Incorporating MaaS Concept into an Operational Activity-Based Modelling Platform

Extended abstract submitted to hEART 2019

Hafiz Muhammad Ahsan Iqbal*, Muhammad Adnan, Bruno Kochan, Tom Bellemans & Davy Janssens

Transportation Research Institute, Hasselt University, Wetenschapspark 5 Box 6, B-3590 Diepenbeek, Belgium

February 28, 2019

1 Motivation and background

Travel has been treated as being driven by demand for personal activities in activity-based models. These models predict which activities will be conducted, where, when, and for how long, in addition to such travel characteristics as mode choice and length of travel. Consequently, travel choices in these models are part of a broader activity-scheduling process that is based on modeling the demand for activities rather than merely trips and that take into account individual time and space constraints (Glickman, Ishaq, Katoshevski-Cavari, & Shiftan, 2015a). In current transport systems, short-term travel behavior is to a large extent governed by long-term choices of mobility resource holdings. Examples may include personal car, a public transport ticket (whether pay-per-journey or season ticket), a bicycle, subscription to a car or bike sharing service etc. These market-traded mobility resources which have moderate-to-high fixed costs (purchase, maintenance, etc.) subsequently allow traveling with the 'optimal' modes to access certain types of activities. Eventually, distinct mobility portfolios arise dividing a population into car drivers and transit riders (Becker, Balać, Ciari, & Axhausen, 2018). However, in relatively few studies (Moshe & Bowman, 1998; Shiftan, 2008), activity-based framework has been applied to investigate relationships between various long-term individual decisions, such as auto ownership, transit pass holding, and one's daily activity patterns (Glickman, Ishaq, Katoshevski-Cavari, & Shiftan, 2015b).

The concept of Mobility as a Service (MaaS) aims to break the determining role of mobility resource ownership in favor of a pay-per-use approach and monthly subscription to its offered plans (Becker et al., 2018). These plans can be used as a travel demand management tool to assist in the shift towards more sustainable travel (Matyas & Kamargianni, 2018). With the advanced ICT technology, MaaS concept is able to offer various mobility solutions to its

* Corresponding author. E-mail address: ahsan.iqbal@uhasselt.be Tel: +32-11-269114

customers with the different conceptualization of travel. In this new context, people will have a wide list of options to choose from, based on public and private transport modes, multiple needs and preferences, and a service which allows them to pursue more activities within the same timeline (multitasking) (Jittrapirom et al., 2017). As Maas is an emerging trend and its implementation in the real world is still limited (Matyas & Kamargianni, 2017), there are a limited number of studies that develop travel demand models for MaaS (Jittrapirom et al., 2017). In the past years, an attempt was made to transfer this concept to private cars and public transport, and thus turn travelers into mobility consumers. For example, (Sochor, Karlsson, & Strömberg, 2016) conducted a six-month field test in the city of Gothenburg, Sweden, in which participants could purchase a monthly credit for the use of different mobility services. They show that participants generally over-estimated their actual travel demand. Such observation points at one key behavioral implication of MaaS: current transport modes are typically dominated by fixed costs, so that acquisition of a mobility resource often predetermines later mode choice (because of low marginal costs) (Becker et al., 2018; Becker, Loder, Schmid, & Axhausen, 2017). This way, it enables travelers to take unbiased and hence, more suitable mode choice decisions (Becker et al., 2018).

To better understand how individual and households organize their daily activities, activity-based modeling techniques are considered crucial. However, attempting to deliver innovative services like MaaS, it requires extensions in current activity-based modeling, considering the more dynamic context of modern lifestyle and responses to travel recommendation systems (Jittrapirom et al., 2017). However, many activity-based modeling tools are designed to determine traffic flows from private cars and public transport but are not fit for the purpose to represent the functionality of shared mobility. Moreover, they are mainly trip based, which makes difficult to understand the end-to-end user's journey and identify potential customers for mobility services providers. Using these tools, it is impossible to predict how a shared mobility or demand responsive service can contribute to improve the level of service to the users or quantify first mile and last mile service (Franco, Johnston, & Mccormick, 2018). Thus, a critical reflection on how to expand current activity-based models and their travel scheduling (sequence, location, mode, etc.) choice models is needed to better capture the comprehensive nature of the travel behavior and decision-making process related to MaaS concept (Jittrapirom et al., 2017).

