Multi-agent based simulation of individual traffic in Berlin

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Multi-agent simulations of traffic are expected to become an important tool for transportation planning in the mid-term future. In this paper, we will give a brief introduction to this kind of traffic models in general and to the specific implementation chosen for this study and highlight some of their advantages. We will then make use of the study region of Berlin to show different approaches which can be taken to implement such a model for a German city, what kind of results can be expected from these approaches and how they relate to more classical approaches. Further, the paper will evaluate the computational aspects e.g. tractability, resources and performance of the model when being applied to a study region as large as Berlin. Finally, the first results of the simulation runs are shown and compared to other studies.

In multiagent-based simulation models, traffic is modelled on the level of single individuals – the agents – as opposed to aggregated vehicle counts or traffic streams. The models follow the general approach of demand generation, distribution, mode choice and assignment known from the “classical” 4-step-process of traffic modelling, but the individual steps are replaced by procedures which allow to keep track of the individual agents throughout the entire workflow.

The agents are regarded as a synthetic representation of the real population of the study area. Each agent is assigned one or more plans for one day. These plans are made up of activities (e.g. work, shop,…) and the legs – characterized by their modes and routes - between the activity locations. The activities are bound to specific geographic locations (not zones!) and carry scheduling information (start time, duration) - whereby the initial schedules are taken as “planned schedules” which don’t take into account travel times on the loaded network and which will be adapted within the simulation process.

The creation of the synthetic population and the assignment of activity patterns to the agents can be regarded as the demand generation step of the 4-step-process. The choice of locations for the different activities corresponds to the traffic distribution step of the classical approach. Mode Choice can be handled either within the plans generation process by the creation of different sets of plans according to given modal split values or later within the simulation process by allowing the agents to actively choose plans with different modes based on criteria like experienced travel time. Depending on the data being available and on the focus of the study, all these steps can be carried out differently. For example, a synthetic population and the plans can be generated “from scratch” by using census data and time usage patterns, but by making some assumptions, it’s also possible to generate simple populations from existing OD-matrices.

The mobility simulation process, which corresponds to the assignment step of the traditional model, consists of a physical simulation of vehicle movement. Different approaches (e.g. cellular automata, queue models) which model vehicle movement on different levels of detail and which allow for different kinds of evaluations and results can be followed. But besides their strengths, these approaches also differ largely in computational tractability and therefore in the size of populations they can handle. All of them differ from classical assignment procedures in that they are able to generate realistic representations of congestion and their dynamic effects throughout the network.

This mobility simulation step is integrated into an iterative process which allows the agents to evaluate the performance of their plans and to modify different aspects of them (e.g. routes, departure times, mode choice). As the plans currently are considered to cover one day, this general workflow of execution – evaluation – modification is called “overnight learning”.

The study population of Berlin is about 3.5 Mio. agents, making it one of the largest samples examined by use of a true agent-based traffic simulation. In this study, we will only consider private road traffic; therefore the number of agents will be reduced according to the assumed modal split values. The road network being used in the study is the “official” planning network which consists of about 13000 links covering the major roads of Berlin and also Brandenburg. For initial tests of the network data and the computational tractability, the population and the network capacities will be scaled down to 10%, 30% etc.

Due to the size of the study population, the mobility simulation uses the more general queue model for vehicle movement. The MAtSim software used for this study is able to run in parallel mode, distributing the mobility simulation across several nodes in a Beowulf cluster.

The generation of a synthetic population and the plans of the agents will be done by stepwise more complex approaches. In the initial attempts which focus more on the evaluation of computational aspects and the general model parameters, artificial populations will be generated from existing OD-matrices. In a second approach, we will concentrate on a more realistic representation of the morning peak and the “work” activities which allows for first comparisons to real traffic counts. As the “official” OD-matrices used for transport planning in Berlin are all 24h-matrices which don’t fit well into the dynamic approach of the mobility simulation, time-dependent OD-matrices have to be estimated. This approach will then be extended to include also the “school” and “child care” activities.

In the final approach, a true synthetic population will be build from statistical data. The agents of this population will carry more complex plans which also include the secondary activities like shopping, leisure and recreation and so on. The time usage patterns and travel behaviour of the agents will be derived from different studies (e.g. *MiD*, *Zeitbudget-Erhebung*). One of the most interesting outcome of the study will be if this set of input data will be able to produce realistic traffic patterns or if a lot of tuning will be needed in order to match the traffic counts available.

The output of multiagent-based simulation models can be used in different ways. On the one hand, basic parameters which are also available from “classical” models and which are widely used in transportation planning (e.g. traffic volumes, average speeds, average trip distances and travel times) can be extracted from the model output – on every temporal resolution required. But furthermore, the agent-based approach allows for extended analysis. As the agents represent persons with specific properties like age, employment or income, it is always possible to evaluate the model output in terms of questions considering the "who"-perspective. For example, scenarios including regulative measures can be evaluated in terms of "who is being affected" – a question of major interest in the debates on network extensions or road pricing.

Future extensions of the model will include the representation of public transport, commercial traffic and impact models (noise, air pollution). These extensions will allow for very exiting new perspectives in transportation planning.

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