A large-scale hybrid micro- and mesoscopic simulation approach for railway operation

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Extended Abstract

In several countries, the demand for rail transport is expected to increase significantly in the coming years. This is due to several effects: Transport policies which aim at a modal shift from motorized road traffic to rail, the increase in population, rising economic production, or changes in spatial structures. It is therefore increasingly important to account for the operational aspects of the rail system. One of the key elements is to identify and eliminate bottlenecks through infrastructural policies (e.g., network expansion, passing tracks) or operation concepts (e.g., train connections, headways, transfer stations). Today, transport planners are challenged by planning tools which require expert knowledge and human interaction. These tools, e.g., Viriato[1], only provide assistance but do not allow for an automated feasibility check and evaluation of the railway schedule. The assistance is provided to the transport planner by visualizing the railway lines using so called space-time diagrams, also referred to as the graphical representation of the railway schedule. The planning process then requires to manually check if space-time curves intersect and if yes, the infrastructure provides sufficient capacity, e.g., number of tracks. If not, the schedule is manually adjusted, and train departures need to be shifted to an earlier or later time which then requires again a check for potential conflicts. More complex tools such as OpenTrack[2] provide additional functionality, including the detection of conflicts by simulating train operations on detailed track layouts. The microscopic simulation approach requires a lot of computation time and does not allow for large-scale applications at the national level. Furthermore, the usage of a microscopic

[1] https://sma-partner.com/de/software/fahrplan-planung-mit-viriato
[2] http://www.opentrack.ch/opentrack/opentrack_e/opentrack_e.html

simulation software requires the transport planner to provide detailed inputs about the track layouts, train paths etc.

This talk proposes an innovative railway simulation approach which fits in between the complex microscopic railway operation simulation approach and the simplistic planning tools. The proposed approach provides functionality for a feasibility check and conflict detection of timetables and a given infrastructure. At the same time, the approach is easy to use, open-source and allows to investigate large-scale railway concepts at the regional or even national level. Furthermore, the modeling approach allows for a detailed consideration of transport demand, which may be relevant in the case of train control and incident management.

The methodological concept is to develop a hybrid micro-mesoscopic simulation approach which extends the agent-based simulation framework MATSim[3] (Multi-Agent Transport Simulation, Horni et al., 2016). The first part of the talk describes a first prototype implementation which makes use of MATSim's signals functionality. The second part of the talk addresses a more advanced implementation approach.

In both implementations, MATSim's basic functionality is modified and adapted to the railway simulation context:

(1) Vehicles have a spatial dimension along several infrastructure segments (*MATSim links*). The front part of a train may be one link and the back part of the train on another link.
(2) Vehicles accelerate and decelerate based on vehicle- and infrastructure-specific attributes.
(3) The interaction of vehicles as well as the modeling of the infrastructure is adapted to the railway system. The network contains of capacity constrained resources, a resource is either a single MATSim link or a sequence of links. Trains are enabled to reserve infrastructure resources (block segments, moving blocks), and reservation requests interact with each other. Conflicting infrastructure reservations require some kind of prioritization.

References

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[3] http://www.matsim.org