Cooperation between Human and Machine for Shop Scheduling Under Uncertainties

Guillaume Pinot Nasser Mebarki Jean-Michel Hoc

IRCCyN — UMR CNRS 6597
Nantes, France
firstname.lastname@irccyn.ec-nantes.fr

HOPS Conference 2008

Table of Contents

Introduction

Group sequencing:

- is a scheduling method;
- describes a set of schedules;
- guarantees a minimal quality corresponding to the worst case.

A better human-machine system for the execution of the schedule can be done.

Group Sequencing

Group sequencing:

- provides sequential flexibility during the execution of the schedule;
- guarantees a minimal quality corresponding to the worst case.

To manage sequential flexibility, usage of “groups of permutable operations.”

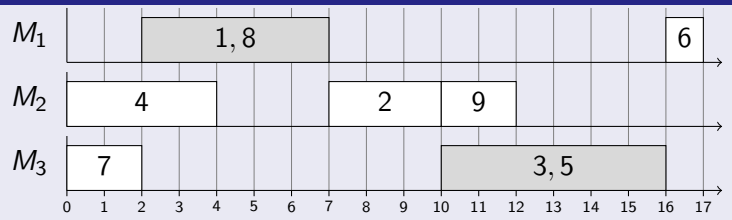
Example: a Job Shop Problem

i: the index of the operations, $\Gamma^-(i)$: the set of the predecessors of O_i, m_i: the resource needed by O_i, p_i: the processing time needed by O_i.

A Job Shop Problem

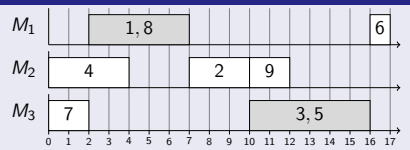
i	1	2	3	4	5	6	7	8	9
$\Gamma^-(i)$	$\varnothing$	$\{1\}$	$\{2\}$	$\varnothing$	$\{4\}$	$\{5\}$	$\varnothing$	$\{7\}$	$\{8\}$
m_i	M_1	M_2	M_3	M_2	M_3	M_1	M_3	M_1	M_2
p_i	3	3	3	4	3	1	2	2	2

A Solution to This Problem

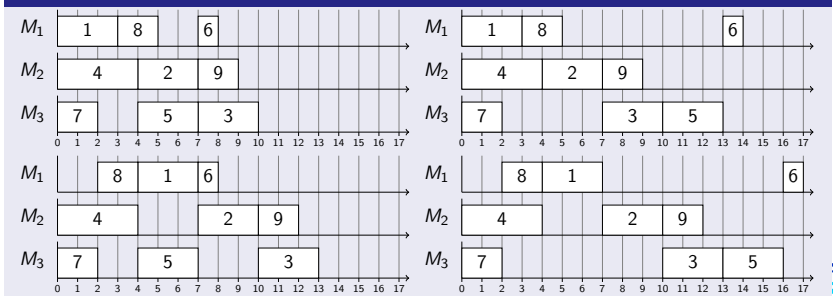


Execution of the Example

The Group Sequence



The Corresponding Semi-Active Schedules



Why is Group Sequencing Interesting?

Why is group sequencing interesting?

- proactive reactive method;
- flexibility on sequences;
- widely studied in the last twenty years: [Erschler and Roubellat, 1989, 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, Pinot et al., 2007];
- evaluation of the group sequence in the worst case in polynomial time for *minmax* regular objectives as $C_{\max}$ and $L_{\max}$.
- evaluation of the group sequence in the best-case is feasible for any regular objective [Pinot and Mebarki, 2008].

A better human-machine system can be done for the reactive phase.

ORABAID

ORABAID method is:

- the first system using group sequencing;
- used in the ORDO software [Roubellat et al., 1995];
- the only system used in real manufacturing systems.

Description of the human-machine system

The human-machine system for the reactive phase is based on the free sequential margin:

- free margin adapted for group sequencing;
- easily computable;
- allow to monitor the satisfaction of the deadlines;
- it is recommended to execute the operation with the greatest margin.

	Margin
O_1	-2
O_2	0
O_3	3

Analysis of the human-machine-system

Advantages:

- The system alerts the human when deadlines must not be satisfied;
- The human makes the decision.

Drawbacks:

- The system recommends a decision;
- The workload to analyze the different decision is very high;
- The human can became inactive.

Description of the human-machine system

Different indicators:

- free sequential margin;
- worst-case quality;
- best-case quality;
- processing time;
- *etc.*

	Margin	$L_{\max}^{WC}$	$L_{\max}^{BC}$	p_i
O_1	-2	2	0	5
O_2	0	1	0	3
O_3	3	-1	-2	7

Goals of this system

To correct ORABAID's drawbacks:

- The system does not recommend a decision;
- The machine exposes its knowledge to the human, which should help the human to make the decision;
- The human should became active.

Conclusion

We have proposed a new human-machine system for the reactive phase of group sequencing:

- it corrects ORABAID's drawbacks;
- it uses the best-case and the worst-case quality;
- the human should became active.

To validate this proposition, experiments will study different aspects:

- the implication of the operator in the decision;
- the effectiveness of the new decision support system in comparison with the other;
- the usage of the indicators by the operator.

These experiments will be done in collaboration with Clément Guérin and Jean-Michel Hoc.

Thank You

Thank you for your attention.

Bibliography I

Artigues, C., Billaut, J.-C., and Esswein, C. (2005).
Maximization of solution flexibility for robust shop scheduling.
European Journal of Operational Research, 165(2):314–328.

Erschler, J. and Roubellat, F. (1989).
An approach for real time scheduling for activities with time and resource constraints.
In Slowinski, R. and Weglarz, J., editors, *Advances in project scheduling*. Elsevier.

Esswein, C. (2003).
Un apport de flexibilité séquentielle pour l'ordonnancement robuste.
Thèse de doctorat, Université François Rabelais Tours.

Bibliography II

Pinot, G., Cardin, O., and Mebarki, N. (2007).
A study on the group sequencing method in regards with transportation in an industrial FMS.
In *Proceedings of the IEEE SMC 2007 International Conference*.

Pinot, G. and Mebarki, N. (2008).
Le meilleur des cas dans un ordonnancement de groupes.
In *ROADEF 2008, Livre des résumés*.

Roubellat, F., Billaut, J.-C., and Villaumie, M. (1995).
Ordonnancement d'atelier en temps réel : d'ORABAID à ORDO.
Revue d'automatique et de productique appliquées, 8(5):683–713.

Bibliography III


Wu, S. D., Byeon, E.-S., and Storer, R. H. (1999).
A graph-theoretic decomposition of the job shop scheduling problem to achieve scheduling robustness.
Operations Research, 47(1):113–124.