Group Sequencing can be a solution to
this drawback: it gives sequential
flexibility to the job shop solution that
allows to absorb some of the
uncertainties.



Group Sequencing

Groups of permutable operations were first introduced in [Erschler and Roubellat, 1989]. The goal of this method is to have a sequential flexibility during the execution of the schedule and to guarantee a minimal quality corresponding to the worst case. For a theoretical description of the method, see [Artigues et al., 2005]. To manage sequential flexibility, this method uses “groups of permutable operations.”



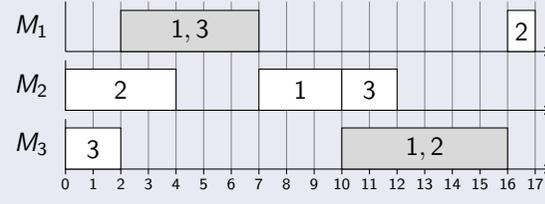
Example: a Job Shop Problem

i represents a job, j an operation, $M_{i,j}$ the resource needed by the operation j from job i , and $p_{i,j}$ the processing time needed by the operation j from job i .

Problem

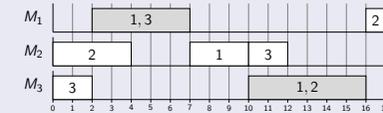
i	j	$M_{i,j}$	$p_{i,j}$
1	1	1	3
1	2	2	3
1	3	3	3
2	1	2	4
2	2	3	3
2	3	1	1
3	1	3	2
3	2	1	2
3	3	2	2

a Solution

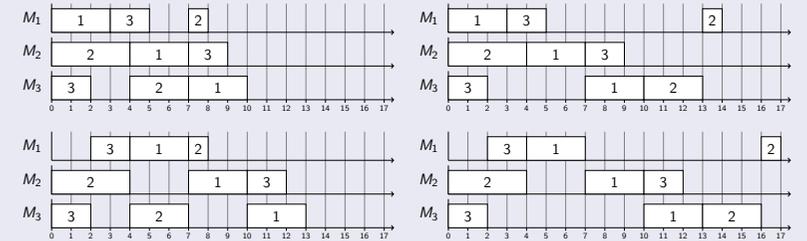


Execution of the Example

The Group Sequence



The Corresponding Semi-Active Schedules



Why is Group Sequencing Interesting?

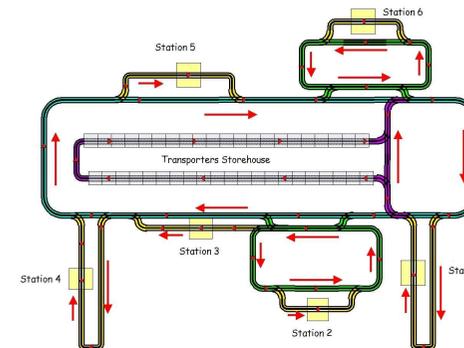
Why is Group Sequencing Interesting?

- predictive reactive method;
- flexibility on sequences;
- evaluation of the group sequence in the worst case in polynomial time for *minmax* regular objectives as C_{\max} and L_{\max} ;
- widely studied in the last twenty years: [Erschler and Roubellat, 1989, Billaut and Roubellat, 1996, Wu et al., 1999, Artigues et al., 2005]
- no need to model the uncertainties;
- the method is able to absorb some uncertainties: [Wu et al., 1999, Esswein, 2003] and this presentation.



The Flexible Manufacturing System under Study

The Flexible Manufacturing System:



A Job shop with transportation.

Group Sequencing:

- Every station keeps up to date a group sequence of operations to execute;
- A station accepts an operation only if it is included into the current group;
- When a group is empty, the station changes to the next group.



Protocol

We use la14, a job shop problem with no transportation.

Different executions:

- OSS:** A predictive schedule that is an optimal solution for the problem without transportation time. The quality is $C_{\max} = 1292$. The sequence of operations on each machine are given by the schedule.
- OGSS:** A predictive-reactive schedule that is a group sequence where the quality of all semi-active schedules are $C_{\max} = 1292$.
- DGSS:** A predictive-reactive schedule that is a group sequence where the worst-case quality is $C_{\max} = 1382$ and the best-case quality is $C_{\max} = 1292$ with more flexibility than OGSS.
- DS:** A reactive schedule, using the FIFO rule.



Conclusion

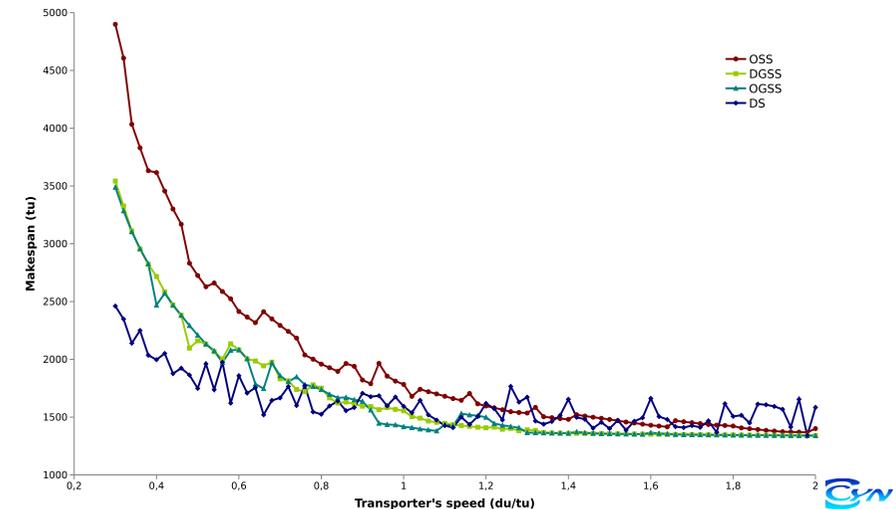
We presented:

- the problem of scheduling under uncertainties;
- group sequencing;
- a use of group sequencing on an FMS;
- the effectiveness of group sequencing on an FMS in regards with transportation.

In future works, we will experiment this property on other objectives such as the maximum lateness.



Results



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