A reactive algorithm for a dial-a-ride problem with real-time disruptions

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Abstract
The problem considered in this presentation stems from a non-profit organization in charge of transporting patients from their home to medical appointment locations. The aim of this work is to propose a reactive algorithm for this dial-a-ride problem so as to adapt the transportation plans in order to manage real-time disruptions, such as patient delays or appointment cancellations. The plans should be modified quickly, while trying to minimize the changes to avoid confusion for the users.

Keywords: Dial-a-ride, reactive algorithm, health care, disruption

The problem considered in this presentation stems from a non-profit organization in charge of door-to-door transportation of patients for medical appointments. Patients are picked up at home and are then dropped at the appointment location (outbound request). They may also be picked up at the end of their appointment to be driven back home (inbound request). Some patients have specific requirements, e.g. they may require an accompanying person or to be transported in a wheelchair. Each appointment has a predefined start time and end time, but in practice its duration may actually vary (most often, increase) unpredictably.

This problem is called a dial-a-ride problem (DARP) in the scientific literature. The classic dial-a-ride problem (DARP) mainly arises in door-to-door transportation services for elderly or disabled people (see [2]). The DARP consists in planning a set of journeys, i.e., of routes and associated schedules, for a fleet of vehicles to satisfy the outbound and inbound requests, so that several constraints are met, as for instance: time window constraints (the pickups and the deliveries have to be achieved within given time intervals), maximum ride time constraints of clients, and capacity constraints of vehicles (see [4, 3]). The objective function of the DARP can differ from one application to the next and may consider economic elements and service level aspects. For instance, it might be to maximize the number of satisfied requests, to minimize the number of required vehicles, or to minimize the waiting time of the patients (see [5]).

In the application targeted in this work, the primary aim of the organization is to maximize the number of requests that it can handle with its own fleet. Accordingly, every evening, the dispatching office selects the transportation requests that will be served on the next day and it establishes the route and corresponding schedule of each vehicle (see [1]). However, several elements may unexpectedly change when the plan is actually implemented. For instance, the real duration of an appointment may differ from the forecast; the physician may cancel the appointment; the patient may decide to go home by her own means; and so forth.

In practice, along the day, the dispatcher is informed of each disruption and must make a decision as to how to adapt the plans in response to this incoming information. The decision can be especially difficult to make due the fact that the schedules produced by the initial optimization phase are usually tight, since they tend to maximize the number of requests to be served. Our work aims at adapting the current solutions so as to manage the disruptions while accounting for three potentially conflicting objectives, namely: satisfying all patient requests, to the best possible extent; limiting the plan changes, so as to avoid confusion for the drivers and patients; and minimizing the patient excess journey duration, as a measure of service level. This is achieved by exploring small neighborhoods of the current solution and progressively enlarging these neighborhoods in order to restore feasibility when a perturbation occurs. Moreover, the dispatcher should be able to react in few seconds, so as to take care of the patients as early as possible and to define the recourse action before the next disruption occurs. However, as often, making decisions in real time often enforces trade-offs between speed and quality of the responses.

Finally, we will present some computational experiments carried out on different types of scenarios, where a scenario is a sequence of generated disruptions. The algorithm seems to be really fast and the focus is on the quality of the provided solutions and on the explored neighborhoods.

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