Time-table based choice set generation for public transport connection choice based on GPS observations

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In order to accommodate future travel demand cities around the world are currently investigating innovative strategies for customer-friendly and efficient public transport systems. An important step in this process is to understand the passengers' evaluation of different elements of public transport trips and their behavioural reaction to changes in public transport services with regards to mode as well as connection choice. This task is particularly challenging since not only the behaviour of passengers is complex but also the choice situations they are confronted with. Especially in dense urban public transport networks passengers can and have to choose from a large choice set containing alternatives with sometimes very diverse characteristics.

The complexity of the choice task makes it difficult to survey the actual behaviour of travellers. In a traditional questionnaire based survey, a lot of attributes of the conducted trip, e.g. chosen lines, exact departure times, access and egress modes and times, transfer points, etc., have to be asked from and remembered by the respondents. An alternative to this detailed questioning is the observation of the travel behaviour using person-based GPS devices. With the help of suitable post-processing procedures, these information can be directly deduced from the GPS traces with a higher detail and accuracy than typically achievable with recollection-based questionnaires.

Yet, fully utilising the advantages offered by the high detail and accuracy of choice observations

requires choice alternatives that are described in similarly high detail. This can only be achieved with timetable-based choice set generation. However, timetable-based choice set generation is not a trivial task. First, to account for temporal components as well as spatial components increases the search space substantially. Second, the alternatives exhibit several dimensions of similarities that strongly influence the perception of these alternatives. Third, the access and egress segments of a public transport trip are strong determinants for the choices made by travellers and, therefore, have to be part of the connection alternatives. Due to these obstacles only few approaches to generate full size timetable-based connection choice sets have been presented in the literature so far. Prevalent are branch & bound based approaches such as the ones presented by Friedrich *et al.* [1] and Hoogendoorn-Lanser *et al.* [2]. In a preprocessing step, they transform the timetable into connection segments, create a branching tree starting at the trip origin and use different constraints to keep the tree-size manageable and the resulting connections realistic.

A different approach that – to our knowledge – has not yet been applied to public transport connection choice set generation is the transformation of the timetable into a network that can then be used for shortest path calculation. A suitable approach for this timetable transformation has been introduced by Rieser and Nagel [3] who use the resulting network for finding least cost public transport connections by applying a modified Dijkstra that takes into account multiple start and end stops in the public transport network and the corresponding access and egress segments. An advantage of this approach is that the cost function can be specified individually by the user.

Another advantage is that it can be straightforwardly combined with choice set generation procedures that have been established for road-based route choice. Relevant examples for these road-based choice set generation procedures are the link elimination approach by Rieser-Schüssler *et al.* [4], the doubly stochastic approach by Nielsen [5] and Bovy and Fiorenzo-Catalano [6] and the labelling approach by Ben-Akiva *et al.* [7] that has been extended by Broach *et al.* [8] to result in more than one alternative per label.

The goal of the proposed paper is to evaluate the suitability of the timetable transformation approach for public transport connection choice set generation. Therefore, a selection of the choice set generation procedures listed above will be run on the transformed network and the resulting choice sets will be compared to each other and to a choice set generated with a branch & bound approach. The comparison will include different aspects, e.g. the reconstruction of the chosen connection, the similarity between the connections and the realism of the connections with regard to different criteria such as number of transfers, travel time or access and egress time. Moreover, the computation time of the different procedures will be discussed. The result will be suggestions for other researchers aiming to do highly detailed public transport connection choice modelling.

The data for the study originates from a person-based GPS diary survey. 300 participants living in and around Zurich – an area in Switzerland with a very dense public transport network – are asked to carry a person-based GPS receiver for a week and to fill out three psychometric scales

and a household and person questionnaire on-line. Moreover, they confirm and correct the results generated by the automatic post-processing of their GPS tracks in a web-based prompted recall survey. The public transport trips within the GPS traces are identified using the post-processing routines developed by Rieser-Schüssler *et al.* [9] and the chosen connections are determined with a newly developed public transport map-matching.

References

[1] Friedrich, M., I. Hofsäss and S. Wekeck (2001) Timetable-based transit assignment using branch and bound techniques, *Transportation Research Record*, **1752**, 100–107.

[2] Hoogendoorn-Lanser, S., R. van Nes and P. H. L. Bovy (2006) A rule-based approach to multi-modal choice set generation, paper presented at the *11th International Conference on Travel Behaviour Research (IATBR)*, Kyoto, August 2006.

[3] Rieser, M. and K. Nagel (2009) Combined agent-based simulation of private car traffic and transit, paper presented at the *12th International Conference on Travel Behaviour Research (IATBR)*, Jaipur, December 2009.

[4] Rieser-Schüssler, N., M. Balmer and K. W. Axhausen (forthcoming) Route choice sets for very high-resolution data, *Transportmetrica*.

[5] Nielsen, O. A. (2000) A stochastic transit assignment model considering differences in passengers utility functions, *Transportation Research Part B: Methodological*, **34** (5) 377–402.

[6] Bovy, P. H. L. and S. Fiorenzo-Catalano (2007) Stochastic route choice set generation: Behavioral and probabilistic foundations, *Transportmetrica*, **3** (3) 173–189.

[7] Ben-Akiva, M. E., M. J. Bergman, A. J. Daly and R. Ramaswamy (1984) Modelling inter-urban route choice behaviour, in J. Volmuller and R. Hamerslag (eds.) *Proceedings of the Ninth International Symposium on Transportation and Traffic Theory*, chap. 15, 299–330, VNU Science Press, Utrecht.

[8] Broach, J., J. P. Gliebe and J. Dill (2011) Bicycle route choice model developed using revealed preference GPS data, paper presented at the *90th Annual Meeting of the Transportation Research Board*, Washington, D.C., January 2011.

[9] Rieser-Schüssler, N., L. Montini and C. Dobler (2011) Improving automatic post-processing routines for GPS observations using prompted-recall data, paper presented at the *9th International Conference on Survey Methods in Transport*, Termas de Puyehue, November 2011.