International Symposium on Transportation Data and Modelling (ISTDM 2021)

21-23June 2021, University of Michigan, Ann Arbor, USA

An Agent-based Simulation Model for Intermodal Assignment of Public Transport and Ride Pooling Services

Ester Lorente[a,b], Jaume Barceló[b], Esteve Codina[b], Klaus Noekel[c]

[a]*PTV Group Iberia, Plaça Catalunya 1, 08002 Barcelona, Spain*

[b]*Department of Statistics and Operations Research, Universitat Politècnica de Catalunya (UPC), C5-Carrer Jordi Girona 1-3, 08034 Barcelona, Spain*

[c]*PTV Group, Haid-und-Neu-Str. 15, 76131 Karlsruhe, Germany*

Keywords: Intermodal assignment; Mobility as a Service (MaaS); shared mobility services; ride pooling

1. Introduction

Typically, the assignment models proposed cover only private and public transport, shared services, and walking, focused on unimodal trips and not in their intermodal combination. Furthermore, shared services are still a new mode of transport which impact is still uncertain. Thus, some studies have been carried out on this research field. In particular, the International Transport Forum realized a series of studies based on simulation on different regions: Lyon (ITF (2020)), Dublin (ITF (2018)), Auckland (ITF (2017)a), Helsinki (ITF (2017)b) and Lisbon (ITF (2016)). Concluding that these services would improve the existing public transport network without replacing it. Moreover, suggesting they could become a feeder for the current network in areas with inefficient public transport coverage.

Therefore, it arises the need to study intermodal approaches for public transport and shared services. With regard to vehicle sharing services intermodal approaches, there are already solutions such as the one proposed by Friedrich and Noekel (2017).

However, with respect to ride pooling intermodal approaches, the approaches are more complex as they involve not only the individual availability of each vehicle, but also the shareability of the vehicle in route, as well as always satisfying the time restrictions of all passengers. And thus, since it is still a rather unexplored field, this research will address a combination of ride pooling and public transport.

To develop and evaluate such system, two main components are required: the intermodal assignment dispatcher and a simulator to assess the use case based on simulation. This paper addresses the second component, the simulator, describing the methodological approach used, its implementation and computational testing.

In addition, since there are already operational ride pooling dispatchers, both in the market and from previous research such as that proposed by Jamshidi (2019), this paper assumes the availability of an existing ride pooling dispatcher whose functionalities are expanded with suitable algorithms.

2. Methodology

The system has been designed using available resources that already address the ride pooling service to focus the main research on the design of the intermodal combination, as shown in Figure 1.

The two reused resources consist of the ride pooling dispatcher (MaaS Dispatcher) and the ride pooling service simulator (MaaS Simulator). Both developed by PTV Group and available for internal developments only. In this case, it is required to update the Simulator to extend to an intermodal simulation and not only for a ride pooling service. The details of which will be described later.

In this sense, the intermodal dispatcher is designed on top of the already-implemented ride pooling dispatcher. The new dispatcher, which is called Outer Dispatcher, will then combine the ride pooling routes provided by the MaaS Dispatcher with a public transport journey planner.

In the existing ride pooling version, all requests go from the Simulator to the MaaS Dispatcher. Requests which could be either the booking requests for a customer ride or the relevant system start-up and location updates. In the new intermodal context with two dispatchers, the booking requests are handled via the Outer Dispatcher. And

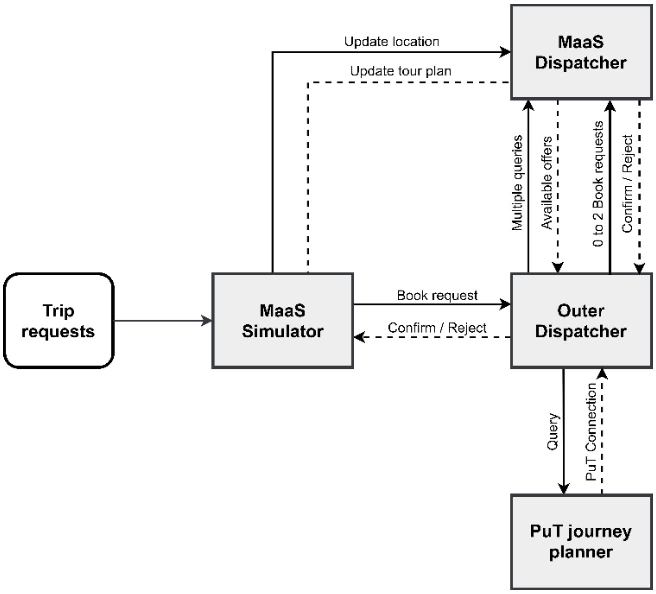

Figure 1. Architecture for the intermodal assignment system.

