Generation of Demand-Responsive Transport Scenarios Library in MATSim

Chengqi Lu[1] and Michal Maciejewski[1]

[1]Technische Universität Berlin, Chair of Transport Systems Planning and Transport Telematics, Straße des 17. Juni 135, 10623 Berlin, Germany

Extended Abstract

The demand-responsive transport (DRT) service is becoming more and more popular nowadays. The choice of the operational strategy for the DRT system can play an important role in improving the service quality and reducing the operational costs. In the literature, there are a great number of studies on the operation of the DRT systems. To begin with, the matching between vehicles and demands can be treated as a classical bipartite matching problem. Examples can be found in Maciejewski, Bischoff, & Nagel (2016), Hörl et al. (2018) and Treleaven et al. (2013). Meanwhile, the matching problem can also be solved by heuristic approach, such as in Bischoff & Maciejewski (2016). In addition to the matching problem, the relocation of the empty vehicles is also an important part in the DRT operation. In one study (Pavone et al., 2012), the author has proposed the idea of rebalancing, which actively send empty vehicles across the network to balance the demand and supply in different areas of the system. When it comes to ride-pooling, the problem becomes more interesting and complex. The study from Alonso-Mora et al. (2017) proposes an integer linear programming based approach to tackle the ride-pooling problem and the algorithm has been tested in the New York City, with real world taxi data. In another study (Kucharski & Cats, 2020), the authors try to reduce the search space in order to reach a close-to-exact solution in a shorter time.

The algorithms proposed in these and other studies are usually developed given a specific context, implemented for different DRT models/scenarios and, more importantly, simulated or evaluated in different frameworks. That makes it very challenging to compare their performance. To tackle this problem, there are several simulation platforms dedicated to the operation of the DRT system. The MATSim DVRP extension (Maciejewski, Horni, et al., 2016) enables the simulation of the dynamic transport service. A test bed for dynamic vehicle routing algorithms is then built based on that framework (Maciejewski et al., 2017). On the other side, Ruch et al. (2018) has developed the AMoDeus platform to evaluate and simulate different types of the DRT operational strategies. In one study (Ruch et al., 2021), the authors try to quantify the benefits of ride-pooling in multiple scenarios within the AMoDeus platform. Results have suggested that the efficiency gain of the ride-pooling algorithms depends on the scenario.

Because of the popularity of the DRT, a specific extension for DRT has also been added to MATSim. After several years of development, many features of the above-mentioned simulation platforms are integrated in the MATSim DRT extension. Meanwhile, it also attracts more and more users from different fields. Therefore, it is desirable to construct a DRT scenarios library within the MATSim framework, which can be used to testing the functionality of an existing or a newly implemented DRT operational strategies. Inspired by the Solomon data set (Solomon, 1987), which is a commonly used test bed for the vehicle routing problems, an open-source DRT scenarios library that included various demand patterns has been created (Lu & Maciejewski, 2023). In this library, there are currently 5 different scenarios: New York Manhattan, Berlin, Oranienburg, Kelheim and Vulkaneifel. Brief introductions to each scenario are provided below. In addition, the library also provides necessary tools for users to modify the existing scenarios and generate custom scenarios.

- The New York Manhattan scenario is generated based on the actual operational data of the Yellow Taxi Cab data in Manhattan[1]. The data from the website is disaggregated onto the

[1]https://www.nyc.gov/site/tlc/about/tlc-trip-record-data.page

network generated from the Open Street Map. This leads to 84,421 DRT requests traveling within Manhattan throughout the day. This scenario represents a high density and stable demand pattern.

- The Berlin scenario is generated from the open Berlin scenario (Ziemke et al., 2019). By introducing the DRT service to the Berlin scenario and letting agents explore the new travel modes, a city-wide DRT demand is acquired after running the standard MATSim iteration process. There are 24,997 DRT requests in the Berlin scenario. Note that the open Berlin scenario uses a 10 percent population model, which means the DRT demand has also been scaled down tenfold.
- The Oranienburg scenario is also generated from the open Berlin scenario. Oranienburg is a small town next to Berlin. Many residents in that town perform daily commute between the town and Berlin by commuter trains. DRT can be introduced to provide residents better access to/egress from the train station. The departure times of the DRT requests have been slightly adjusted according to the actual train schedule. There are 1120 DRT requests in the Oranienburg scenario. Same as in the Berlin scenario, this scenario also corresponds to a 10 percent population model. This scenario is a good representative of the first and last mile problems.
- The Kelheim scenario is generated based on the population model from mobile phone data (Neumann & Balmer, 2020) and the actual operation of the DRT service in the area[2]. Kelheim is a small town in Bavaria, Germany. The DRT system operates 3 minivans and is popular among the local residents. Currently, there are 120 to 130 DRT trips during a normal working day. This small scenarios can be used to test some of the more complex operational strategies.
- The Vulkaneifel scenario covers a large rural area in Germany. The DRT requests are generated from the 25 percent population model based on mobile phone data. Depending on the adoption rate, there can be up to 13,294 DRT requests throughout the day in the whole region (25 percent model). While most of the existing studies in the literature focus on the DRT in urban setups, the potential utilization of DRT vehicles to provide more flexible mobility service in rural areas are often overlooked. The Vulkaneifel scenario serves as a test bed for the DRT operational strategies oriented to the rural area mobility service.

Keywords: Demand-Responsive Transport (DRT); Vehicle Routing Problem (VRP); Benchmarking

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