Minimizing the makespan for the job-shop scheduling problem with availability constraints

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1 Problem

The vast majority of research in scheduling assumes that resources are continuously available for processing throughout the scheduling horizon. However, this assumption may not be true in the industrial context, since a resource may become unavailable for different reasons. Even if there is a trend during the two last decades in scheduling literature to integrate the availability constraints, the majority of existing studies concentrate on special cases with only one unavailability period, and do not investigate general problems such as job-shop, hybrid flow-shop and flexible job-shop [1].

Working on scheduling problems arising in complex workshops of semiconductor manufacturing, the integration of these availability constraints in the scheduling solution is one of the challenges that we face and that will allow us proposing more realistic and robust schedules. Machines, considered as the resources within the semiconductor workshops, may become unavailable due to breakdowns and preventive maintenance. As we are working on deterministic approach, the unavailabilities that results from random breakdowns can't be taken directly into consideration. Then, our study takes into account deterministic unavailability periods which are due to preventive maintenance known in advance (i.e. planed) or the case when it is possible to redo the scheduling when the unavailability periods are known. Also, within the rolling-horizon setting, it is possible that a machine is unavailable at the beginning of the scheduling period because it continues to process uncompleted jobs scheduled during the previous period. This case can be classified into the deterministic one. In the scientific literature, there is also another classification that distinguishes four cases for an operation to be interrupted by an unavailability period: strictly non-preemptive, resumable, non-resumable and semi-resumable operations [2] and two cases for an unavailability periods allowing interruption of operations: crossable and non-crossable unavailability periods. In our case, the operations are strictly non-preemptive; i.e. they can be interrupted neither by another operation nor by an unavailability period.

Therefore, we address the makespan minimization in a job-shop environment where the machines are not available during the whole planning horizon. The starting and finishing times of these unavailability periods are known in advance and fixed. Operations are strictly non-preemptive.

2 Proposed Approach

Facing the requirement to obtain good solutions for problems with large sizes, we propose a local search heuristic. The disjunctive graph model is used to represent the schedules where the unavailability periods are implicitly considered during the start date computation.

To make the local search efficient, the sufficient conditions from [3] are adapted to the case of the job shop with unavailability periods. These conditions reduce the neighborhood size by eliminating moves that will not improve the solution. In addition to these conditions, an adaptive start date computation algorithm is proposed to improve the schedule. This Algorithm is inspired by the one given by [4] in order to improve the schedules for the flexible job-shop problem with p-batching constraints. After each move, the proposed algorithm improves the obtained schedule by filling up the idle time occurring before the unavailability periods due to the fact that operations cannot be interrupted by an unavailability period. This algorithm combines the start date computation with the dynamic modification of the graph by advancing suitable nodes. In addition to these ideas, results of an implementation will be presented during the conference.

References

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