Dynamic assessment of large scale multimodal transport systems

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1 Introduction

Analysing and predicting multimodal trips will become more important in the near future because of their expected contribution to more sustainable transport systems. The planning of these kind of trips involves multiple different types of travel choices related to available travel modes, transport service types, boarding and alighting locations, transfer locations, and parking facilities. Releasing constraints on assumed trip composition and threating transfers as important elements of trips are essential aspects of modelling such complex multimodal travel behaviour. Current transport models, however, fail to capture the full complexity of trips in which two or more modes (distinguished by vehicle and service type) are used between which travellers have to make a transfer. So far, a computational efficient multimodal assignment model, considering dynamics over time and network capacity constraints, is not known yet.

The primary objective of this paper is to present a theoretical framework for a dynamic multimodal assignment model and show its performance on a realistic large scale network. To this end, a prototype of the model is applied to model travel behaviour in the metropolitan area around Amsterdam. Thereafter, modelling results are quantitatively analysed and compared with those of a model typically used in the current state of practice. This extended abstract is structured as follows. First, the main modelling concept is introduced, followed by a description of the full modelling framework. Next, the case study is described and some expected and preliminary results are indicated.

2 Modelling approach

Traditional models fail to adopt the full integration of both private and public transport systems as observed more and more in practice. As the result of a strict separation between modes, little attention for slow modes and the lack of detailed transfer modelling, these models fall short in adequately considering the wide range of available mode combinations. Trips in which travellers combine private and public main modes, are either ignored or inefficiently dealt with by pre-specifying specific mode combinations that are then threated as additional artificial modes [1,2]. The method adopted in this study is the so-called supernetwork approach. This modelling approach is based on a network representation in which all modes are integrated and where the separation between modes disappears. Each layer in the supernetwork represents a main mode, namely car, bicycle, pedestrian, underlying transit and main transit. Zone centroids are located in the pedestrian layer while the remaining layers are connected to the pedestrian network at appropriate places by artificial links representing transfer possibilities [3].

A distinction is made between underlying and main transit, stemming from differences in travel behaviour and desired level of detail. In the underlying network, the service quality is determined by aggregated travel times and frequencies for each directly connected pair of nodes [4]. For the main transit network on the other hand, every line is threated individually [5] and special boarding, alighting, and dwelling link are added to account for exact departure and travel times. The presence of these additional links allows for detailed modelling of transfers, including walking, waiting, parking, etc. As a supernetwork comprehends all modes, routes in such a network do not only describe a sequence of links, but as well the related mode or combination of modes. Hence, the impact of transfers is explicitly included in the assignment process. Previous studies on application of the supernetwork concept disregard the time component [6] or are applicable on small networks only, while focussing on a single main mode vehicle type [7,8].

3. Modelling framework

A modular model set up is proposed, consisting of four main components: construction of the supernetwork, a-priori choice set generation, simultaneous choice modelling and combined network loading (figure 1). After the automated construction of the supernetwork, the set of all attractive travel alternatives is generated. Naturally, all travel decisions involved in planning a multimodal trip are included in these alternatives and mode choice can now be modelled as part of the route choice. A-priori choice set generation allows for maximum flexibility in choice models. There are no restrictions on the type of choice models and route based attributes can easily be included. Furthermore, computation time is limited since no iterative path search algorithm needs to be performed during the assignment. A stochastic shortest path search is applied to meet all the choice set requirements for a dynamic multimodal assignment (such as multimodal variety and time robustness).