However, it is still unclear how to re-design a whole transport system to reap these benefits of MaaS. In particular, this will require changes in the supply side of the system, i.e. restructuring public transport services (Hensher, 2017) and integrating it with novel systems of shared mobility (Cervero, 2017). On the demand side, there is a need to learn more about the preferences of travelers in such integrated mobility systems (Matyas & Kamargianni, 2017). Indeed, differences observed between Uber riders and taxi customers indicate that even small changes in the service types may attract different customer segments (Becker et al., 2018; Rayle, Dai, Chan, Cervero, & Shaheen, 2016).

2 Aims

The aims of this research are:

- To propose a framework to model mobility resource holdings within the framework of activity-based models
- To apply the proposed framework in a study area
- To evaluate the model performance

3 Proposed framework

This study elaborates on a model that predicts mobility resource ownership as part of the complete activity-travel schedule in FEATHERS (an ABM model) in the era of shared mobility. The model will accommodate the interactions between long-term choices of mobility resource holdings and short-term mobility decisions. It will evaluate the possibilities to (further) integrate travel choices with the model for shared mode (public transport, shared car, shared bike, taxi, etc.) choices. In contrast to many existing mobility-resource ownership models, which are based on socio-demographic and built-environment characteristics only, this model will further extend an ABM by adding large scale car-sharing, bike-sharing and taxi schemes (in the form of shared modes) to study their interactions with each other as well as with the existing transport system. Also, a potential integration with long-term choice of mobility resource holdings through accessibility measures will be tested.

In this research, the activity-based model tool FEATHERS (Bellemans et al., 2010) is used to investigate the potential impact induced by MaaS services along with the existing transport services in the Flanders region of Belgium. In FEATHERS, synthetic population of study area aims to pursue their desired daily activities whilst trying to minimize their generalized cost and time of travel. A key advantage of FEATHERS is that it offers a zone level travel demand response towards changes in service attributes such as travel times or costs. Agents will have defined levels of mobility resource ownership (cars, shared-bike, shared-car, etc.) through

MaaS mobility plans in favor of a monthly subscription or pay-per-use approach, which reflect the current distribution in the local population. In the standard model, cars, public transport (timetable-based and routed), bike, taxi, and walk are available modes. For this research, bike-sharing and car-sharing services will be added in the mode choice model of ABM (Figure 1).

A system of discrete choice models will be developed while assuming a hierarchy of model components in the model system. The proposed model system is shown in Figure 1. A mobility-resource ownership model, at the highest level of the model system, will predict the probability of a number of mobility-resources available to the household and individual level. Following this model, a person's primary activity will be determined in ABM using the primary activity model. The proposed framework then will determine the destination of primary activity for activities outside the home and the main mode of the tour.

A full set of traffic analysis zones will be used as choice alternatives in the estimation of destination choice models. The main mode of the tour model will a combined revealed-preference (transport network attributes from open source platforms) and stated-preference model (section 3.1). Finally, time of the day for each segment of tour will be estimated in time of day model. Estimating the model using these data sources will provide a reliable model that is sensitive to policies not currently implemented (Mobility as a Service concept) in the Flanders, Belgium.

Figure 1 depicts the linkages of various model components in the model structure. In the model hierarchy, each model depends on the model above it and is linked to models at the "lower level" through "logsum" variables or accessibility measures. These variables reflect the attractiveness of lower-level choices.

