An improved supernetwork approach for modelling the effects of park-and-ride

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Abstract

Park-and-ride (P+R) has been identified by transport planners as a key element of any sustainability package that can help promote multi-modal trips, improve air quality and alleviate congestion in urban areas. P+R facilities are mostly situated in urban fringe areas and enable people coming from suburban and rural areas to park their cars and switch to public transport (PT) to access destinations located in urban areas [1]. The traffic share of car use from urban edges to urban areas, which is otherwise infused into critically congested urban areas, is supposed to be diluted by PT. Hence, it is argued that P+R has positive benefits through reducing overall car usage and energy consumption, replacing long car-only trips with multi-modal trips. With the same purpose and belief, a number of major cities allover the world have introduced or are in the middle of introducing P+R facilities.

In contrast with its popularity in practice, P+R has not attracted the equal scientific interests. A small body of literature has analyzed the planning and the design of P+R facilities with minimizing total travel time as the main objective. Other related studies tend to focus on either the factors influencing the choices of P+R or the effects of P+R schemes on the host urban system. For example, Bos [2] carried out several comprehensive stated choice experiments in the Netherlands to examine what characteristics of P+R facilities and policy measures can increase the usage of P+R. Results show that the quality of connected PT, i.e. frequency and number of transfers etc., is of the highest importance to travelers and that "carrot" strategies are generally more effective than "stick" ones. However, inconformities are reported when it comes to effects of P+R to the urban system are concerned. While P+R seems to performan satisfactory in many cities [3], it is mentioned that P+R in some cities has limited impact on reducing congestion [4].

Although the existing studies provide insightful suggestions for transport planners in implemtating P+R, none of them can capture traveler response to P+R facilities at a higher level of detail that takes into account travelers' full daily activity program, trip chains, the real schedule of PT, and the trade-off between private vehicles (car or bike) and PT. Without that consideration, it is unlikely to capture traveler response to P+R and in turn the effects of P+R to the urban system accurately. Liao *et al*. [5] proposed a supernetwork approach that can evaluate traveler response to P+R at such a level of detail. The supernetwork [6,7,8] is constructed to include all the relevant choice facets of an traveler's activity program in terms of the choice preferences and, thus, capable to represent the traveler's action space. And any path through the supernetwork represents a particular activity-travel pattern to the activity program. Hence, the choices of P+R facilities are fitly embedded in the full activituy-travel patterns. And more importantly, sensitivity analysis on any kinds of factors is supported, which has a great implication to transport planners. A series of scenario studies are illustrated on a few potential P+R users to demonstrate the fine properties of this approach [5]. This approach has mainly focused on the preferences from the demand side. Nevertheless, the capacity of the P+R facilities from the supply side has not been considered since the illustration is tailored for a small group of travelers. If scaling up, that would cause inaccurate choices to P+R facilities. Moreover, the capacity of the road network was not considered either in [5] and car speeds on different types of road are assumed fixed. This assumption is mostly unrealistic and leads to no clue of whether P+R facilities have effects on the traffic flow in the hosted urban areas.

The purpose of the current paper is to present an improved supernetwork approach that also incorporates the capacity of P+R facilities and the road network based on [5]. To that effect, two mechanisms are derived for the incorporation. A new parking location choice model is proposed while a traveler facing the situation that a pre-chosen P+R facility is fully occupied. As far as capacity on road network is concerned, the real-time travel speed of car mode is calculated according to the classic BPR function, while the predicted travel time follows the travel time profiles. Other settings related to the mode of walking, bike and PT are assumed the same as [5]. To better evaluate the effects P+R, this improved approach needs to be applied to two groups, namely, potential P+R users and untargeted P+R users. It contributes to assess whether P+R attracts the targeted group and, consequently, how the traffic flow pattern changes alongside the choices of P+R.

We develop the improved approach and test it in Eindhoven region (The Netherlands), where the inter-city train station is regarded as the only P+R facility. The two groups of

travelers are obtained from the synthesized population used in [8] and travelers' preferences are set by rule of thumb, which are not the focuses of this paper. Likewise, the new approach is tested under different scenarios concerning pricing of parking, quality of PT, and activity location connective-ness. Thus, the study shows how a supernetwork approach can be applied as a systemic tool for modeling the effects of P+R and that the improved approach makes a step further for its application by practitioners.

Keywords: supernetwork; P+R; multi-modal; capacity

References

[1] Meek, S., S. Ison, and M. Enoch. Evaluating Alternative Concepts of Bus-based Park and Ride. *Transport Policy*, 18(2), pp. 456-467, 2011.

[2] Bos, D.M. Changing Seat: a Behavioral Analysis of P&R use, Trail Thesis Series, The Netherlands (dissertation), 2004.

[3] Van der Waerden, P., M. De Bruin, H.J.P. Timmermans, and P. van Loon. Travelers' Willingness to Use Park and Ride Facilities and Additional Transport in the Context of Commuting and Shopping Trips to City Centers. *In Proceedings of the 90-th Annual Meeting of the Transportation Research Board*, Washington, D.C., 2011.

[4] Mees, P. Transport for Suburbia – Beyond the Automobile Age. Earthscan, London, 2010.

[5] Liao, F., T.A. Arentze and H.J.P. Timmermans. A supernetwork approach for modeling traveler response to park-and-ride. *In Proceedings of the 91-th Annual Meeting of the Transportation Research Board*, Washington, D.C., 2012.

[6] Arentze, T.A. and H.J.P. Timmermans. Multistate supernetwork approach to modeling multi-activity, multimodal trip chains. *International Journal of Geographical Information Science*, 18(7), 631–651, 2004.

[7] Liao, F., T.A. Arentze and H.J.P. Timmermans. Supernetwork Approach for Multi-modal and Multi-activity Travel Planning. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2175, 38-46, 2010.

[8] Liao, F., T.A. Arentze and H.J.P. Timmermans. Constructing personalized transportation network in multi-state supernetworks: a heuristic approach. *International Journal of Geographic Information Science*, 25(11), 1885-1903, 2011.