Cooperative traffic signal control – Integration of vehicles into the control of connected transportation systems

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Introduction
In light of emerging communication technologies, developing strategies to realize the potential benefits of vehicle-2-x communication has become of major interest in the field of traffic engineering in recent years. Within the work of this PhD a theoretic approach for cooperative traffic signal control for urban areas will be developed. The intention behind this concept is to offer a fully adaptive traffic light control while still providing information about signal phase and timing. Thus, it will be possible to generate and transmit green light optimal speed advisory (GLOSA) to cooperative vehicles.

The work carried out within this PhD aims at the development and implementation of an urban traffic light control that could be deployed in the field within the next 10 to 15 years under consideration of a realistic development of technologies. Therefore, different penetration rates of cooperative vehicles will be taken into account. The developed traffic light control intends to raise the efficiency of traffic flow in urban areas and to reduce the number of stops significantly and thus leading to lower fuel consumption and emissions.

Control Approach
The aim of the proposed control approach is to obtain an optimized signal timing by taking into account non-aggregated microscopic data from conventional detection and floating car data (FCD), which are provided by equipped vehicles via vehicle-2-infrastructure (V2I) communication. Conventional detection, provided by inductive loops for example is considered because a high equipment rate of cooperative vehicles cannot be expected in the near future. A state estimation is used to fuse data from different sources and to estimate the traffic state in cases where incomplete measurement data are available.
The same traffic flow model that the state estimation relies on is used to obtain an optimized signal timing and optimized vehicle speeds mutually. In the optimization task, several constraints such as intergreen times or maximum vehicle acceleration are taken into account according to the principles of model predictive control (MPC) as described in [1].

By implementing MPC, future information about the signal timing and the traffic state is calculated and can be used to provide GLOSA information to equipped vehicles via infrastructure-2-vehicle (I2V) communication, allowing drivers to avoid stopping. Figure 1 depicts the principle of the proposed algorithm.

The algorithm is implemented in Python and common interfaces are used in order to exchange data with commercial optimization software such as CPLEX from IBM and the microscopic traffic flow simulation SUMO [2]. Within this framework, simulation studies are carried out in order to evaluate the proposed control strategy. Results are presented in [3] for networks of equipped intersections and under consideration of transit prioritization. The results indicate general reductions regarding the number of stops, the total time spent in the network and emissions. Especially the number of stops and emissions decrease further with increasing equipment rates. The performance improvements are observed due to the high flexibility of the signal group based control and the predictive decision making that considers vehicle speeds and signal timings mutually. As a result, the number of stops can be halved when considering low traffic volumes and a complete equipment of the vehicle fleet. In case of no equipped vehicles, a reduction of 30% is observed [4].

Fig. 1: Control Approach.

References