

# USING TABU SEARCH FOR DYNAMIC SCHEDULING:

## *The Extended Job-Shop Scheduling Problem*

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**Abstract:** In most practical environments, scheduling is an ongoing reactive process where the presence of real time information continually forces reconsideration and revision of pre-established schedules. Scheduling algorithms that achieve good or near optimal solutions and can efficiently adapt them to perturbations are, in most cases, preferable to those that achieve optimal ones but that cannot implement such an adaptation. This reality, motivated us to concentrate on tools, which could deal with such dynamic, disturbed scheduling problems, both for single and multi-machine manufacturing settings, even though, due to the complexity of these problems, optimal solutions may not be possible to find. We decided to address the problem drawing upon the potential of Tabu Search to deal with such complex situations.

**Key words:** Dynamic Scheduling, Rescheduling, Tabu Search, Dynamic Adaptation.

Research on the theory and practice of scheduling has been pursued for many years. Theoretical scheduling problems concerned with searching for optimal schedules subject to a limited number of constraints have adopted a variety of techniques including branch-and-bound and dynamic programming. From the point of view of combinatorial optimization the question of how to sequence and schedule jobs in a Job-Shop environment looks rather complex and is known to be NP-hard.

Most real-world multi-operation scheduling problems can be described as dynamic and extended versions of the classic Job-Shop scheduling combinatorial optimization problem.

The scheduling approach presented in this paper is applicable to both static and dynamic manufacturing environments for optimizing criteria that are possible to establish. It is based on the decomposition of the problems into Single Machine Scheduling Problem (SMSP), one for each machine involved in processing, and later integration for obtaining a solution to the original problem, i.e. to the Extended Job-Shop Scheduling Problem (EJSSP). Therefore, the deterministic EJSSP problem is decomposed into a series of deterministic SMSP. We assume the existence of different and known job release times  $r_j$ , prior to which no processing of the job can be done, and job due dates  $d_j$ . Based on these, release dates and due dates are determined for each SMSP and, subsequently, each such problem is solved independently by a Tabu Search method. Finally, the solutions obtained for each SMSP are integrated into the main problem, i.e. the non-basic EJSSP.

The integration of the SMSP solutions may give an unfeasible solution to the EJSSP. In this case, the schedule must be repaired. This is carried out by means of what we call the Inter-Machine Activity Coordination Mechanism (IMACM).

The work reported in this paper is concerned with the resolution of realistic Job-Shop Scheduling Problems (JSSP). Moreover, it is concerned with integrated scheduling of jobs which are products composed by several parts or components which may be submitted to a number of manufacturing and multi-level assembly operations.

We present a scheduling system, having two main pieces of "intelligence", to solve such complex problems. One such piece is a Tabu Search-based method for deterministic scheduling. This includes a Tabu Search method for single machine problems and the IMACM mechanism that attempts to ensure a good feasible solution for the deterministic EJSSP. The other piece is a rescheduling mechanism that includes a method for neighborhood regeneration under dynamic environments, increasing or decreasing it according new job arrivals or cancellations.

We could not make a comparative performance study with other methods for two reasons: first, because no benchmark problems were found, in the literature surveyed, for the EJSSP we address. Second, because the same was true for methods, i.e. none was found addressing the EJSSP. However, we continue searching for reported work, which might refer problem instances suitable for performance comparisons. We are also working on the improvement of the scheduling mechanisms and developing further testing to improve the quality of solutions.