Traffic control algorithms for mixed vehicle traffic – A simulation-based investigation

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Extended Abstract

Peak-hour traffic congestion has become one of the most challenging problems in modern societies causing serious infrastructure degradation and underutilization. Longer travel times, lower speeds and extended congestion in the network, are only a few of the immediate consequences. An efficient way to influence traffic performance and, hence, alleviate traffic congestion on motorways is the development and implementation of appropriate traffic control strategies utilizing vehicle automation and communication systems (Markantonakis et al., 2019). In the near future, vehicles equipped with such systems are expected to revolutionize the ordinary features and capabilities of a conventional vehicle (Diakaki et al., 2015). Vehicle original equipment manufacturers (OEMs) are investing heavily in automation, while software is becoming a critical component of vehicles. At the same time, traffic and road authorities are seeking new technology solutions to increase safety and to reduce traffic congestion and emissions. These solutions are often dependent on the vehicle’s potential to recommend, support or even execute appropriately designed traffic control tasks and the ability to provide various types of support for drivers and vehicles. As a result, there is a need to prepare the road infrastructure to support the coexistence of conventional and automated vehicles, targeting to the transition period when the penetration rate of connected automated vehicles (CAVs) will gradually increase.

A number of control strategies, targeting maximum throughput at motorway bottleneck locations, was developed by the DSSL group within the FP7 ERC project TRAMAN21. These include an Adaptive Cruise Control (ACC) parameter adaptation strategy, a Mainstream Traffic Flow Control (MTFC) strategy and a Lane-Change Advice (LCA) strategy. The first control strategy changes in real time the driving behaviour (specifically the employed time-gap and the acceleration strength) of ACC-equipped vehicles in motorway sections according to the corresponding traffic conditions which improves the motorway traffic flow efficiency (Spiliopoulou et al., 2018). Three different modes of operation are available: i) gradually decrease of ACC time-gaps at near-capacity traffic in order to increase capacity; ii) additional application of minimum time-gaps at active bottleneck areas; iii) additional application of an acceleration increase at active bottleneck areas in order to increase the discharge flow. The second control strategy employs mainstream traffic flow control using variable speed limits (VSL) as an actuator (Markantonakis et al., 2019), when approaching areas with a particular infrastructure layout, for example, lane drop or other bottlenecks, in order to establish optimal traffic conditions (Carlson et al., 2010). The third control strategy delivers appropriate lane-changing actions to selected connected vehicles using a feedback-feedforward control law (Markantonakis et al., 2019). The basic goal of the LCA strategy is to achieve a desired distribution of vehicles among the lanes in the immediate proximity of a bottleneck, so as to exploit the capacity of each and every lane.

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thus increasing the overall cross-lane capacity (see Roncoli et al. (2016), (2017) for more details). Preliminary investigations demonstrated that the proposed strategies improve the motorway traffic flow efficiency significantly, even for low penetration of CAVs.

A library of software tools, that implement the control algorithms in a generic way for any network topology given by the user, has been developed recently within the H2020 project INFRAMIX. Extended simulations have been performed using the advanced simulation environment VSimRTI (Protzmann et al., 2017). VSimRTI is a framework for the assessment of new solutions for cooperative intelligent transportation systems. The control algorithms are thoroughly assessed via comprehensive investigations involving a large variety of penetration rates for CAVs, infrastructure types and capabilities, and traffic conditions (free flow, critical, congested).

Several of the developed tools will soon reach maturity allowing for their immediate practical usage, e.g. at the project’s test sites, as well as further exploitation. Based on the simulation evaluations conducted within INFRAMIX, the most promising appears to be the ACC parameter adaptation strategy and is the one chosen to be presented in more details. Compared to previous publications of the DSSL group on this strategy (Spiliopoulou et al., 2018; Manolis et al., 2020), the investigations presented include a new microscopic simulation environment, a more realistic mixture of traffic, a more realistic model for the required communication between vehicles and the infrastructure, and different options utilised to examine the minimum requirements from an infrastructure point of view.

References


