Sequential approaches for solving shunting problems at passenger railway stations

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1 Introduction

In passenger railway transportation, shunting is the management of train-units which stay long enough in a station to be parked at specific yards called *shunting yards*. Shunting yards consist of parallel tracks called *shunting tracks* which can include equipment for cleaning or maintenance. Therefore, shunting yards are used to prepare train units before departure.

Shunting planning includes several decisions. First, arriving train units must be assigned to departures, it is a matching. Train units can be coupled or uncoupled to match train configurations required for departure. Moreover, train units are parked at one or several shunting tracks according to the availability of the equipment required for maintenance operations. Similarly, movements are set from platforms to shunting tracks, between shunting tracks and from shunting tracks to platforms. It is a route planning, since paths are assigned to train units and movements are scheduled based on running times and potential conflicts. Finally, depending on maintenance crews availability, maintenance operations are scheduled. Even if these decisions are often taken separately, they are usually strongly interdependent. The Generalized Train Unit Shunting problem (G-TUSP) is the problem of shunting operations planning. Delays and maintenance operations cancellation are minimized as well as the duration of shunting movements and the number of coupling or uncoupling operations. The G-TUSP integrates the following subproblems :

- The Train Matching Problem (TMP), the problem of matching arriving and departing train units.
- The Track Assignment Problem (TAP), the problem of choosing train units location.
- The Shunting Routing Problem (SRP), the problem of determining route and schedule to shunting movements.
- The Shunting Maintenance Problem (SMP), the problem of defining train units maintenance scheduling.

The problem which combines TMP and TAP is known as the Train Unit Shunting Problem and has been tackled with sequential algorithms [1] and integrated approaches based on an integer linear programming (ILP) formulation [4] , as well as column generation, greedy algorithms and a constraint programming method [2]. G-TUSP is introduced in [3], with a mixed integer linear formulation (MILP) which integrates the four mentioned sub-problems. This formulation provides good solutions despite high computation times for operators. In this paper, we propose sequential algorithms for solving the G-TUSP. These algorithms integrate some groups of subproblems.

2 Algorithmic approach

The G-TUSP is set thanks to a microscopic representation of the infrastructure and the consideration of dummy trains in order to manage coupling and uncoupling. The paper proposes algorithms in which a group of sub-problems is solved exactly while the decision variables related to the other sub-problems are set.

Two sequential algorithms solve the TAP and the SRP in an integrated MILP formulation [3] with TMP or SMP solution. Two other sequential algorithms solve the TAP with a heuristic and then SRP with a MILP formulation [5]. The heuristic for the TAP is based on monotonic sequences construction and bin packing approximations. In these four algorithms the SRP is solved in a first step with a fixed routing while in a second step alternative routes are introduced.

3 Experiments

Four algorithms are tested on scenarios based on Metz-Ville station in France. Instances are generated with real daily timetables. These timetables include trains to shunt and passing trains. We consider expected delays and tracks closures in a set of 32 instances.

The experiments highlight the interest of integrating TMP and SMP in case of delay. The results also show that solving the TAP separately with a heuristic greatly reduces computational times. The G-TUSP is even better solved once the TAP is tackled. When the TAP is tackled first, results remain satisfying especially for delays scenarios. Furthermore, the computational results point out that the interdependence between TAP and SRP have a strong impact on the quality of solutions in case of track-closure.

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