Adaptive Path Choice Decisions in Public Transport Systems: An Agent-Based Assignment Model

Oded Cats *

Department of Transport Science,

Royal Institute of Technology, Stockholm, Sweden

Haris N. Koutsopoulos

Department of Transport Science,

Royal Institute of Technology, Stockholm, Sweden

Tomer Toledo

Faculty of Civil and Enviromental Engineering

Technion – Israel Institute of Technology, Haifa, Israel

***** Email: cats@kth.se

1 Introduction

Public transport systems are becoming increasingly complex with the incorporation of various modes, services and information and communication technologies. A large range of Advanced Public Transport Systems (APTS) facilitates the design of real-time operations and demand management. APTS applications enable both operators and travelers to take more adaptive decisions based on real-time information. The analysis of public transport performance requires a dynamic tool that will enable to emulate the dynamic loading of travelers and their interaction with the public transport system.

The conventional static public transport assignment models cannot capture how the system evolves over time and the complex time-dependent interactions between system components. The modeling of variations in public transport demand and supply conditions is essential for the analysis of public transport operations and performance. Moreover, a dynamic representation is necessary in order to model the adaptive strategies exercised by both operators and travelers.

The evolution of a new generation of public transport simulation models with dynamic assignment capabilities is at its early stages. Liu et al. [1] the developments in public transport path choice modeling are lagged behind the counterpart developments in road networks. Based on the developments in the latter they anticipate multi-agent non-equilibrium models to emerge in the public transport domain as well. Simulation models can

facilitate the dynamic loading of travelers over a dynamic representation of the public transport system conditions. None of the existing models represents both supply and demand aspects dynamically [2].

2 Dynamic Path Choice Model

The objective of this study is to model path choice decisions dynamically within the framework of an agent-based simulation model. Passenger path choice process is modeled as a two-stage semi-compensatory model.

Following previous studies, the large universal-set is first reduced to a consideration-set by applying a non-compensatory rule-based choice-set generation model. A recursive search method applies a series of logical, behavioral and dominancy rules. A path alternative is defined as an ordered combination of stops, public transport lines and connection links (access, egress and transfer links that can be carried out by walking between two points) that passengers may travel through in order to get from their origin to their destination. Hence, common lines that connect the same set of transfer stops are considered as a single alternative. This process results in a path-set for an origin-destination pair of locations in the network.

The path-set is given as input to the dynamic path-choice model. Dynamic filtering rules are applied before the choice process is performed. Traveler decisions are modeled in the probabilistic framework of random utility choice models. In contrast to static assignment models, the dynamic path choice model considers traveler trips as a sequence of adaptive travel decisions that are associated with traveler progress in the network. Furthermore, at no point the traveler has to choose between paths. Instead, each travel decision considers alternative actions that are relevant for a given trip stage. The structure of the choice tree is fundamentally the same for all traveler decisions – boarding, alighting and connection (access, egress and transfer). Each travel decision can be represented as a choice tree with a set of actions as the first level and path alternatives at the second level while the set of actions vary between decision contexts.

The utility of a path alternative is determined by its expected attributes as anticipated by a specific individual. Note that the choice model is not applied at the path level but rather at the action level. However, the evaluation of alternative actions requires the assessment of all the path alternatives that are associated with the corresponding element [3]. The evaluation of alternative travel actions depends on traveler's preferences and individual's expectations with respect to future travel attributes. These expectations depend on traveler's

prior-knowledge, preferences as well as the level of information that is available when making the decision [4]. Traveler's ability to carry out a boarding decision is subject to vehicle capacity constraints.

3 Agent-based Simulation Model

The dynamic path choice model was implemented in BusMezzo, a public transport simulation model [5]. The model represents the interactions between traffic dynamics, public transport operations and traveler decisions under various system conditions and APTS. Each type of agent in the simulation - car, public transport vehicle or traveler - carries out decisions, interacts with other agents and so affects the way the system evolves over time [6]. This multi-agent approach is used for emulating the dynamic loading of travellers and their interaction with the public transport system through successive travel decisions. The different sources of public transport operations uncertainty including traffic conditions, vehicle capacities, dwell times, vehicle schedules and service disruptions are modeled explicitly.

BusMezzo generates a population of individuals based on a time-dependent origin-destination (OD) passenger demand matrix. Individuals are assigned with pre-defined origins and destinations in the network along with a set of preferences and prior-knowledge that may vary between individuals. Origins and destinations may correspond to any location that is within walking distance to a stop.

4 Applications

A web-based survey was conducted in order to estimate the path utility function. The main explanatory factors –in vehicle, waiting time and walking times as well as the number of transfers- were embedded in the dynamic path choice in the simulation model.

The dynamic public transport assignment model was applied to the Stockholm metropolitan rapid public transport system. The multimodal system consists of commuter train, metro, light rail trains and trunk bus lines. The case study demonstrates the feasibility of the proposed path choice approach. The assignment results indicate that time-dependent passenger loads vary considerably at the individual vehicle run level under different operational and travel information scenarios. The information that is available to travelers' when making a certain decision is determined by the dissemination means and their locations as well as by individual characteristics.

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