Vehicle and Crew Assignment for Flexible Bus Networks

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1 Introduction

The present work contains part of the introduction and the mathematical model presented in [2]. Urban bus agencies have to assign their vehicles and drivers to cover timetables, that is, determine the set of trips that must be covered by each vehicle and define the daily duties of the drivers. A sequential approach for solving these problems leads to suboptimal solutions for the transit systems so we have considered an integrated approach (other integrated approaches [1, 3, 4]). In many developing countries, the problem is more complex since the vehicle and crew assignments have to be made every week or even every day since the fleet of vehicles and the available drivers drastically change over time (e.g., after payday up to 30\% of the drivers will either not show up or not pass the alcohol breathalyzer).

This flexible transportation network has some advantages: the duty of the drivers may change every week, and the driver breaks can be placed anywhere during the day as long as the legal restrictions are satisfied (a driver cannot work more than 10 hours and a driver cannot drive more than four hours in a row without a break of at least 30 minutes). To illustrate the gain obtained by considering this flexible context we show a solution that uses six drivers $d_1, \ldots, d_6$ and six vehicles in Figure 1 (example and figure taken from [2]). In the horizontal axis, we have the hours. Each blue, green or orange rectangle is a trip (round times of the trips are all equal to one hour). Red rectangles are the legal breaks of the drivers separating driving blocks of less than four hours. Note that the duty of a driver may not start and end at a specific time slot, that is, the duty of driver $d_4$ starts at 6 :35 and ends at 15 :35. If between two trips the driver does not rest for at least 30 minutes then this small break is not considered as a legal break and it must be added to the consecutive driving time. Notice that the break for each driver is at a different time: driver $d_4$ performs three trips, followed by a break because he could not make another trip without exceeding the four hours time limit, then, the driver only makes trip 6 of the orange line and rests again to be able to chain four trips in a row.

Therefore, we do not have generic duties that can be assigned to any driver, they must be designed together with the vehicle assignment to minimize the number of drivers needed in the solution. Thus, we need to identify each driver and each vehicle in order to define a feasible trip-vehicle-driver assignment for each line. Additionally, we consider compatibility between each pair: vehicle-driver, driver-line, and line-vehicle. Indeed, not all the drivers are allowed to operate the new buses of the fleet, a driver may not know the route of a line, or a vehicle may have its line number painted so it cannot be used for another line (in Figure 1, driver $d_4$ is only allowed to operate on the blue line). We do not limit the number of vehicle swaps that a driver may have along his daily schedule. To the best of our knowledge, this is the first time that these characteristics are considered all together by an integrated approach for the vehicle and crew bus scheduling problems.
FIG. 1 – Schedules of the drivers $d_1,\ldots,d_6$. Each blue, green or orange rectangle is a trip; red rectangles are the legal breaks that the drivers must have to avoid working blocks of more than four hours (from [2]).

2 Contribution and perspectives

The major contributions are the definition of a new integration of the vehicle and crew scheduling problems together with an integer linear programming based on network flow formulation for the proposed problem. In the presentation, we will present our model and show perspectives on how decomposition schemes may be generated. Indeed, classical column generation based algorithms cannot easily be applied since there is a lack of structure on the daily duty of the drivers.

— One of the main drawbacks of our formulation are the constraints related to the legal breaks. Thus, a cutting plane algorithm where these constraints are left out and introduced whenever they are violated, could improve the computational times.

— In this model we consider an heterogeneous vehicle fleet but the case where homogeneous vehicles (or only few sets of different vehicles) is considered is closer to the real instances and could imply interesting decomposition schemes.

— In our formulation, all driver are specific but homogeneous. In the bus companies which have flexible settings as the ones described in this communication, drivers are classified with respect to their punctuality, their assistance and the number of accidents they have had. Thus, instead of considering all drivers as specific, the model could benefit of having few sets of drivers, each driver in a set would be equivalent to the others in the same set.

Références


