Beam search heuristic for multi-modes project scheduling under constraints applied to aircraft assembly line : non preemptive and preemptive under condition cases *

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Abstract:

We discuss the problem of project scheduling for aeronautic assembly lines. The scheduling problem under study may be viewed as a new extension of the M-RCPSP (Multi mode Resource Constrained Project Scheduling Problem) with multi skilled labors. In many different industry areas, including aircraft assembly, the problem includes many specific constraints related to human factors, regulatory guidelines and management methods. It is an attribute frequently encountered in real life.

According to internal and external constraints, work center in an assembly line adopts one shift, two shifts or three shifts per day depending of shift work type. One or more teams are allocated to set off shifts according to production calendar. Every Labor is a renewable disjunctive resource characterized by its list of skills, its frame time availability and its team identity. A labor can be assigned to a specified activity only if it meets the required skill.

Each work center is divided into a set of work zones. Every work zone is a renewable cumulative resource characterized by its capacity and its spatial location. The resources are renewable and each activity can be performed only in one of several execution modes and assigned to one or several work zones. It can be executed only by a given number of labors having the required skills. Each execution mode is characterized by a known duration and given resource requirements. Each activity with predecessors cannot be started before the last predecessors would be finished.

The resource transfer is possible with certain time requirement and at certain cost, but should be kept to a minimum. We consider a resource transfers for labors when a labor is moved physically from one location to another. A setup time and management rules are considered to deal with the labor transfer.

We restrict ourselves to deterministic approaches. The single shift work type with exactly one team, correspond to the non-preemptive case. Otherwise, we deal with the preemptive case and the shift scheduling. In this case, we consider:

- A type of shift work (e.g. 2, 3, 4 shifts) per work center.
- A set of shifts that cover a project cycle
- Length of shifts: Duration of the work shift vary from 4 to 7,5 hours depending on production calendar. This duration does not include breaks.
- Number of teams: For each work center, one team is allocated to each shift.
- A team size and labors profile : It is determined by requirements of activities and management methods
- The rotation of teams is allowed or not.
- The overlapping of shifts is not allowed
- …

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In the preemptive case, we do not allow the preemption of activities within the shifts. We allow activity preemption at a discrete time that corresponds to the end of shifts. The management rules are considered:
If the preemption is possible for an activity, a management rule determines if the execution is possible with preemption or if the activity must be delayed to the next shift.
If an activity is preempted, a management rule determines when an activity is resumed, the conditions of execution of the remaining activity (the mode may not change, the mode can change or the mode must be faster …)
The scope is to determine a mode(s), a start time(s) and resource allocation for each activity so that all constraints are obeyed in order to minimize the makespan.

The resource-constrained project scheduling problem (RCPSP) is a classical well-known problem where project activities of a project must be scheduled. Many variations and extensions of the RCPSP have been examined and studied during the last decades. The NP-hard nature of the problem which is difficult to use to solve realistic projects makes the use of heuristic and meta-heuristics necessary in practice. Kolisch [1] [2] summarizes and categorizes a large number of heuristics that have recently been proposed in the literature and evaluates the performance of several state-of-the-art heuristics and metaheuristics.

Kadrou [3] consider the MRCPSP problem with resources flexibility, called MRCPSP-RF. Under particular hypotheses and conditions (no resource transfer, no management rules, no preemption …), the MRCPSP-RF studied by Kadrou can be compared to our problem in non preemptive case. Kadrou shows the effectiveness of heuristics with parallel schemes that are based on the generation of non dominant combinations. Kadrou has also proposed different meta-heuristics approaches. He concludes that the tabu search combined to insertion techniques is the meta-heuristic the most efficient meta-heuristic to solve the MRCPSP-RF.

We will present our meta heuristic inspired by « beam search » and compare it with Kadrou's metaheuristics.

References

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