Prediction method of public transport travel times based on current timetable data, real-time data, and historical data - an application of Max-Plus Algebra

Master's Thesis of Mahmudul Hasan Shovon

Mentoring:
Dr.-Ing. Antonios Tsakarestos
Dr.-Ing. Karl Dumler

External Mentoring:
Johan van Ieperen (INIT SE)

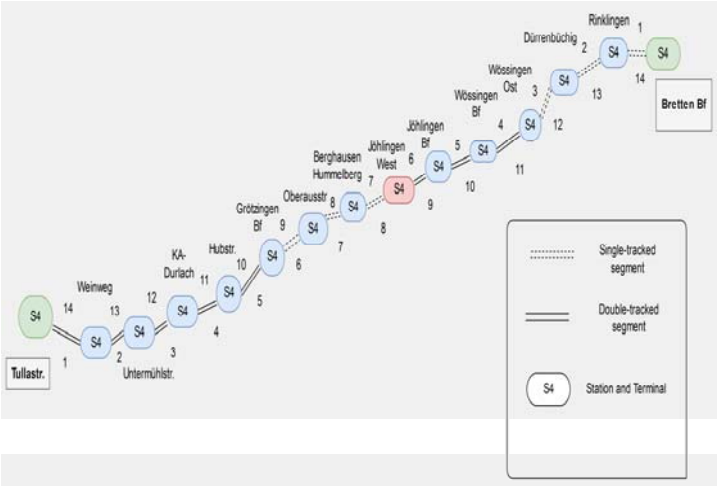

Figure: Studied network with segment numbers

Karlsruhe is very famous for its tram network, which integrates the downtown tramway infra-structure with the regional rail system. The network is very dense in the city, and at least one tram is passing through the city center in every two minutes during the peak hours. Prediction of the vehicles is not precise until now, as some part of the network is still operated as mixed traffic. Take for instance a situation where a tram is blocked by a truck: the departure time of this tram for the next stop will simply be pushed forward because the calculation is based on the time to travel the remaining distance to the next stop. Thus, delay is a common phenome-non for this city. Besides, the single-tracked sections are also contributing to interrupt the trams in different places and delay is propagating all over the network through secondary and consecutive delays. Max-plus algebra is a mathematical approach to model railway systems which are operated according to a periodical timetable (Braker, 1993). This tool has been widely used to determine the maximum performance of the railway network and analyze stability for timetable (Goverde R. , 2005).

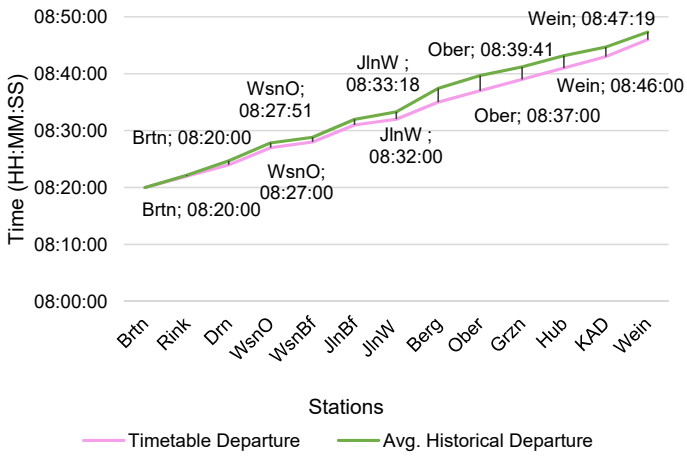

Figure: Projection of Timetable and Historical Departure for Trip 85458

PETER (Performance Evaluation of Timed Events in Railways) was used to simulate the models and analyze the behavior of the network in response to initial delays at the starting station. Run time and dwell time for timetable data and historical data were compared, and departures from the stations were projected to realize the travel time among the segments. A significant difference was observed between the planned schedule and historical data of the studied trips. The departure times were collected from the model, and those were plotted over the stations. The prediction for departures was analyzed for all the stations. Only the significant departures for few stations are pointed out in the figure. Both trams start at the same time, but the tram representing historical data requires more time to reach Weinweg and depart from there. The difference between the lines increases from Jöhlingen West, where the second single-track section (return direction) starts for trip 85458. Maximum deviation was observed at Oberausstraße, and after running in the double track section, the delay decreased progressively.

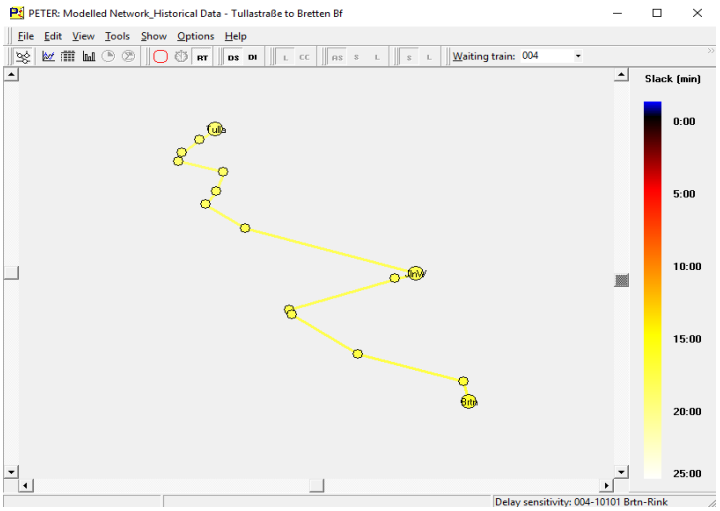

Figure: Delay sensitivity of trip 85458 at Bretten Bf for Historical Data

Max-plus algebra was widely applied on rail network of the Netherlands for analyzing robust-ness and stability of timetable. In this thesis, the algebra was applied to analyze the prediction of a tram network. However, the available timetable data lacked the required level of detail to model tram-train network, which leads to assume the dwell time at stops and headways between the segments. Generic input file for the software PETER, was manually constructed due to the unavailability of the program, DONS. The key encounter was to model the tram-train network with run time and dwell time in seconds resolution rather than full minute steps to predict the travel time for this thesis. It is very difficult to interpret the run time and dwell time in seconds, as it requires a lot of calculation. But for the prediction of public transport vehicles, especially in tram net-work, minutes must be split into seconds to have precise run time and dwell time. So, detailed analysis was done to have precise values. Improved prediction of the public transport can be achieved if the Max-plus algebra is integrated with artificial intelligence.