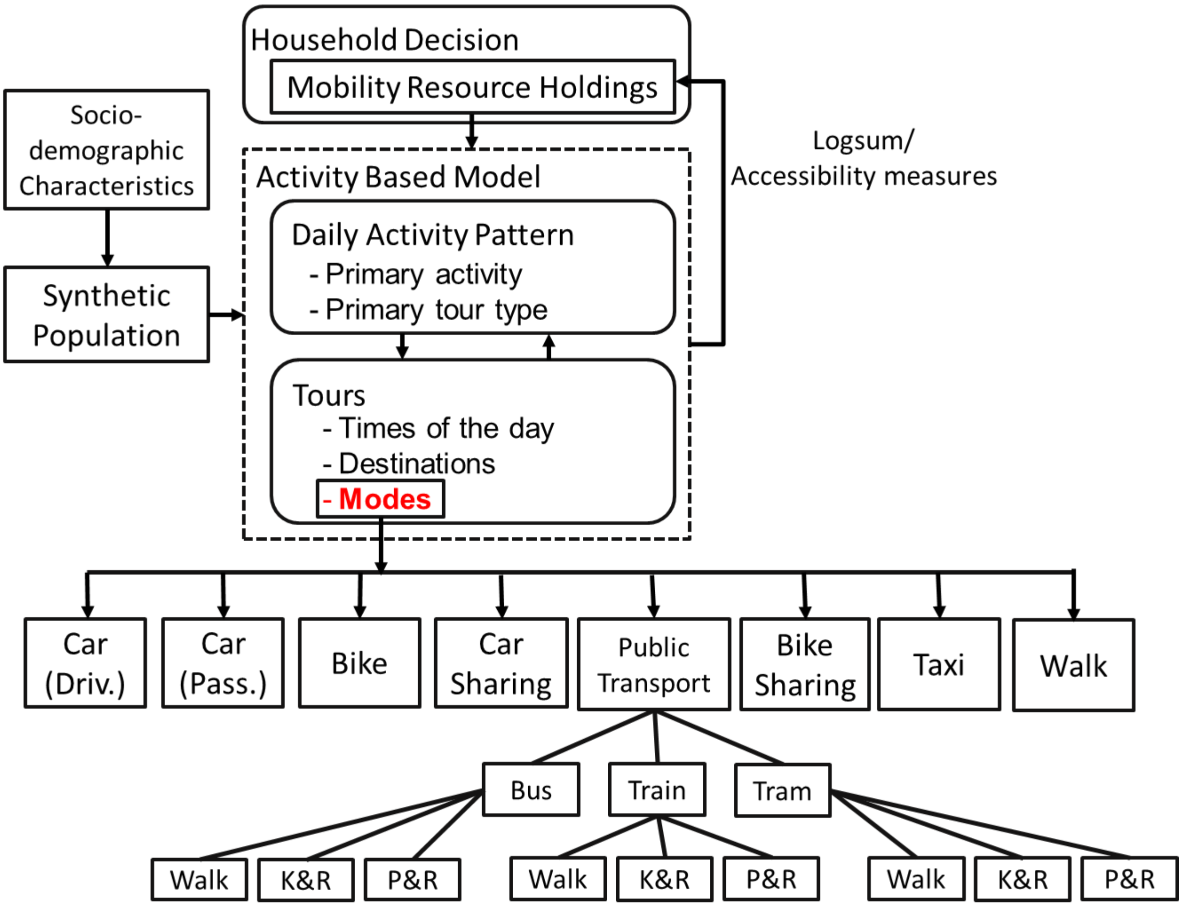

Figure 1: Proposed research framework

3.1 The choice experiment survey

In this study, the choice experiment will be designed to understand: (a) the prospective impact of MaaS in terms of mode choice preferences within the Flanders region, Belgium (b) how MaaS offering will likely update mobility-resource ownership models and activity-travel patterns. Due to the novelty of the MaaS concept in the study area, containing a definite list of modal options, set the bases of stated preference choice experiment to collect behavioral data for this study. Although, there are single shared mode markets exist in Flanders region such as shared-bike, taxi, and shared-car. A typical one-week long travel behavior and activity pattern of each respondent, through a set of background questions, is required in such a choice experiment where respondents face choice options pivoted around their current travel behavior.

The survey instrument will have several major parts. Socio-demographic information of each respondent will be asked in the first part of the survey. The questions will be relating to the respondent's home postcode, age group, employment status, commuting mode and frequency, gender, ability to drive, disabilities, daily access to a car, car-share membership (and pod distance from home), number of household cars and drivers, and household structure. In the second part, respondents will be asked to state a week-long travel pattern. The questions will be in terms of the number of one-way trips undertaken by different modes (public transport, taxi, bike and car) for each day of the week, daily public transport (PT) fare, daily taxi cost, daily distance and time travelled by car, daily parking cost, as well as typical access mode and access time if PT is used in that week. Based on collected travel patterns of each respondent, pivot experiment design will be generated around current travel experience. Following this, MaaS concept and each component of its plans will be introduced and interpret to each respondents before starting stated preference survey.

In the third part, the already collected information in previous parts of survey will be used to design a number of MaaS offerings presented in the form of choice tasks to each respondent. These choice tasks will be primarily based on the information of each travel mode usage (including PT, car and taxi) and having a valid driving license. The choice tasks will be designed for urban and rural areas of Flanders separately based on respondent's home address in the first part of the survey. In the light thereof, we will try to explore user preferences for each mode choice among the given MaaS plans based on their geographical needs and settings.