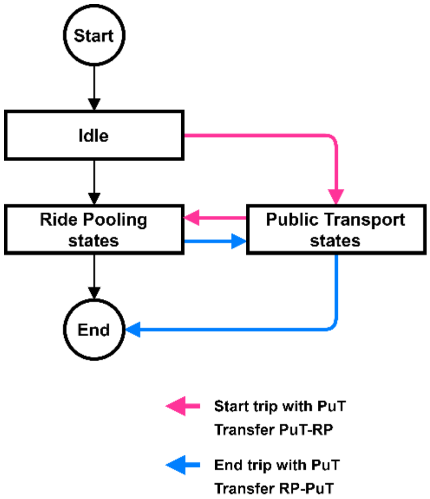

Figure 2. Updated Customer agent states in MaaS Simulator.

regarding the vehicle location updates, these are handled directly through the MaaS Dispatcher as it is the one that manages the vehicle fleet.

Regarding the MaaS Simulator, this component performs a simulation based on events and states. It has two types of agents: Vehicles and Customers. The Vehicle agent represents a vehicle driving between PUDO locations whose behavior is not necessary to be modified.

On the other hand, the Customer agent represents the customer booking a ride and performing it. However, in this case it is indeed necessary to update it to simulate an intermodal combination. In this sense, a loop is established between the states and events of both modes of transport. The simplified states diagram of which can be observed in Figure 2. Regarding the events, the same rules apply. One can start and finish in both modes and transfer to the other when the leg is completed.

To test such system, all components are required including the Outer Dispatcher which is the entity that computes the intermodal assignations. Since the current study focuses on defining the new Simulator, a simple intermodal version of the Outer Dispatcher has been implemented. The objective in forthcoming development which will address an in-depth exploration of the Outer Dispatcher algorithms.

Thus, the Outer Dispatcher defined for this work computes routes with a maximum of three legs, being the first and last leg of ride pooling and the intermediate one of public transport. In the case that a public transport station was close to the origin, the route will start directly with public transport. Otherwise, the ride pooling service will be used to travel from the origin to the station. The same rule applies to the destination. Additionally, in a situation where two ride pooling legs with a sum of total distance exceeding the straight distance between origin and destination, then only the ride pooling service would be used. Otherwise, the route will result from a combination of legs.

3. Results

The case-study city selected in this study is the Barcelona metropolitan area, in Spain. The required data is obtained from the Barcelona Virtual Mobility Lab model (Montero et al. (2018)). For testing purposes, a small subarea has been selected, to make easier the debugging of all the mechanisms of the intermodal Simulator, which is the objective of this paper. Accordingly, the selected subarea is the Eixample (Barcelona’s CBD), extracted from the whole Barcelona model and which is highlighted in Figure 3.

