Cooperation between Human and Machine for Shop Scheduling Under Uncertainties

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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.

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Group Sequencing

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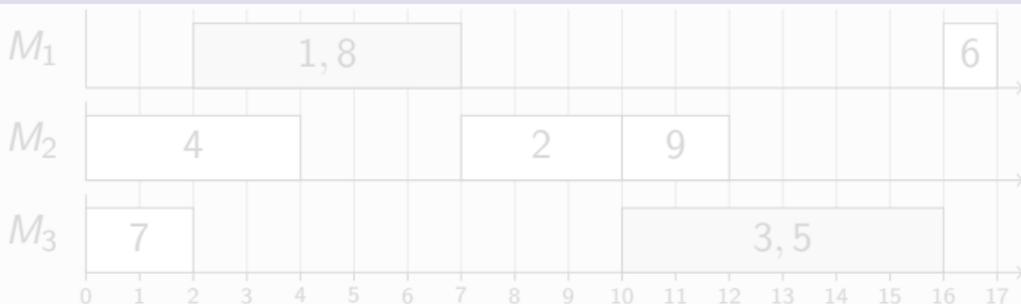To manage sequential flexibility, usage of "groups of permutable operations."

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

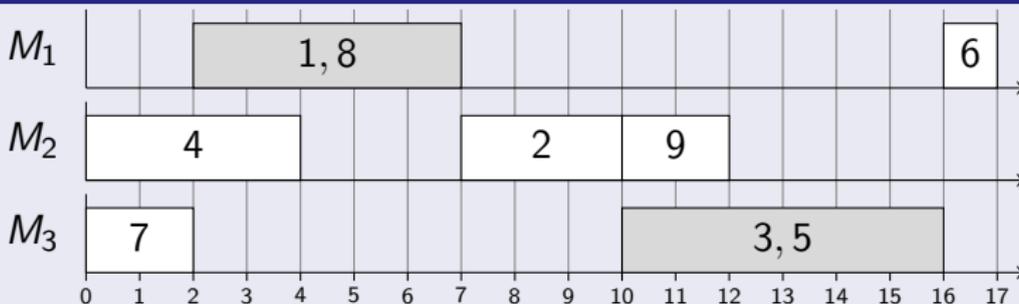| i	1	2	3	4	5	6	7	8	9
$\Gamma^-(i)$	$\varnothing$	$\{1\}$	$\{2\}$	$\varnothing$	$\{4\}$	$\{5\}$	$\varnothing$	$\{7\}$	$\{8\}$
m_i	M_1	M_2	M_3	M_2	M_3	M_1	M_3	M_1	M_2
p_i	3	3	3	4	3	1	2	2	2

A Solution to This Problem

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Execution of the Example

The Group Sequence
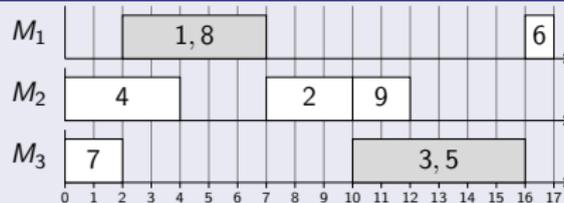
The Corresponding Semi-Active Schedules

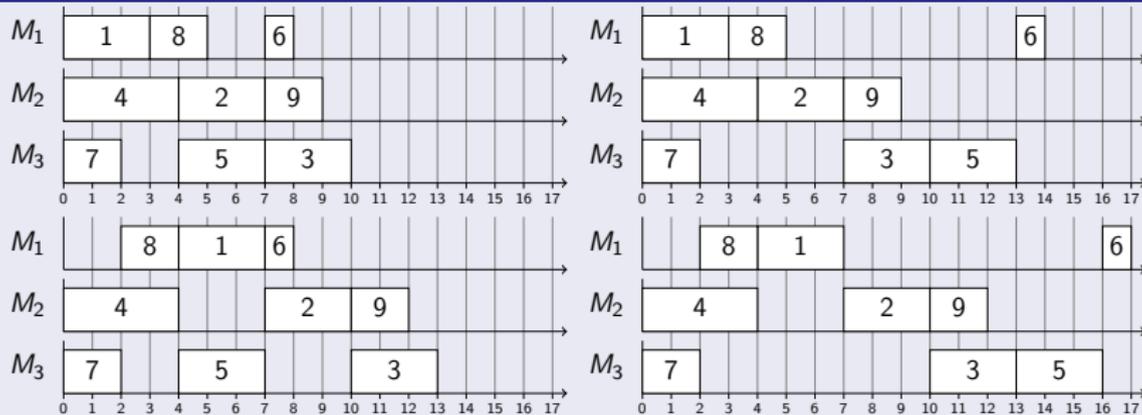# Why is Group Sequencing Interesting?

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].

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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

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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.

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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

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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.

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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.

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Thank You

Thank you for your attention.

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