4 Expected results

Validating the proposed modeling framework, described above, with the activity-based model, describing the current transport system, will provide first insights into how MaaS concepts would impact the transport system with respect to measures of system performance. In particular, they will indicate, how a car-dependent community (Flanders region) would take MaaS offerings whilst maintaining an attractive level of service for travelers. Also, they may shed light on the questions of the extent to which mobility resource ownership to be updated further to trigger a substantial modal shift. Although the study will be conducted for the example of a Flanders region, the results can inform policies towards integrated mobility systems worldwide.

5 Bibliography

- Becker, H., Balać, M., Ciari, F., & Axhausen, K. W. (2018). Assessing the welfare impacts of shared mobility and Mobility as a Service (MaaS). *Research Collection*. Retrieved from https://doi.org/10.3929/ethz-b-000286485
- Becker, H., Loder, A., Schmid, B., & Axhausen, K. W. (2017). Modeling car-sharing membership as a mobility tool: A multivariate Probit approach with latent variables. *Travel Behaviour and Society*, *8*, 26–36. https://doi.org/10.1016/j.tbs.2017.04.006

- Bellemans, T., Kochan, B., Janssens, D., Wets, G., Arentze, T., & Timmermans, H. (2010). Implementation Framework and Development Trajectory of FEATHERS Activity-Based Simulation Platform. *Transportation Research Record: Journal of the Transportation Research Board*, *2175*, 111–119. https://doi.org/10.3141/2175-13
- Cervero, R. (2017). Mobility Niches: Jitneys to Robo-Taxis. *Journal of the American Planning Association*, *83*, 404–412. https://doi.org/10.1080/01944363.2017.1353433
- Franco, P., Johnston, R., & Mccormick, E. (2018). Role of Intelligent Transport Systems (Its) Applications in. *Transport and Communications Bulletin for Asia and the Pacific*, *88*(88), 18–31.
- Glickman, I., Ishaq, R., Katoshevski-Cavari, R., & Shiftan, Y. (2015a). Integrating activity-based travel-demand models with land-use and other long-term lifestyle decisions. *The Journal of Transport and Land Use*, *8*, 71–93. https://doi.org/10.5198/jtlu.2015.658
- Glickman, I., Ishaq, R., Katoshevski-Cavari, R., & Shiftan, Y. (2015b). Integrating activity-based travel-demand models with land-use and other long-term lifestyle decisions. *The Journal of Transport and Land Use*, *3*(3), 1–23. https://doi.org/10.5198/jtlu.2015.658
- Hensher, D. A. (2017). Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change? *Transportation Research Part A: Policy and Practice*, *98*, 86–96. https://doi.org/10.1016/j.tra.2017.02.006
- Jittrapirom, P., Caiati, V., Feneri, A.-M., Ebrahimigharehbaghi, S., González, M. J. A., & Narayan, J. (2017). Mobility as a Service: A Critical Review of Definitions, Assessments of Schemes, and Key Challenges. *Urban Planning*, *2*(2), 13. https://doi.org/10.17645/up.v2i2.931
- Matyas, M., & Kamargianni, M. (2017). Stated Preference Design for Exploring Demand for “Mobility as a Service” Plans. *5th International Choice Modelling Conference*, 16. Retrieved from https://docs.wixstatic.com/ugd/a2135d_d85b6b0955d5458a81db61bc8edc02a2.pdf
- Matyas, M., & Kamargianni, M. (2018). The potential of mobility as a service bundles as a mobility management tool. *Transportation*, (0123456789). https://doi.org/10.1007/s11116-018-9913-4
- Moshe, B., & Bowman, J. L. (1998). Integration of an Activity-Based Model System and a Residential Location Model. *Urban Study*, *35*(7), 1131–1153.

- Rayle, L., Dai, D., Chan, N., Cervero, R., & Shaheen, S. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy*, *45*, 168–178. https://doi.org/10.1016/j.tranpol.2015.10.004
- Shiftan, Y. (2008). The use of activity-based modeling to analyze the effect of land-use policies on travel behavior. *Annals of Regional Science*, *42*(1), 79–97. https://doi.org/10.1007/s00168-007-0139-1
- Sochor, J., Karlsson, I. C. M., & Strömberg, H. (2016). Trying Out Mobility as a Service: Experiences from a Field Trial and Implications for Understanding Demand. *Transportation Research Record: Journal of the Transportation Research Board*, *2542*, 57–64. https://doi.org/10.3141/2542-07