Following the choice set generation, travellers are assigned to the routes. In a multimodal setting, choices between modes, routes and travel times cannot be made independently and are therefore modelled simultaneously. As a result, the question of the right sequence of travel choices disappears while it becomes easier to take correlation among alternatives into account. Travel choices need to be modelled time dependent because characteristics of travel alternatives will vary over time. Therefore, a subset of travel alternatives is selected for every preferred time interval. To allow for departing or arriving early or later than preferred (in order to save travel time or money), alternatives can be included several times, differing in departure time and time specific route attributes. Finally, the propagation of travellers over the network is simulated in order to account for interaction between traveller and limited capacities of roads, transit vehicles, and parking facilities. In an iterative process, including the choice modelling and network loading component, an equilibrium state is established, providing input for long term network planning. Special attention is paid to transfers between continuous modes (such as car) and discontinuous modes (for example trains).

4. Case study ‘Metropoolregio Amsterdam’

A prototype of the model, based on the theoretical framework, has been developed in Matlab and was subsequently used to predict travel behaviour during morning peaks in the metropolitan area around Amsterdam (Metropoolregio Amsterdam). As this area is characterized by high densities, a heavily loaded transport system and a large range of available modes, it is well suited for testing our multimodal model in a dynamic and capacity constrained context. Preliminary results show a wide variety of considered modes and mode combinations. The full paper will elaborate in detail on the comparison between the modelling results found in this study and those of more traditional models. A quantitative analysis will be performed focussing on network size and complexity, choice set composition and route shares. Furthermore the underlying mechanisms of differences in modelling output will be analysed and explained.

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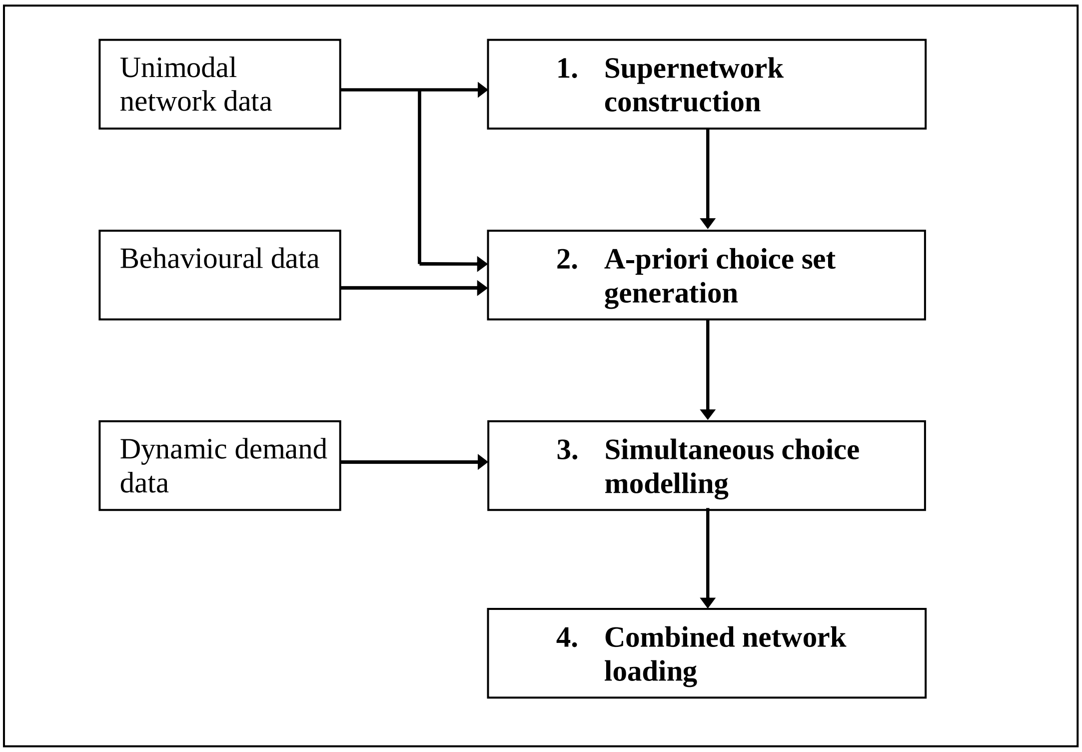

Figure 1 – Modelling framework