Proposition de recherche doctorale

Spatio-Temporal Relevance of Information for Local Information Dissemination in VANETs

Mots clés :

- Directeur de thèse : Jérôme Härri
- Co-encadrant(s) :
- Unité de recherche : Laboratoire de recherche d'EURECOM
- École doctorale : École Doctorale Informatique, Télécommunications, Électronique de Paris
- Domaine scientifique principal: Divers

Résumé du projet de recherche (Langue 1)

After the huge success of passive safety systems and similar success indicators seen with recent advanced driver assistance systems towards a "zero accidents" vision in future Intelligent Transport Systems (ITS), the next big potential is seen in cooperative systems. For this to become reality, a robust and reliable vehicle-to-vehicle and vehicle-to-roadside information exchange is a necessary prerequisite as an enabling technology. In Europe ETSI TCITS is paving the way towards this by standardizing the communication in Vehicular Ad-hoc NETworks (VANETs). The VANET communication architecture follows basically the layered approach as proposed by ISO-OSI, with some additional vertical planes for cross layer information exchange. The most important layers for this thesis are the Medium Access Control (MAC) layer, the Facility layer and the applications. On the MAC layer, the basic access scheme is Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), a probabilistic and thereby non-deterministic access technique. It is part of the ETSI ITS-G5 technology in Europe, which is based on IEEE 802.11p, an amendment of the Wireless Local Area Network (WLAN) specification adopted to VANETs. The interface between the applications and the communication part of the lower layers is realized by the facility layer. It is predominantly responsible for the transmission of Cooperative Awareness Messages (CAMs) and Decentralized Environmental Notification Messages (DNMs) and the associated information aggregation. CAMs are broadcasted periodically and include information about the status of the transmitting vehicle. They are used to create awareness for each vehicle and are the basic messages for multiple safety applications like Cooperative Adaptive Cruise Control (CACC) or Lane Change Warning (LCW). DNMs are event based messages, i.e. they are generated on an event and kept alive in a certain geographic area as long as the event is valid (geobroadcast). Safety applications based on DNMs are for instance Emergency Brakelight Warning (EBLW) and Road Hazard Warning (RHW). Independently, which type of messages are transmitted, the vehicles in the immediate vicinity, either of other vehicles or event location, have to be informed quickly and reliably. As a result, how to perform a reliable and low-latency 1-hop broadcast is still an important research question within the VANET research community.

Résumé du projet de recherche (Langue 2)
2.1 Basic problems in VANET communications CSMA/CA is the basic medium access technology in VANETs. It was inherited by the already existing WLAN specification IEEE 802.11, which was actually designed for static wireless networks. Some minor modifications, such as the operation mode "outside the context of a Basic Service Set (BSS)" i.e. omitting the association/deassociation procedures, have been adapted for VANETs. Due to its probabilistic and non-deterministic access mechanism, a maximum latency for the channel access can not be guaranteed. Moreover, the CSMA/CA access scheme is known for its rapid performance degradation the more vehicles try to access the channel. The reason for that is the increasing probability of packet collisions during transmission. Because the most applied communication mode in VANETs is the (geo-)broadcast mode, no acknowledgments are used to inform the transmitter about correct packet receptions. On top of that, broadcasting can lead again to the famous "hidden terminal problem" and "exposed terminal problem" in wireless networks, because no RTS/CTS mechanisms can be used for broadcasting. As a result, the used access technology might not be appropriate for safety applications, which rely on quick and reliable 1-hop broadcasts.

2.2 The research question The basic research question we address in this thesis is the following: How to provide reliable 1-hop broadcast information dissemination using an unreliable medium access technology? Our initial statement on that is: A 100 % reliable information dissemination is not required everywhere and everytime! The relevance of information is space and time dependent, taking account of the application requirements! The relevance of information depends on the importance of certain information dependent on the current situation. The current situation is influenced by time, space, driver, vehicle, environment, etc. The main focus of this thesis is the relevance of information for applications dependent on space and time. Currently, the requirements of the basic set of applications have been chosen very loosely. For most of the applications a maximum latency and a minimum transmission frequency is given in the standard documents. Fixed requirement definitions of this kind are not time and space dependent. Consequently, multiple applications running in parallel, the communication part have to fulfill different requirements for the information relevance or specifically different information relevance, and hence their requirements regarding the transmission profile. If multiple applications are running in parallel, the communication part have to fulfill different requirements for the information relevance or specifically different transmission profiles for the different applications. Because there is only one communication part for several applications, a necessary investigation is to find a way how to adapt the transmission profile to fulfill the requirements of all applications. Thereby, it has to be considered, that different applications can have mutual influence with respect to their requirements.

2.3 Approach According to the problem description above, the main goals of this thesis will be to identify the relevance of information for different applications, and find out how to optimize the 1-hop broadcast, especially for multiple applications running in parallel.

For this purpose, the following hypotheses will be investigated in more detail: 3.1 Hypothesis 1: The relevance of information is space and time dependent, taking account of the application requirements! The relevance of information depends on the importance of certain information dependent on space and time. First the spatio-temporal aspects of information relevance and time and space dependent, taking account of the application requirements! The relevance of information defines the importance of certain information aspects. The consideration of information theoretic aspects is completely missing within the standardization process, and is still an important research topic in the community. Due to the unpredictability of a wireless channel, a 100 % reliable packet transmission is not possible, anyway. But this is not absolutely necessary. It is important to disseminate information to vehicles where and when it is relevant. The relevance of information about a certain vehicle has not the same value everywhere and everywhere, i.e. it is time and space dependent. Considering a platoon of vehicles running CACC, it is more important to be aware of the vehicles ahead. On the contrary for LCW it is more important to be aware of the fast approaching vehicles behind. According to the application, the information relevance in time and space is different. Consequently, multiple applications running on one vehicle have different requirements according to the awareness because of the diverse relevance of information. 3.2 Hypothesis 2: Transmission parameters have an influence on the spatio-temporal behavior of information relevance. The variation of transmission parameters and their influence on the spatio-temporal behavior of information relevance have to be investigated. A current setting of transmission parameters is defined as a transmission profile. A transmission profile can be used to fulfill a certain spatio-temporal information relevance requirement. 3.3 Hypothesis 3: Applications have different requirements on information relevance. By means of the investigations above, some example applications, like CACC, have to be chosen. These applications have to be analyzed to identify their requirements with respect to spatio-temporal aspects of information relevance, and hence their requirements regarding the transmission profile. If multiple applications are running in parallel, the communication part have to fulfill different requirements for the information relevance or specifically different transmission profiles for the different applications. Because there is only one communication part for several applications, a necessary investigation is to find a way how to adapt the transmission profile to fulfill the requirements of all applications. Thereby, it has to be considered, that different applications can have mutual influence with respect to their requirements. 3.4 Hypothesis 4: Dynamic transmission profile adaption can increase the reliability of applications despite of varying situations. Because the application requirements vary in time and space, also the transmission profile has to be adapted in time and space. By the ability of detecting the situation including cooperative information exchange, the transmission profile can be adapted over time and space, corresponding to the current situation and its application requirements. This can improve the application reliability in general.