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A New Model for Rail-Based Park-And-Ride with Feeder Bus Services

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Abstract

Many studies have been done to model and design park and ride scheme, since park and ride has long been considered as a strategy to alleviate traffic congestion and reduce emission. However, due to the difficulty in modelling an urban transport network system, research on park and ride still needs to overcome some limitations. This paper proposes a robust model by combining the driver's mode choice and route choice, which are based on a combined cross nest logit (CNL) and user equilibrium (UE) model. Mathematical programming and varitional inequality are used to solve a network optimization. The main contributions of this paper are: (1)considering travel time uncertainty on roads which can affect both modal split and route choice. (2)taking multi-class demands into consideration because different people have different requirements for the travel time and level of service. In other words, mean-excess travel time (METT) model are proposed in this paper to depict uncertainty environment. Heterogeneity is considered by commuters' variations of METT parameter which depends on travelers' trip characteristic and income level.

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Keywords: park and ride; CNL; combined model; travel time uncertainty; VI

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1. Introduction

PNR is a multi-mode travel mode that combines auto and public transport together (Parkhurst, 1995). Park and Ride (PNR) refers to a travelling mode that travelers first drive their vehicles to a parking site, access to a public transport facility, and take public transport to finish the remaining part of their trip(Noel, 1988).

The traffic congestion and air emission in CBD is a big challenge for its sustainable development (Dijk, de Haes, & Montalvo, 2013). In this sense, peripheral PNR is capable of solving these problems at some extent by attracting travelers who previously drive directly to the city center to park their vehicles at a parking site located in peripheral area of the city center and then take public transport to finish the remaining part of their trip (Cairns, 1998). It is obvious that if the private vehicle demand can be transferred to public transport, the traffic congestion should be reduced which ultimately leads to a reduction in emission (Duncan, 2010). In suburb areas with low residential density, PNR provides a better accessibility to public transport services. In other words, vehicles can be expanded to the catchment of public transport services (Cairns, 1998). In summary, PNR can positively improve the operational efficiency by reducing demand on the auto side (W. Liu, Yang, & Yin, 2014).

However, PNR did not always show its advantages in practice. The main problem lies on the demand split and route choice (X. Chen, Liu, Islam, & Deng, 2014). Many researches based on the statistical analysis of observations and surveys indicated that PNR in some places are unattractive to auto drivers, but public transport users (W. Liu et al., 2014). As the demand for auto mode is unreduced, traffic congestion and air emission are not mitigated (Truong & Marshall, 2014).

Approaches to study PNR have been quite different such as survey, GIS, expert system, but this paper will focus on the network equilibrium approach to model the PNR (Meek, Ison, & Enoch, 2010). Since equilibrium theory has more advantages for it consider demand split and route choice together and evaluate the role of PNR on the urban transport network instead of just focus on single or several sites (X. Y. Chen, Chen, Liu, & Deng, 2014).

The route choice for people who choose PNR is also different from a general route choice which leads to a redistribution of traffic flow on the transport network (Parkhurst, 2000). As a result of flow redistribution, some problems such as longer travel distance trip generation and increased air pollution were identified (Duncan & Cook, 2014).

After discussion the general concept of PNR, it is also necessary to discuss the role of public transport which is an important part of PNR. Public transport services for PNR can be generally categorized into two parts: rail-based and bus-based. Rail-based PNR utilizes train or tram, while bus-based PNR utilizes bus. Compared to bus services, travel time on rail is more reliable. In other words, rail based public transport services are more reliable than bus based public transport services. Thus, this paper will focus on the rail based peripheral PNR.

Li (2007) utilized a combined modal split and traffic assignment with elastic demand to model PNR in a bi-modal transport network. To be specific, Li utilized a multi-nominal logit (MNL) model for the modal split and MNL based stochastic user equilibrium (SUE) for the route choice. Then, he built a viriational inequality (VI) model to analysis PNR in an urban transport network and utilized a decomposition method to solve it. This paper believes that MNL cannot appropriately reflect the complex of mode choice of PNR because MNL cannot reflect the similarity between different modes (Papola 2004). Generally, studies for PNR consider three modes: auto, rail, and PNR. PNR is a combination of auto and rail, which has overlap with auto in the first part of their trip and with rail in the last part of their trip. It is unreasonable to treat them as independent. Therefore, cross nest logit (CNL) model for modal split is used (Marzano & Papola, 2008). CNL is capable of modelling a similarity as a generalization of the two levels hierarchical logit model (Marzano, Papola, Simonelli, & Vitillo, 2013). For route choice, this paper utilizes user equilibrium (UE) theory to reflect users' route choice. Furthermore, this paper considers travel time uncertainty and multiclass demand.

Uncertainty is unavoidable for travelers making decisions, such as modal choice, route choice, and transfer location choice. In this paper, we propose the - reliable mean-excess travel time that explicitly considers both reliability and unreliability aspects of travel time variability in the route choice decision process. Unlike travel time budget model (TTB), it answers "how much time do I need to allow?" and "how bad should I expect from the worse cases?" (Chen & Zhou, 2010). Therefore, travelers' behavior is evaluated in a more accurate way under an uncertain circumstance.

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