DECISION SUPPORT TOOL FOR DEMAND RESPONSIVE TRANSPORT THROUGH SIMULATION

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ABSTRACT

Demand Responsive Transport (DRT) is seen as a means to providing mobility for passengers living in low density population areas and impaired passengers with a reasonable cost. Conventional public transport is too expensive to provide a desired level of mobility for these categories of passengers. Hence DRT has been introduced in order to replace or supplement existing transportation schemes. However, multiple DRT schemes were discontinued due to a high cost or poor patronage. In this work we argue that a simulation tool is required to analyze DRT applicability in given conditions before implementing it. As a first step towards this tool, we describe the requirements that DRT impose on a simulator.

1   DECISION SPACE

The aim of Public Transport (PT) is to provide sustainable and affordable means of transportation. Demand Responsive Transport (DRT) concept appeared as a paratransit service, later it has been adopted for low density population areas. We argue that it may be beneficial for the general public to increase the mobility of passengers and (or) to reduce the cost and environmental impact of transportation due to ride sharing and on-demand operation. When planning a DRT system, the same decisions as for traditional PT should be considered as pricing, stops allocation, number of vehicles, type of vehicle, etc. But the core idea of DRT is to provide flexible transport, which opens up a huge design space. DRT service may be a bus on a route with deviations if requested or a door-to-door shared taxi. Vehicles routing may be static requiring prebooking a trip or dynamic adapting to real-time requests. For an operational design space taxonomy we refer readers to section 4 in Davison et al. (2012). A large decision space makes it hard to find an optimal operation scheme. Door-to-door service may be desired by, for example, elderly and impaired passengers, but it costs the most. Sparse predefined stop points may limit accessibility for some passengers, but it opens up potential for optimization. The goal of our work is to develop a simulation tool for decision support for DRT design. This simulation tool shall help to assess the impact of particular design choices and to assess in which geographical and demographic situation DRT may be suitable.

2   SIMULATION REQUIREMENTS

Among other topics, Ronald et al. (2015) and Ronald et al. (2017) discuss limitations in recent DRT simulation. They are: unrealistic demand, unrealistic travel time, exclusion of passenger attributes, limited attention to mode choice, low exploration of pricing policies, different performance metrics in simulations, no real-world validation. This list shows that most of the existing literature describes proof of concept

Table 1: Impact of DRT design options on simulator requirement.

Property	Options	Simulation Requirements
Booking time	In advance, Real-time	Static, Dynamic, Mixed routing
Stops allocation	Flexible, Fixed stops	Flexible stops position
Synchronization with other public transport modes	Departure or Arrival time restriction	DRT and PT co-simulation
Passenger priorities	Walking restrictions, Time preferences	Passenger attributes Mode choice
Communication with passengers	None, On request, Throughout the journey	Communication of agents Dynamic vehicle routing Passenger attributes
Heterogeneous transport	Leg space, Pram space, Wheel-chair space	Passenger and vehicle attributes, Routing algorithm

simulations. In contrast, we aim to develop a realistic DRT simulation. DRT design decisions define the potential results of DRT integration: system cost, travel time, accessibility, coverage, service level, environmental impact. Particular decisions set requirements for a simulator. Similar to (Davison et al. 2012) we conducted a literature review and a workshop with practitioners in the PT domain to identify an elaborate design space for DRT. Then we analyzed how to implement different DRT design options in simulation and identified that there is no off-the-shelf simulator supporting all of them. In Table 1 we present the most notable DRT design options that define extra requirements for a simulator.

A simulator should support static vehicle routing when only prebooking is allowed, dynamic routing when only real-time requests are allowed, and mixed routing in the realistic case when both are allowed. Also dynamic routing should be supported when passengers are allowed to cancel requests. A special routing algorithm is also required for heterogeneous travelers and vehicles as well as a support for theirs heterogeneous attributes. Heterogeneous attributes like a possibility to walk to a near pick-up point or passenger's cost/time value are required when passenger's priorities are considered and route alternatives are prepared accordingly. Some DRT schemes assume synchronization with other PT, for example, serving DRT at the end of potential trips from a large hub station of other PT service. Explicit simulation of conventional PT is highly desirable in this case.

The next stage of this work is to conduct an in-depth review of the capabilities of open-source simulators and to define a suitable tool for building upon. In a short prestudy, we identified that only MATSim (Horni et al. 2016) provides DRT support, yet it is not ready for off the shelf DRT simulations. Co-simulation of DRT with other PT modes is stated being possible, but not explored in literature. Support for heterogeneity of agents is probably insufficient. It is not clear if continuous communication between agents in time is possible. Another possibility is to build a custom simulator from scratch, which is suitable when design space is restricted, but we aim for design space exploration, what makes this option complex and risky.

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