First Constraint Programming based approach for the Truck Driver Scheduling Problem

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Introduction

In order to increase road safety, legal drivers' rules define a general framework of drivers' work conditions, including mandatory driver breaks and rest periods during workdays. This set of rules impose restrictions on driving time, working time, as well as the scheduling of several types of breaks along the shifts and weeks. The routes defined by solving classic vehicle routing problems are often long and do not respect these regulations. Thus arises the need to validate and adapt these routes so that they comply with the rules imposed. The Truck Driver Scheduling Problem (TDSP) aims to determine the sequence of driver activities according to the rules on drivers' hours and working time, so that the driver visits all customers in a given order, respecting the time windows of each client. Thus, let us consider a sequence of customer locations that must be visited by a truck, and the European Union (EU) regulations [1]. A work activity with a known duration must begin at each customer within a given time window. The driving time to go from one customer to another is known. In this work, we propose a first Constraint Programming (CP) model to solve the TDSP, meeting EU legal driver' rules for a planning horizon of one-week time. In more detail, we consider the following set of constraints: (i) a truck driver cannot drive more than 4.5 hours without a break of at least 45 minutes, referred to as a full break; (ii) a driver break of 45 minutes can be split into two periods of at least 15 minutes and 30 minutes each, in that order; (iii) after a total of 9 hours of driving, a driver must take a rest period (sleeping time) of 11 hours; (iv) the total driving time can be increased to 10 hours twice a week; (v) the rest period can be reduced to 9 hours three times a week; (vi) a working period of 6 hours must encompass a break of not less than 15 minutes; (vii) if uninterrupted working time is a minimum of 6 hours and a maximum of 9 hours, a break of 30 minutes must be done; (viii) finally, if uninterrupted working time is longer than 9 hours, a break of 45 minutes must be scheduled. Even the most recent works addressing the TSDP or the combined Vehicle Routing and Truck Driver Scheduling Problem (VRTSDP) simplifies several constraints and solves the problem for a week-long planning horizon. For example, [2], [3] and [4] do not include constraints (iv) and (v). Given that we consider a time horizon of 5 days, we do not include the rules for weekly limits on working time, driving, and rest period between weeks as well as most authors. As stressed in [2], night work is not profitable compared to day work, which justifies not considering night work. In this work, we propose an exact CP-based formulation that defines driving periods, working periods, breaks, waiting times, and rest periods according to EU regulations, respecting the visit order given by the route and the customers' time window.

Constraint Programming Model

The CP model is based on the evaluation of one sequence σ of customers that starts and ends at the depot, and compute for each customer $i \in \sigma$: the arrival time (A_i); the starting time of the service (St_i); the finishing time (Ft_i); the departure time (D_i); the duration of the break before the service (Bf_i) and after the service (Ba_i). For each customer i, we consider a service time p_i, a time window $[e_i, l_i]$, and a transportation time $T_{i,j}$ to go from customer i to j. Figure 1 presents an example feasible solution. The proposed CP formulation uses a modeling strategy based on set variables definition, which consists of defining subsets of customers with no more than 4.5 hours of driving, subsets with no more than 6 hours of working time, and so on.

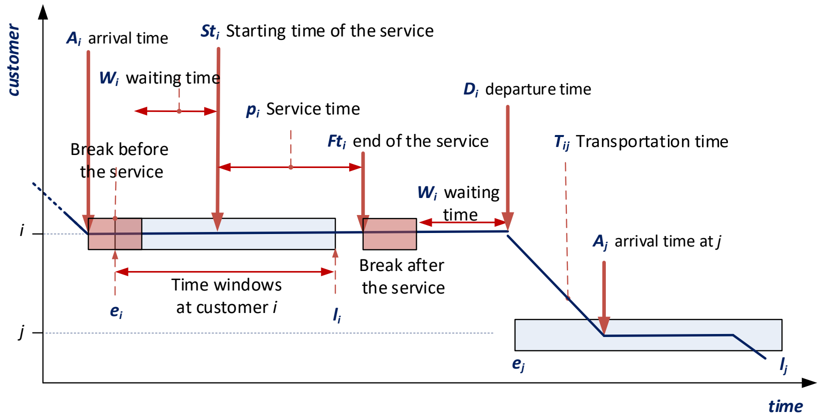

Figure 1. Description of a feasible solution

The experiments have been carried out on a subset of 29 instances considering both makespan minimization and completion time. The instances, results and solutions, including an illustrative scheme of an optimal solution, are available on https://perso.isima.fr/~phlacomm/site3/CP_Roadef_2021.html.

Concluding remarks

This work presents the first approach to solve the TDSP using a CP-based approach. The proposed method seems to be well tuned for the problem, which is strongly constrained. A large majority of instances are solved to their optimality in less than 10 seconds. We are currently developing a time-efficient heuristic that will be used to generate an initial solution to be an input to the CP model and then accelerate its convergence to the optimal solution. We are also developing a second CP model based on automata scheme, which has been extensively studied recently. As presented by [2], in a significant number of cases, there is no feasible solution if night work is not considered. For this reason, we emphasize the importance of including the possibility of night work in future works.

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