The Dial-A-Ride Problem with Scool Bell time Adjustment

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Medical and Social Institutions (MSI) and specialized schools for students with disabilities use specialized transport services every day. As a result, paratransit represents one of the main costs for specialized schools and is also expensive for public authorities. We investigate a practical case from France, where these establishments typically have around 80 % of their users benefiting from a specialized transportation service. In this study, the considered MSI and specialized schools (called *schools* in the remaining of this abstract) are interested in studying the benefits of pooling their transport. The organization of such transport systems requires solving a Dial-a-Ride Problem (DARP) to design the best possible routes for vehicles that pick up their passengers at home and drop them off at their destination, provided they can share part of their route [2]. When several schools have similar start times, it is hard to design feasible routes that can pick up passengers living in the same area and going to separate schools. Hence, modifying the schools' start times, which is known as School Bell time Adjustment (SBA) in school bus routing [1], facilitates transportation pooling. We address the optimization problem which consists of simultaneously determining the school start times and vehicle routes and denote it the Dial-A-Ride Problem with School Bell time Adjustment (DARP-SBA).

The Dial-A-Ride Problem with School Bell Time Adjustment

We consider a set of schools denoted by $\mathcal{E}$. The set of users is denoted by $\mathcal{U}$. Each user $u \in \mathcal{U}$ has a transportation request from a pickup node p_u to a delivery node d_u. This request is associated with a maximal ride time R_u and loads q_u^S and q_u^W. In the morning case, each school $e \in \mathcal{E}$ has a *morning interval* $[a_e, b_e]$ during which all deliveries can be scheduled. Deliveries occur within a so-called *dynamic time window* of width W_e that ends at the school start time.

The DARP-SBA consists in determining a start time H_e for each school $e \in \mathcal{E}$ within its morning interval, selecting a set of vehicles and designing the route of each selected vehicle such that : all transportation requests are served ; all maximum ride times, pickup and depot time windows are satisfied ; all users can be dropped off at their school within its time window ; the capacities of the vehicles are satisfied ; and the overall vehicle, traveling and route duration costs are minimized.

Figure 1 gives a graphical representation of a solution with two routes ω_1 and ω_2 visiting a school e. Note that nodes d_1, d_2, d_3, d_5 and d_6 represent the same physical location. One of the key challenges of this problem is that routes should be synchronized at schools, where a dynamic time window is fixed in time when determining the school bell time.

Matheuristic approach and experiments

To solve the DARP-SBA, we propose a matheuristic which combines the following ingredients :

— In each iteration, solutions are generated by a large neighborhood search (LNS) derived from [2]. It the repair operator solves a DARP in which the schools time windows have been

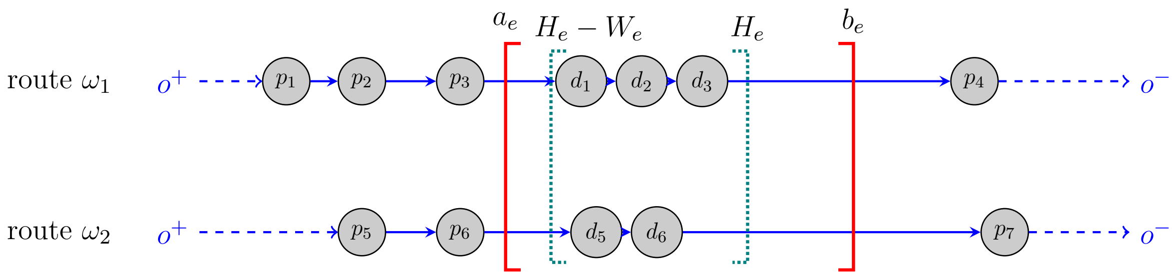

FIG. 1 – *Partial time space representation of two routes ω_1 and ω_2 visiting a school e.*

filtered. The complete timing problem is solved by a MILP solver only for complete and promising solutions to validate their feasibility. Feasible routes are collected in a route pool.

— On a regular basis, a relaxed, restricted DARP-SBA model is solved for this route pool with a time limit. It selects and combines routes generated at different LNS iterations, possibly adjusting school bell times.

— Filtering rules and adaptive strategies are used to ensure a faster exploration of neighborhood and the good use of the LNS and MIP components.

Our experimental study considers a set of 34 schools in the area of Lyon and the 575 users transported to these schools. Three types of instances (S,M,L) have been produced by splitting the data set in eight, four and two sub-problems, respectively. To evaluate the potential impact of SBA, we have considered four scenarios. In scenario 0, vehicles cannot visit more than one school. Scenarios 20 and 60 correspond to DARP instances where the delivery time windows are [8 :20, 8 :40] and [8 :00, 9 :00], respectively. Finally, scenario 20/60 corresponds to the DARP-SBA with a dynamic time window of width $W_e = 20$ minutes and a morning interval $[a_e, b_e] =$ [8 :00, 9 :00] for each school $e \in \mathcal{E}$. Table 1 shows the results of all scenarios aggregated by instance types.

	Impact of SBA (cost)				Gap to scenario 20 (%)		
	0	20	20/60	60	0	20/60	60
S	9,223	8,485	8,040	7,582	8.70	-5.25	-10.65
M	9,223	8,336	7,743	7,333	10.64	-7.11	-12.03
L	9,223	8,290	7,571	7,076	11.25	-8.68	-14.64
Avg.	9,223	8,370	7,784	7,330	10.20	-7.01	-12.44

TAB. 1 – *Impact of SBA on transportation cost*

A first observation is that the greatest savings can be achieved by pooling transports between schools, with around 10% savings on routing costs. Scenario 20/60 shows that adjusting school bell times enables additional cost reduction by 7% on average. The unrealistic scenario 60 allows for only 5.5% of additional savings with respect to SBA. This work was recently published in [3].

Références

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