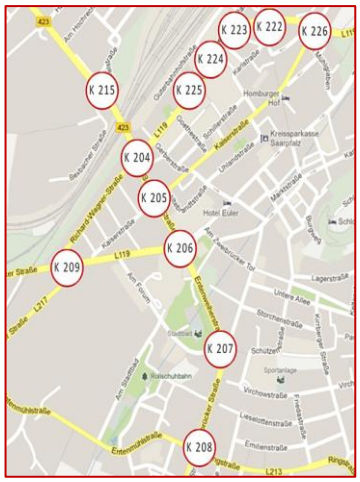
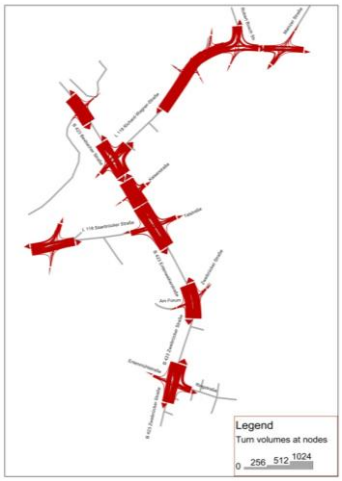
Analysis of macroscopic signal optimization for urban road networks

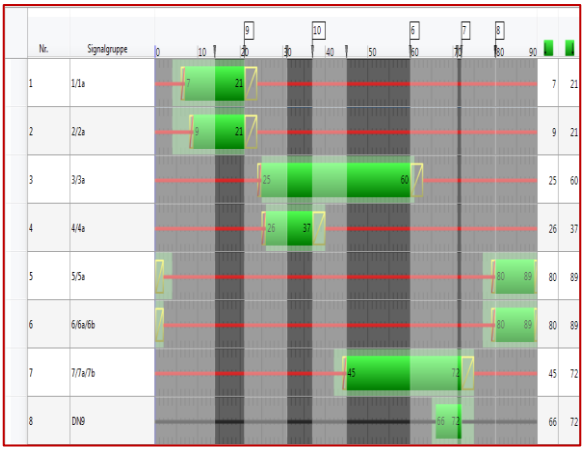
Master‘s Thesis of Nora Szabo

Supervisors:
Dipl.-Ing. Dipl.-Wirtsch.-Ing. Tobias Schendzielorz (Lehrstuhl für Verkehrstechnik, TU München)
Dr.-Ing. Volker Waßmuth (PTV AG Karlsruhe)

The coordination of traffic lights through the provision of green waves in one or more directions is an effective instrument to reduce travel time losses and unnecessarily taken stops, thus to provide continuous traffic flow. Parallel to the development of online optimization procedures, PTV AG has developed an offline optimization tool within VISUM, which is based on a comprehensive transportation model, hence whole vehicle paths (Origin-Destination pairs) are taken into account. The delays for all vehicles in the network are minimized by optimizing the green time split, cycle time and offset of the fixed-time controlled traffic lights. Within the scope of this thesis, this procedure has been applied to a case study in Homburg (Saarland), with the objective to evaluate the performance and appropriateness of the network-wide, macroscopic optimization of signal timing plans. The results of optimization were compared to the non-optimized scenario, as well as to the result of a conventional optimization, which was available from an earlier project.







The macroscopic optimization has been executed in two consecutive steps, for the two usual peak periods of the day. On the nodes level, the optimization of green time and cycle time of 12 controllers were performed, whereas on the network level, the offset of the neighbouring controllers were adjusted. The main directions were detected automatically based on the highest volumes – along these 4 paths, green waves had to be developed. Due to special network circumstances, an overlapping section makes the coordination in all directions difficult, hence the network-wide consideration during the optimization means to find a satisfactory compromise.
After the effective optimization, the microscopic simulation of three scenarios took place, separately for the morning and evening peak – besides the resulted signal timing plans of the macroscopic optimization, the current control, as well as the conventionally optimized signal plans were simulated. Based on the outputs of the simulation, these three scenarios have been compared to each other by means of clearly defined evaluation criteria.

There were some constraints, which had to be considered. The optimization was limited to fixed-time controlled signal plans, and an implicit change in the stage sequence was not possible. The complexity of junctions and other special network circumstances may also limit the degree of freedom during the optimization.
On some sections, which played a minor role before optimization, significant improvements have been achieved.
The qualitative evaluation justifies the appropriateness of the macroscopic optimization tool, since the tendency with both optimization procedures regarding the improvement is the same. In order to reach better results and to avoid discrepancies, the simultaneous optimization of three variables is recommended. The benefit of an automatic optimization procedure (reduced calculation time) is realized especially in huge networks, where fixed-time control is the applied control process. This control type makes all traffic scenarios eligible for optimization, where the travel demand is perceived to be constant over a longer time – typically the morning and evening peak hours, or special events such as football games, concerts or road closures.