Medium Access Control for Vehicular *Ad Hoc* Networks

KATRIN SJÖBERG

2014-04-15

Abstract:

Cooperative intelligent transport systems (C-ITS), where vehicles cooperate by exchanging messages wirelessly to avoid, for example, hazardous road traffic situations, receive a great deal of attention throughout the world currently. Many C-ITS applications will utilize the wireless communication technology IEEE 802.11p, which offers the ability of direct communication between vehicles, i.e., *ad hoc* communication, for up to 1000 meters. In this thesis, medium access control (MAC) protocols for vehicular *ad hoc* networks (VANET) are scrutinized and evaluated. The MAC protocol decides when a station has the right to access the shared communication channel and schedules transmissions to minimize the interference at receiving stations. A VANET is a challenging network for the MAC protocol because the number of stations in is unknown *a priori* and cannot be bounded. Therefore, the scalability of the MAC method has a major influence on the performance of C-ITS applications.

Two different MAC protocols are studied: carrier sense multiple access (CSMA) of 802.11p and self-organizing time division multiple access (STDMA). These two MAC methods are examined with respect to the communication requirements and protocol settings arising from C-ITS standardization. Based on these constraints, suitable performance measures are derived such as MAC-to-MAC delay and detection distance, where the former catches both the delay and reliability.

In STDMA, the channel access delay is upper-bounded and therefore known before transmission, since regardless of the number of stations within radio range, all stations are always guaranteed timely channel access. In CSMA, the channel access delay is not upper-bounded and it is unknown until transmission commences, as it is based on the instantaneous channel load and stations can experience a random delay when in backoff.

The evaluation of CSMA and STDMA is performed through extensive computer simulations, modelling a 10 km highway with six lanes in each direction. Vehicles travel along the highway and broadcast position messages periodically with different update rates. Two different channel models have been used during the evaluations, one distinguishing between a receiver being in line-of-sight (LOS) or obstructed LOS (OLOS) from the transceiver, while the other does not consider this.

The simulation results, for both channel models, show that CSMA has on average a smaller channel access delay than STDMA. However, the results also reveal that STDMA always achieves a better reliability than CSMA, especially for distances of 100-500 meters between transmitter and receiver. The distance, at which approaching stations receive the first messages from each other, is up to 100 meters longer for STDMA than CSMA. This thesis therefore concludes that STDMA is a very suitable MAC method for VANET-based C-ITS applications.

Keywords: CSMA, self-organizing TDMA, STDMA, SOTDMA, medium access control, MAC, vehicular ad hoc networks, VANET, vehicle-to-vehicle communications, V2V, V2X, IEEE 802.11p, WAVE, DSRC, ETSI ITS-G5, ISO CALM M5, real-time communications, scalability, traffic safety, cooperative system, cooperative ITS, C-ITS