Combined agent-based simulation of private car traffic and public transit

Marcel Rieser and Kai Nagel, VSP, TU Berlin

Abstract
Agent-based Transport Simulations look at individual travelers and simulate their movements through a transportation network. Currently, such simulations are either limited to a small region, or only support a single mode (usually private car traffic) for computational reasons. MATSim (Multi-Agent Transport Simulation) is such a tool that can handle large scenarios (e.g. up to whole Switzerland), but currently only simulates cars.

But the need for tools that support large scenarios as well as multiple transportation modes is rising. Not only the metropolitan areas are growing, but also the dimensions in which measures must be handled. The introduction of road pricing or new transit offerings usually cannot be limited to a small area, but has to take larger regional effects also into consideration. Similarly, looking only at a single transportation mode is useless as most measures also target a shift in the modal split.

In our work, we first describe how we extended MATSim to handle also other transportation modes besides private car traffic, with a strong emphasis on public transit. This includes not only the simulation of such traffic, but also the agents' mode choice decisions. The agents make use of a utility function to score their experiences with different transportation modes, which influences which mode they choose in following iterations of the simulation. This basically means that we no longer rely on existing mode choice models, e.g. known from the 4-step process. Instead, mode choice is iteratively adapted during the simulation (“traffic assignment” in the 4-step process). The combination of mode choice and traffic assignment leads to better results compared to a pre-calculated mode choice, as the results will show.

Starting with small, incremental steps, it is shown how the changes to the simulation framework help to improve the realism of current large-scale scenarios (e.g. Zurich, Switzerland). These incremental steps are:
1. Adding a non-car transportation mode for the agents with simple estimated travel times and no real simulation.
2. Improving the estimated travel times with data from timetables and schedules for public transit.
3. Microscopic simulation of public transit, where agents can board and exit transit vehicles, and busses or streetcars can be hold up in traffic jams.
4. Extending the utility function for public transit travelers to also include quality measurements, like seating place availability and delays compared to schedules.

Already with only the first step realized, the quality of the Zurich scenario shows significant improvements when comparing link volumes from the simulation to values of real world counting stations. This shows that the integrated mode choice leads to more realistic agent behavior than what the initial mode choice, based on detailed census information, was able to predict. While census information is often aggregated into grid cells because of data privacy (e.g. in Switzerland usually cells of 100m x 100m), this level of detail seems not to be high enough for predicting transportation mode usage. Instead, the results of this simple extension of the simulation show that the decision pro or against a certain transportation mode depends on a variety of factors, including start and target location of trips, departure time, but also the detailed route and thus the behavior of other agents--something usually not available in traditional mode choice models.
Based on the aforementioned four steps to extend the simulation framework, it is then shown how the simulation framework can be used to research and simulate different kinds of mobility and travel behavior:
- public transit in developed countries, usually based on schedules and with sophisticated pricing schemes
- paratransit and other public transit-like mobility offerings often found in developing countries
- paratransit and flexible car-sharing in developed countries

The paper will present simple test cases as well as examples of large-scale scenarios for at least two of the three aforementioned use cases.