Abstract: Extensions and usage of Veins/Plexe to evaluate QoS requirements of cooperative platooning

András Wippelhauser, László Bokor

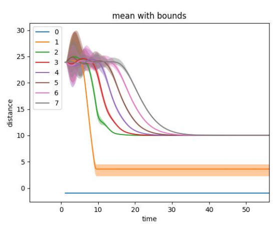
BME, HIT, andras.wippelhauser@gmail.com, bokorl@hit.bme.hu

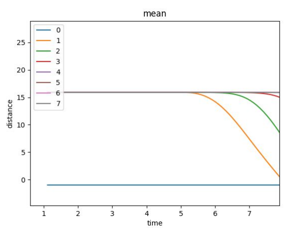
Transportation systems face many challenges nowadays - like the increasing number of traffic jams or green gas emission - which we try to tackle with the help of different engineering methods. The V2X (Vehicle-to-Anything) communication paradigm has the maturity to be integrated in the transportation ecosystem, and the applications built on top of this technology have the ability to help answering the above-mentioned challenges [1].

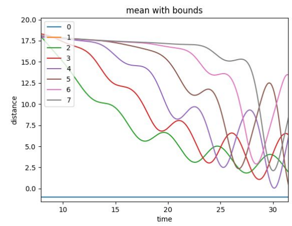
One of these promising applications is the cooperative platooning. It is based on the idea of vehicles following each other with a short inter-vehicle gap, which decreases the air drag at the follower vehicles resulting reduced fuel consumption, increasing the throughput of the highways, making roads safer with less traffic jams, and reducing the natural oscillation in dense traffic thanks to the reliable and real time information exchange between platoon members about the motion state of the surrounding vehicles [2].

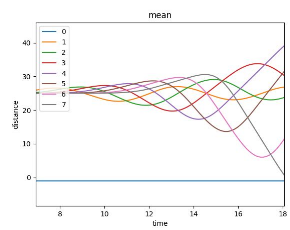
In the cooperative platooning applications we assume that the control of the leading vehicle is handled either with a professional driver or using autonomous driving. The rest of the vehicles are controlled by a so-called cruise control algorithm. Nowadays adaptive cruise control (ACC) is a common feature in vehicles, but to let vehicles closer to each other, cooperative ACC (CACC) algorithms are needed requiring more and real-time information about the states of platoon members, which can be provided via V2X communication [3]. The key property is called string stability, which is a strict requirement against the platooning applications. If an algorithm is not string-stable and we induce it with a specific frequency, it starts to oscillate until the controlled vehicle crashes into a neighboring vehicle. It is a proven fact that in case of fixed relative distance based linear control algorithms, the string stability cannot be ensured using information only from the subsequent vehicle [4]. This property can be fixed using communication. There are analytical methods to prove string stability but the general behavior of an algorithm can be more exhaustively examined using simulation methods which make us able to consider more parameters - like how mean the reaction of the algorithms is or how the whole traffic is affected.

In the scope of this paper we examine the communication Quality of Service (QoS) requirements of cooperative platoons using Plexe [5], which is an OMNeT++ and SUMO based platoon simulation system. We extended the original Plexe framework to support explicit declaration of different QoS parameters for the communication link. In order to support extensive study and visualization of the results we also developed a novel result analysis system. In the framework we evaluated different ACC and CACC algorithms applied in two of the most interesting traffic scenarios: sudden hard braking and sinusoidal gain of the leader vehicles.









The aim of our examinations was to show the security and robustness of certain CACC algorithms even in highly loaded channels and to make conclusions about the QoS resistance level of cooperative platooning applications. We executed more than 10,000 simulation runs resulting around 16GB of raw data. Example graphs above show a hard brake scenario (leftmost figures) and the reaction of a non string stable algorithm on sinusoidal gain (rightmost figures).The results confirmed that having proper QoS provisioning and selecting the right control algorithm is crucial in the platooning application, therefore requiring deliberate and well-grounded design choices.

References

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