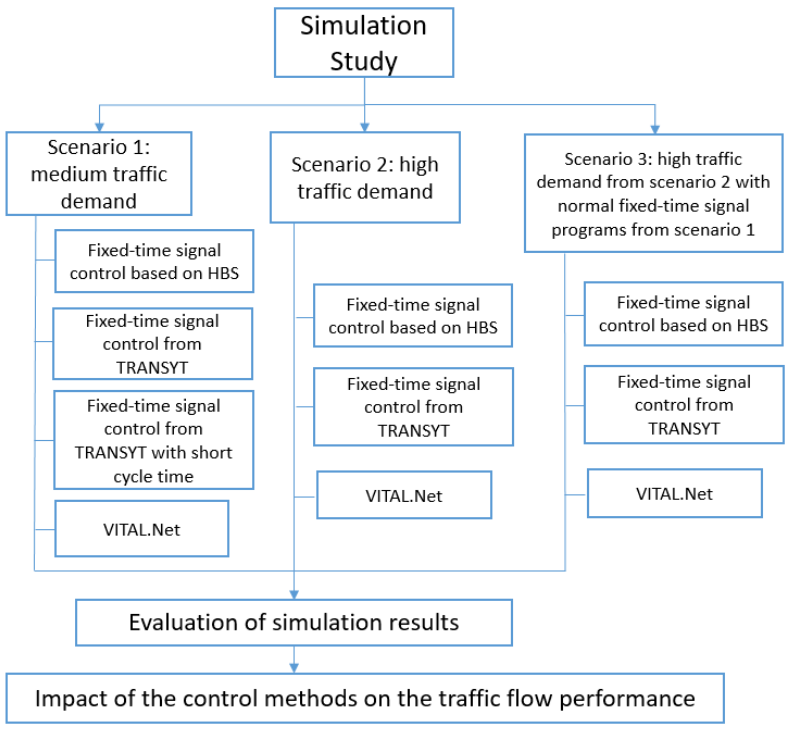
Simulation-based Evaluation of the Potential of Local Adaptive Traffic Signal Control for Controlling Urban Networks

Master‘s Thesis of Ying Xin

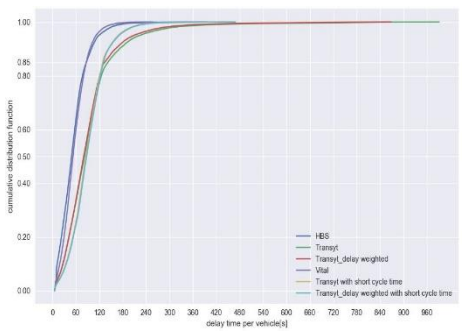
Mentoring:
Dipl.-Ing. Jakob Kaths
M.Sc. Eftychios Papapanagiotou

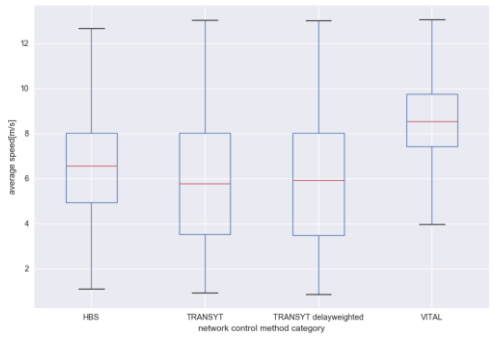
External Mentoring:
Prof. Dr. Peter Wagner (DLR Institute of Transportation System)
Dr. Robert Oertel (DLR Institute of Transportation System)

