Predictable and Scalable Medium Access Control for Vehicular Ad Hoc Networks

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Abstract

This licentiate thesis work investigates two medium access control (MAC) methods, when used in traffic safety applications over vehicular *ad hoc* networks (VANETs). The MAC methods are carrier sense multiple access (CSMA), as specified by the leading standard for VANETs IEEE 802.11p, and self-organizing time-division multiple access (STDMA) as used by the leading standard for transponders on ships. All vehicles in traffic safety applications periodically broadcast cooperative awareness messages (CAMs). The CAM based data traffic implies requirements on a predictable, fair and scalable medium access mechanism. The investigated performance measures are *channel access delay, number of consecutive packet drops* and the *distance between concurrently transmitting nodes*. Performance is evaluated by computer simulations of a highway scenario in which all vehicles broadcast CAMs with different update rates and packet lengths. The obtained results show that nodes in a CSMA system can experience *unbounded channel access delays* and further that there is a significant difference between the best case and worst case channel access delay that a node could experience. In addition, with CSMA there is a very high probability that several *concurrently transmitting nodes are located close to each other*. This occurs when nodes start their listening periods at the same time or when nodes choose the same backoff value, which results in nodes starting to transmit at the same time instant. The CSMA algorithm is therefore both *unpredictable* and *unfair* besides the fact that it *scales badly* for broadcasted CAMs. STDMA, on the other hand, will always grant channel access for all packets before a predetermined time, regardless of the number of competing nodes. Therefore, the STDMA algorithm is *predictable and fair*. STDMA, using parameter settings that have been adapted to the vehicular environment, is shown to outperform CSMA when considering the performance measure *distance between concurrently transmitting nodes*. In CSMA the distance between concurrent transmissions is random, whereas STDMA uses the side information from the CAMs to properly schedule concurrent transmissions in space. The price paid for the superior performance of STDMA is the required network synchronization through a global navigation satellite system, e.g., GPS. That aside since STDMA was shown to be scalable, predictable and fair; it is an excellent candidate for use in VANETs when complex communication requirements from traffic safety applications should be met.

Keywords: CSMA, self-organizing TDMA, STDMA, 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