Robust scheduling within SNCF railway maintenance centers

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1 Introduction

The French national railway company, SNCF, is responsible for the maintenance of its rolling stock. The most heavy maintenance operations, and thus longest ones (several weeks), are carried out in ten different dedicated workshops. The aim is to renovate and modernize railway vehicles every 10 to 20 years, depending on their type and deterioration state. Not only train coaches are maintained, but most of the components as well (electronic cards, bogies, axles). Economic savings and the reduction of the environmental impact of the railway industry are the main challenges while increasing passenger comfort and service quality.

Knowing rolling stock arrival dates in the maintenance workshop, we propose a MILP model to schedule maintenance operations respecting industrial constraints. Each rolling stock unit is considered as a project and operations as activities requiring a certain number of resources to be processed. Thus, we deal with the *multi-skill resource-constrained multi-project scheduling problem* (MSRCMPSP), as resources have multiple skills and several rolling stock units are maintained simultaneously. MSRCMPSP is an extension of the *resource-constrained project scheduling problem* (RCPSP) which was first proposed in [5].

Since then, the problem has been widely studied and various extensions were proposed. It is a proven NP-hard problem and most papers focus on a single project ; sometimes with multi-skill resources. However, very few papers deal with both multiple projects and multi-skill shared resources [3]. The objective is usually to minimize the makespan, i.e. the total time to perform all activities on available resources. In this paper, we focus on minimizing the sum of weighted tardiness of the projects and the sum of their weighted duration.

2 Mathematical modeling

We have a set of activities A to schedule, with processing time p_a and precedence relationship represented as a couple (a, a') meaning that activity a must be executed before a', during a time horizon T. Each activity needs a set of capacitated $r_{a,k}$ resources of type $k \in K$. The goal it to find a resource feasible solution that optimizes one or several criteria and respects maintenance procedure constraints such as precedence constraints with transport times between activities, modelled usually as time lags. Two main modeling approaches for the RCPSP can be found in the literature [4] :

— **Continuous time modeling**, where activities can start at any time of the scheduling horizon. The associated models are based on disjunctive constraints between activities sharing the same resources [1].

— **Discrete time modeling**, where activities can only start at a given period $t \in 1, 2...T-1, T$. The performances of the associated models are very sensitive to the discretization step and the scheduling horizon T since the number of decision variables increases.

The number of operators with a given skill being uncertain on a long horizon and because it is time varying, we use a discrete time model for our problem. For the sake of brevity, we do not present the full model but we introduce and study the performances of two different ways of writing precedence constraints [2] :

$$\sum_{t=1}^{T} tS_{a,t} + p_a + l_{a,a'} \leq \sum_{t=1}^{T} tS_{a',t}; \qquad \forall (a, a') \in P_a \tag{1}$$

and,

$$\sum_{l=1}^{t+p_a-1} lS_{a,l} + p_a + l_{a,a'} \leq \sum_{l=t}^{T} lS_{a',l}; \qquad \forall t \in T, \forall (a, a') \in P_a \tag{2}$$

In our computational experiments, we analyze, on small instances designed using industrial data, the performances of the two modelling approaches. The results in Table 1 show the "classical" method (1) is way faster than the disaggregated approach (2). However, for "difficult" instances, adding disaggregated constraints improves the computational times.

		LeadTime			**Tardiness**		
Instance	Step(h)	$CPU_1(s)$	$CPU_2(s)$	$CPU_{12}(s)$	$CPU_1(s)$	$CPU_2(s)$	$CPU_{12}(s)$
	6	**9**	18	13	**9**	37	14
E245	4	**11**	324	16	**9**	134	22
	2	104	935	**97**	45	1357	**33**
	6	576	1306	**448**	1410	1751	**779**
E3A73	4	960	1538	**853**	1251	-	**936**
	2	**1344**	-	1337	1695	-	**1392**
	6	1042	1788	**928**	1789	-	**1639**
E4A90	4	-	-	**1709**	-	-	-
	2	-	-	-	-	-	-

TAB. 1 – Preliminary results on small instances based on industrial data (CPU<30min)

The detailed model will be presented during the conference and we will discuss our main perspectives : considering the stochastic version and solving large real industrial instances.

Références

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