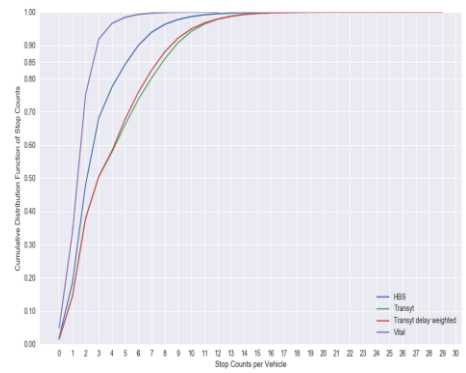


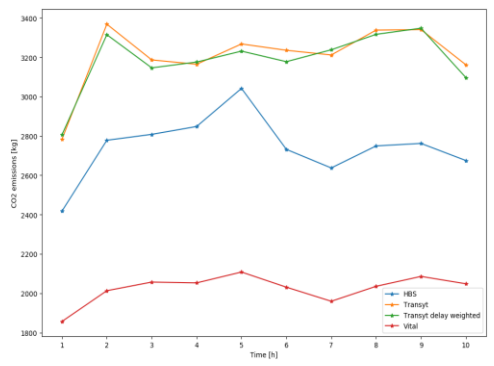
In TRANSYT, Performance Index (PI) is a monetary term that translates the physical significance of the delay time, stop number and congestion within the network into the financial term. The optimization of TRANSYT is to optimize the green split and offset of a signal program set in a road network to minimize the PI value.

VITAL.net is a network adaptive signal control which has been further developed from the basic VITAL delay-based control method. This method consists of three models: traffic model, LSA model and delay time model. LAS model aims to predict the begin time of each phase. In the delay time model, the delay time of each vehicle results from the waiting state in the queue and the acceleration process. In VITAL.Net control method, the total delay time of all the approaching vehicles in the current phase at an intersection will be predicted. The concept of this control approach is to minimize the total delay of the whole intersection by comparing the different delay time resulting from different phase switching time to decide the optimal remaining green time for the current phase.

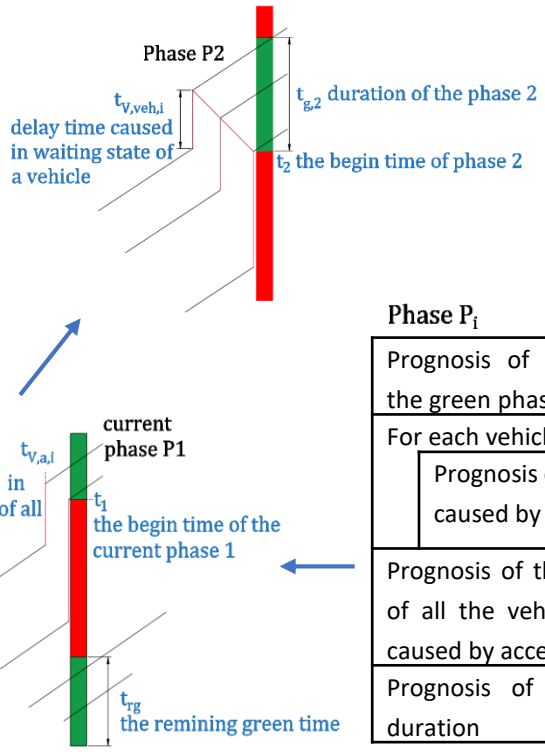








Traffic signal control has the task of traffic management in terms of quality, safety, environmental sustainability, and efficiency. The aim of this master thesis is to evaluate the potential of an adaptive network control system VITAL.Net by a simulation-based comparison with the fixed-time control program TRANSYT in SUMO simulation environment. The simulations of the two control methods are performed in a small urban road network in three scenarios with different traffic demand conditions. TRANSYT is an offline computer program to derive near-optimal fixed-time programs for coordinated signalized networks. In order to expand the diversity of the fixed-time signal program, except the fixed-time signal plans obtained from TRANSYT, another fixed-time signal plan possibility based on HBS method is also simulated as the reference case in the comparison with VITAL.Net method. For the statistic and stochastic reason, in each scenario, the simulation of each control method will be performed three times with three different randomly generated vehicle route files.



The appropriate performance indices of average delay time, average speed, number of stop counts and pollution effect are selected for evaluating the control methods at the network level. The results of the simulation study reveal that the positive effects of the local adaptive signal control are highlighted in the high traffic demand scenario. It would significantly reduce the average delay time per vehicle by more than 60% and improve the average speed of the network by nearly 75% compared with TRANSYT fixed-time control. It means that the vehicle could even keep in a high-speed level under VITAL-net control when the network is highly saturated. From the environmental aspect, the VITAL. Net method could greatly reduce the air pollutants respectively 38% in CO_2 and 45% in PM_x, 40% in NO_x compared with fixed-time control. The results also show that in the medium traffic demand condition VITAL.Net doesn’t show an obvious advantage compared with HBS fixed-time signal programs and performs as well as a well-designed fixed-time “green wave”. It proves that VITAL.Net method has the potential to improve the overall traffic flow quality by minimizing the total delay time and serving the major traffic flow primarily.