Decomposition techniques for parking vehicles in depots

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1 Introduction

The placement of vehicles leaving a depot for performing travels of services is certainly not new, but the literature for an automated placement is very limited [1] [2] [3] [4] [5] [6]. This situation might be explained by the fact that each company has its own operational organization and each depot its own characteristics.

So, we had to imagine a methodology from scratch when one of the largest Swiss company of public transportation asked us to design algorithms for automatically placing the vehicles in its depots. The company owns several hundreds of vehicles of different types, and have almost 8km of lanes in depots for parking them.

At first glance, the problem looks like a bin-packing, since the process is to decide which vehicle to place on which lane, knowing the length of each vehicle and the length of each lane.

However, numerous operational constraints make the problem much complex than a simple bin packing.

- With the exception of few tramway, the vehicles can be driven in the depots only forward
- Given vehicles must be placed on lanes with specific equipments, such as rails for tramway or electrical lines for trolleybuses
- A vehicle cannot leave a lane if another vehicle is in front of it; in few situations, the vehicles on contiguous lanes may also prevent a vehicle to leave a lane.
- The leaving hour of a vehicle must be very precisely respected, but the hour at which it returns to the depot may fluctuate
- When a vehicle enters the depot, it must be parked at a position where it will leave the depot for the next service
- etc.

2 Solution technique

For respecting all these constraints, an more precisely the last one, the problem resolution has been decomposed in several steps.

1. The vehicles are clustered by type, independently from their departure hour. If possible, a lane is composed of vehicles of the same type.
2. Once the vehicles placed on lanes, their departure hour is assigned with respect to the timetable. This assignment must satisfy the precedence constraints.
3. In case no feasible solution is found, some vehicles are moved from one lane to another. This may imply that some lanes may contain different types of vehicles. Then, the departure hour for each vehicle is assigned.
4. The solution is finally post-optimized, to tentatively create blocks of lanes with the same vehicle type, to take into consideration other specific constraints and to maximize the number of lanes without any vehicles.

Although these constraints may look artificial, they are essential for a good management of the depots. Step 1. ensures that a vehicle entering into the depot can be parked directly at the right place for the next service, avoiding costly moves of vehicles in the depot. This step is solved exactly by branch & bound and provide the manager an immediate answer about the feasibility of positioning all vehicles in the depot. In most situations, Step 2 can be solved exactly by branch &

bound. However, if the exact method takes too much time, the algorithm switch to a taboo search based on exchanging the departure hour of 2 vehicle.

Steps 3 and 4 have been implemented with a local search that takes into consideration several other operational objectives. The last step is also important for a good management of the depot. Imagine that hundreds of drivers arrives at the depots almost simultaneously. By making blocks of vehicles of the same type, the drivers immediately know in which portion of the depot they have to go for taking their vehicle.

3 Results

Since the problem is very specific, it is not possible to provide numerical results. Moreover, the algorithms are used in 2 different ways: Few times a year, for instance when the national railway timetable changes, or at the beginning of holidays, ideal parking plans are computed. There are 4 different ideal plans for a week: one for ordinary working week days, one for the working day when the school are closed, one for Saturday and finally one for Sunday. In addition, there are small modifications each day, for instance if there is a sportive competition requiring additional bus services, or a modification in the timetable due to roads that are closed. So, the algorithms are executed each day, but with an additional objective that measure the difference between the current parking plan and the ideal one. The decomposition techniques presented above, combined with the flexibility of metaheuristics, allow to produce parking plans adapted to the operating constraints of the company with limited computational times. Typically, building a parking plane from scratch can be done in less than one hour, and modifying an existing plane in few minutes.

The use of metaheuristics allows to always able to produce a solution, even if the last is not directly feasible an must be manually adapted. This situation occurs for instance when additional services are required, implying total length of the vehicles that is higher than the total length of the parking lanes. The algorithms developed have simplified a lot the work of the responsible of parking the vehicles in the depots, who had more than 20 years of experience and was almost the only one in the company who was able to solve the problem manually.

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