Using CP and MIP techniques to tackle the Multi-mode Resource Investment Problem

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Abstract. Our goal is to identify effective exact approaches to solve the multi-mode resource investment problem. This is a project scheduling problem where a deadline on the latest project completion is imposed and the resource costs need to be minimised.

Keywords: Project Scheduling · Constraint Programming · Mixed-integer Programming

1 Introduction

In many project scheduling settings, the project has to be completed before a given deadline. This is also the case for the multi-mode resource investment problem (MRIP). Here, the project has to decide how many resource units are allocated to the project such that it can finish on time. We distinguish renewable and nonrenewable resources in the MRIP setting where the renewable ones replenish in each time period of the project horizon. The nonrenewable resources are consumed once used. The objective is to find a schedule and resource allocations that minimise the resource costs. The costs depend on the maximum resource peak of used renewable resource units and the overall consumed nonrenewable resource units. The activities of the project need to scheduled without interruption and can consume multiple resources during their execution. The MRIP is the multi-mode extension of the resource investment problem (RIP) which is also known under the name resource availability cost problem and was introduced by Möhring [3]. In the multi-mode setting, each activity of the project can be processed in one of multiple modes that differ in the activity duration and the resource usage. It was firstly considered by Hsu and Kim [1] who proposed a priority rule heuristic. Among activities there are precedence relations, i.e. some activities can only start if all their predecessor activities are finished. We call a schedule feasible if it respects the deadline, the precedence relations and the resource allocations. So far, mostly metaheuristic procedures have been investigated in the context of the MRIP. Therefore, we want to identify which exact procedures are effective at finding optimal solutions for the MRIP.

2 Methodology

We implemented several mathematical formulations as mixed-integer programmes (MIP). They are adaptations of formulations for the resource constrained project scheduling problem (RCPSP) and differ in their decision variables (pulse, on/off and step variables) as well as their modelling of the precedence relations with different constraints. Since constraint programming (CP) techniques became also a powerful tool for project scheduling problems (see e.g. [2, 4]), we also implemented the MRIP as a CP formulation.

Preliminary results show that CP can solve many small sized instances much faster than the MIP approaches. Often, the MIP solver finds also good quality solutions, but is not able to prove optimality. However, both the MIP and the CP procedures still struggle with larger instances and further research is needed there. For example, it could be interesting to hybridize exact approaches and metaheuristic procedures.

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