Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 27 (2017) 109–116

Transportation Research Procedia

www.elsevier.com/locate/procedia

20th EURO Working Group on Transportation Meeting, EWGT 2017, 4-6 September 2017, Budapest, Hungary

Performance assessment of fixed and flexible public transport in a multi agent simulation framework

Jishnu Narayan[a,] *, Oded Cats[a], Niels van Oort[a], Serge Hoogendoorn[a]

[a]*Department of Transport and Planning, Faculty of Civil Engineering and Geosciences, TU Delft, 2628 CN, Delft, Netherlands*

Abstract

The emergence of innovative mobility solutions that offer flexible transport services, is changing the way urban public transport systems will be designed. Such mobility solutions offer on demand transport services and hence can solve the problems inherent with traditional line based and schedule based public transport systems. It is essential to understand the dynamics of this new demand-supply market with co-existing and competing fixed and flexible public transport. However, the performance of the system comprising of users and transit services and the factors influencing them, have received limited attention in literature. In this paper a model is developed to analyse the system performance when the modes of fixed public transport and flexible public transport operate in competition. The model is implemented in the multi-agent simulation framework MATSim with dynamic assignment in which the users optimise their travel plan through iterative learning from the service experienced and altering their travel plan. The scenarios in which the flexible public transport offer private and shared services are considered. The system performance is analysed for varying fleet size of flexible public transport and ratio of cost of flexible to fixed public transport.

Peer-review under responsibility of the scientific committee of the 20th EURO Working Group on Transportation Meeting.

Keywords: modal split, demand responsive transport, public transport, , agent-based simulation

* Corresponding author. Tel.: +31(0)152784066
E-mail address: j.n.sreekantannair@tudelft.nl

2352-1465
Peer-review under responsibility of the scientific committee of the 20th EURO Working Group on Transportation Meeting.
10.1016/j.trpro.2017.12.029

1. Introduction

Conventional public transport systems are characterized by services that are line based and schedule based. They operate along routes and schedules which are mostly fixed during the day offering high frequency services during peak-hours and relatively low frequency services during off peak hours. This requires rigid planning and operations and does not consider the real time variations in demand. Furthermore, it is often not accessible to users from areas with low demand density. This in turn leads to longer waiting times for transit users and the demand from regions of low demand density not being satisfied.

Recent technological advancements, namely real-time fleet management and travel booking platforms, have enabled the emergence of innovative mobility solutions which offer on demand services. These types of flexible public transport services can relieve the disadvantages inherent to fixed public transport systems. The demand is typically specified as a travel request which the operator/driver of the service receives through an online platform. The fleet of vehicles operated by the system may offer door-to-door service picking up passengers from their origin and dropping them off at their destination, or stop-to-stop service in which passengers are picked up and dropped off from pre-defined pickup and drop-off locations. The service offered might be a sequentially shared type in which a vehicle is shared in sequence by many passengers such that at each given time there will be only a single passenger in the vehicle or a simultaneously shared service in which more than one passenger share the vehicle on a given trip. Note that the service discussed here is different from the car (or bike) sharing systems in which travelers pick up vehicles from dedicated stations near their origin and drop off the vehicles at dedicated stations near their destination.

The modelling of fixed and flexible public transport systems have been studied by researchers over the years. Designing fixed public transport systems requires satisfying conflicting objectives. Some of the pioneering works in the area include Res and Baaj (1995), Ceder and Wilson (1986), and Mandl (1980). The problem deals with determining a set of routes over a network comprising of a set of nodes and corresponding links so as to minimize objectives related to passenger travel time, operator's operating cost, or their combination. The modelling of flexible public transport systems has been studied by researchers as a Dial-a-Ride Problem (DARP) which is a generalization of the Vehicle Routing Problem (VRP), which in turn is a generalization of the Travelling Salesman Problem (TSP). The major objective of the DARP is to determine a set of minimum cost paths and schedules to satisfy a set of travel requests subject to a set of constraints on time windows or deviation from the least cost path. Depending on whether the travel requests are known upfront or not, the problem can be considered static or dynamic respectively. An excellent review of the models and algorithms used for DARP is given in Cordeau and Laporte (2007). Due to the complexity of both the problems (NP Hard), generating an exact analytical/mathematical solution becomes nearly impossible for large instances of the problem. Hence heuristic/metaheuristic or evolutionary optimization methods have been used to obtain optimal solutions or improve a set of initial feasible solutions in search for an optimal solution such as in Uchimura et al. (2002), Nanry and Wesley Barnes (2000), Neumann (2014), Kuan et al. (2006), Arbex and da Cunha (2015).

Due to the growing availability of technologies that facilitate the large-scale deployment of flexible public transport services, its interaction with fixed services has recently been a subject of research. An IDARP (Integrated Dial-a-Ride Problem), a generalization of the Dial-a-Ride Problem, was formulated as scheduling travel requests where some portion of the trips is covered by fixed services. In most of those studies, the flexible system is modelled as a complement to fixed public transport services or as a means of access to an extensive public transport network (Posada and Anderson (2016), Uchimura et al. (2002)). In the literature which dealt with competing fixed and flexible systems, the flexible system was in some cases envisaged to consist of a fleet of fully-automated vehicles. The major focus of those works was on the simulation of such services in which fixed service was included as an alternative mode choice (Speranza (2016), Sebastian (2017), Lima Azevedo et al. (2016)). However these studies have not analyzed the effects of factors such as fleet size, operational strategy, and cost ratio on the performance of the system in the context of competing services. It is necessary to understand the extent to which these factors affect the dynamic demand-supply interactions. In this paper, an attempt is made to study the effect of different operational strategies, level of service, and service costs on the overall performance of the system when considering the perspectives of users as well as the operators of both services. The term 'fixed public transport'