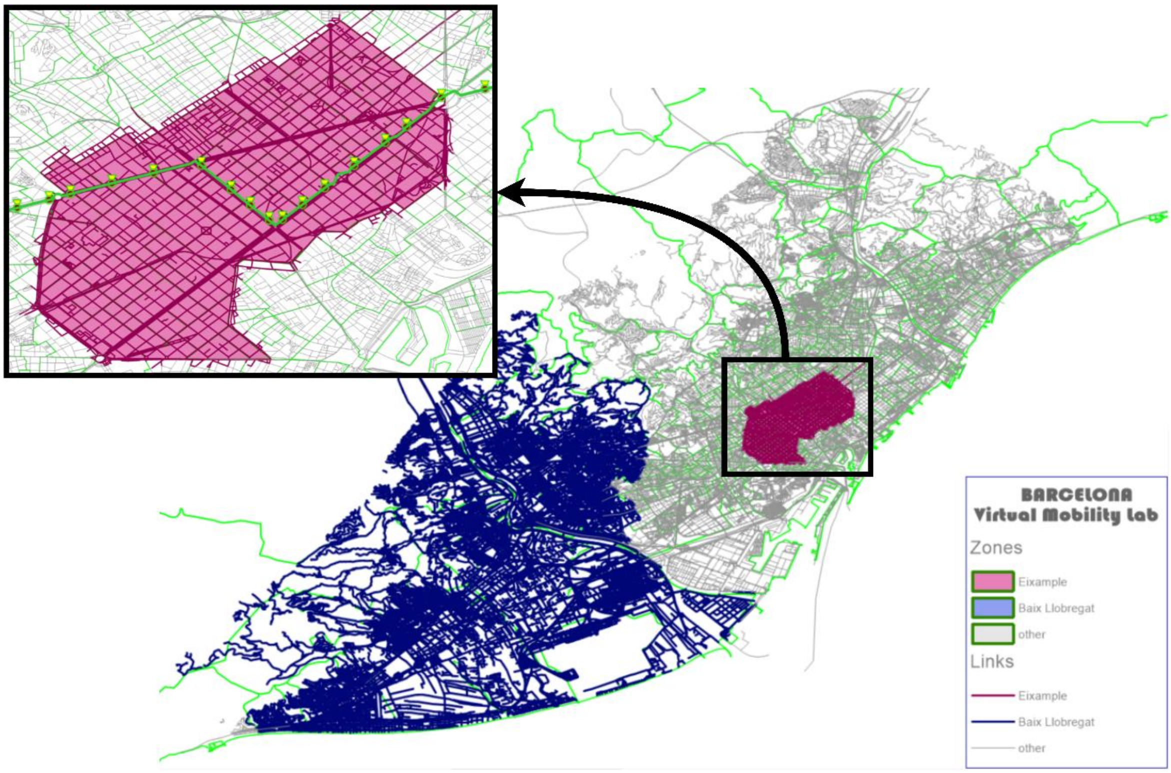

Figure 3. The selected scenario: the subarea of Eixample (Barelona's CBD).

The original model includes the entire public transport network. However, for the initial tests only one of the main bus lines that crosses the entire Eixample has been selected. And it also provides the timetables of all public transport lines, information which will be essential for future development of the Outer Dispatcher.

In addition, different strategically located trip requests have been included so that all different kind of assignment combinations can be undertaken. And as expected, the results show a correct simulation of events and states for all.

4. Conclusion

Intermodal assignment involving shared mobility services is a rather emerging field. This kind of services includes two large families: vehicle sharing and ride pooling. Regarding vehicle sharing, there are already several feasible solutions. However, ride pooling services have other requirements that impede to use the same methodologies.

Thus, this study proposes an intermodal assignment system with a ride pooling service. Which for this first part of the research, described in the paper, an intermodal simulator is defined to evaluate the new use case. Introducing its required architecture.

In addition, it shows that such systems can be developed by assuming the availability of an operational ride pooling dispatcher and extending the behavior of its dedicated simulator for an intermodal environment.

And although the defined intermodal dispatcher was not very realistic, it provides a sufficient solution for the intermodal assignation problem to demonstrate the validity of the simulator. In this sense, a proper study on this topic is left for a second part of the research, to be defined in a forthcoming paper.

5. References

Friedrich, M., Noekel, K. 2017. Modeling intermodal networks with public transport and vehicle sharing systems. EURO Journal on Transportation and Logistics, 6(3), 271–288. https://doi.org/10.1007/s13676-015-0091-7

ITF. 2016. Shared Mobility: Innovation for Liveable Cities. In *International Transport Forum Policy Papers*.

OECD Publishing. https://doi.org/10.1787/5jlwvz8bd4mx-en

ITF. 2017a. Shared Mobility Simulations for Auckland. In *International Transport Forum Policy Papers*. OECD Publishing. https://doi.org/10.1787/5423af87-en

ITF. 2017b. Shared Mobility Simulations for Helsinki. In *International Transport Forum Policy Papers*. OECD Publishing. https://doi.org/10.1787/3d340a2a-en

ITF. 2018. Shared Mobility Simulations for Dublin. In *International Transport Forum Policy Papers*. OECD Publishing. https://doi.org/10.1787/e7b26d59-en

ITF. 2020. Shared Mobility Simulations for Lyon. In *International Transport Forum Policy Papers*. OECD Publishing. https://www.itf-oecd.org/sites/default/files/docs/shared-mobility-simulations-lyon.pdf

Jamshidi, H. 2019. Dynamic planning for recharging shared electric taxies [Delft University of Technology]. http://resolver.tudelft.nl/uuid:8cf9e95c-5010-42f9-8fbb-6e92b804a494

Montero, L., Linares, P., Salmerón, J., Recio, G., Lorente, E., José Vázquez, J. 2018. Barcelona Virtual Mobility Lab: The multimodal transport simulation testbed for emerging mobility concepts evaluation. ADAPTIVE 2018. https://upcommons.upc.edu/handle/2117/123910