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ORIGINAL ARTICLE

A solution procedure for preemptive multi-mode project scheduling problem with mode changeability to resumption

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Abstract Extensive research has been devoted to the multi-mode resource constrained project scheduling problem (MRCPSP). However, little attention has been paid to problems where preemption is allowed. This paper involves the preemptive multi-mode resource constrained project scheduling problem (P-MRCPSP) to minimize the project makespan subject to mode changeability after preemption. This problem is a more realistic model and extended case of multi-mode resource constrained project scheduling problem. A binary integer programing formulation is proposed for the problem. The problem formed in this way is an NP-hard one forcing us to use the Simulated Annealing (SA) algorithm to obtain a global optimum solution or at least a satisfying one. The performance of the proposed algorithm is evaluated on 480 test problems by statistically comparing in term of the objective function and computational times. The obtained computational results indicate that the proposed algorithm is efficient and effective. Also, it is concluded from the results that mode change is very effective to improve the optimal makespan of the project.

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1. Introduction

Resource constrained project scheduling problem (RCPSP) is one of the most important problems in the context of project scheduling which is an NP-hard problem (Blazewicz et al., 1983). The decision variables for the RCPSP are the starting times of activities while the resources availabilities are considered given. The objective is then to minimize the completion time of the project. In the literature there are several algorithms that solve the RCPSP; recent reviews about exact methods and heuristics can be found in Kolisch and Hartmann (1999), Hartmann and Kolisch (2000, 2006), Zhang et al. (2006a,b), Jairo et al. (2010), Hartmann and Briskorn (2010), Agarwal et al. (2011), Fang and Wang (2012), Kone (2012) and Paraskevopoulos et al. (2012).

In RCPSP it is assumed that activities could only be performed in one possible execution mode. In practice, however, it often happens that multiple execution modes can be defined for the project activities. Each activity may be executed in one or more execution modes, each requiring a specific amount of resources consumption and resulting in different durations for an activity completion. More exactly, each execution mode defines as a trade-off between time/cost, time/resource, speed/resource etc. The multi-mode problem (MRCPSP) is a generalized version of the RCPSP, where each activity can be performed in one out of a set of modes, with a specific activity duration and resource requirements. The standard multi-mode resource constrained project scheduling problem involves the selection of an execution mode for each activity and the determination of the activity start or finish times such that the precedence and resource constraints are met and the project duration is minimized. As this problem is a generalization of the RCPSP, the MRCPSP is also NP-hard. Several algorithms that solve the MRCPSP have been proposed in recent years: Hartmann and Drexl (1998), Sprecher and Drexl (1998), Knotts et al. (2000), Nonobe and Ibaraki (2001), Jozefowska et al. (2001), Alcaraz et al. (2003), Bouleimen and Lecocq (2003), Heilmann (2003), Zhu et al. (2006), Zhang et al. (2006a,b), Lova et al. (2006), Jarboui et al. (2008), Ranjbar et al. (2008), Lova et al. (2009), Coelho and Vanhoucke (2011), Ranjbar (2011), Barrios et al. (2011), Afshar-Nadjafi et al. (2013), Nabipoor et al. (2013).

The basic RCPSP and MRCPSP assume that each activity, once started, will be executed until its completion. This assumption can be justified only for activities in which their interruption essentially is inapplicable. For example, in order to integrity of foundation, concrete placement cannot be preempted. However, for activities in which their interruption is applicable, the optimal makespan can be improved by allowing preemption, because the solution space is extended as a result of the constraint relaxation. Welding can be mentioned as a preemptive activity. Preemptive multi-mode resource constrained project scheduling problem (P-MRCPSP) refers to a generalization of the multi-mode resource constrained project scheduling problem (MRCPSP) which allows activities to be preempted at any time instance and restarted later on at no additional cost. The literature

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