Advanced Network Solutions for Cooperative Systems supporting Intelligent Transport Services

Wim Vandenberghe

Supervisor(s): Ingrid Moerman

I. Intelligent Transport Systems

Intelligent Transport Systems (ITS) are ICT systems that enable a more efficient and safer traffic through the use of a wide range of diverse technologies. ITS systems combine (wired and wireless) communication systems, innovative applications and services, integrated electronics and numerous other technologies in a single platform. In the ITS domain, Cooperative Systems are innovative applications that rely on vehicle-to-vehicle (V2V) and local vehicle-to-infrastructure (V2I) communication to increase the "time horizon", the quality and reliability of information available to the drivers about the road conditions and other vehicles and road users in their immediate environment.

The entire ITS spectrum enables a large number of applications with an important social relevance, both on the level of the environment, mobility and traffic safety. When approaching dangerous situations such as a the tail of a traffic jam, an obstacle on the road or a ghost driver, ITS systems make it possible to warn drivers in time to avoid collision. Detected hazardous road conditions such as black ice or an oil trail can be automatically communicated to other drivers. Navigation systems can receive detailed real-time updates about the current traffic situation and can take this into account when calculating their routes. When a traffic distortion occurs, traffic centers can immediately take action and can actively influence the way that the traffic will be diverted. Drivers can be notified well in advance about approaching emergency vehicles, and can be directed to yield way in a uniform manner. This is just a small selection from the large number of applications that are made possible because of ITS systems, but it is very obvious that these systems can make a significant positive contribution to traffic safety. In literature it is estimated that the decrease of accidents with injuries of fatalities will be between 20% and 50% [1].

II. Communication Architecture

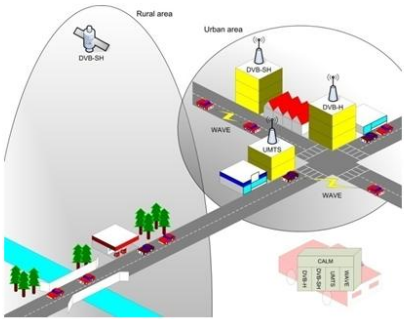

Figure 1: Communication architecture

Attracted by the high potential of ITS systems, the academic world, the standardization bodies and the industry are all very actively involved in research and development of ITS solutions. The pillars of these systems are the communication facilities connecting the vehicles, the roadside infrastructure and the centralized safety and comfort services. Several wireless

W. Vandenberghe is with the Department of Information Technology, Ghent University (UGent), Gent, Belgium. E-mail: wim.vandenberghe@intec.ugent.be .

technologies can be considered when designing ITS architectures, and they can be divided into three categories: Dedicated Short Range Communication (DSRC), wireless Wide Area Networks (WAN) and digital broadcast technologies. Due to the diverse nature of the different technologies, any ITS architecture will always consist of a combination of them (Figure 1).

III. Scalability Problem

One of the key technologies of the ITS communication architecture is the new IEEE 802.11p standard, an amendment to the very successful IEEE 802.11 WLAN standards. However, a major downside of this technology was described in recent literature: it cannot handle scenarios with a dense distribution of communication nodes [2],[3]. This scalability problem could turn out to be a major stumbling block when starting the deployment of Cooperative Systems.

In this doctoral research, one of the most important goals is to define routing protocols for Vehicular Ad Hoc Networks (VANETs) that provide solutions for this key issue. These IPv6 based routing protocols try to combine different aspects of the most common routing protocols with other techniques that could have a positive impact on scalability. Also, the routing should not only support scalable unicast communication, but it is at least as important that it can provide scalable local broadcasting of data.

IV. Development Environment

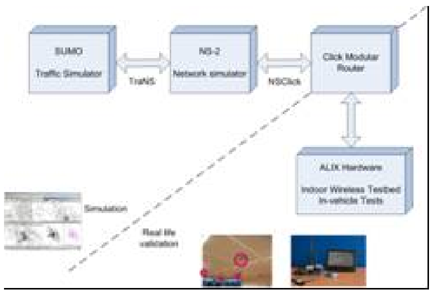

Figure 2: Development Environment

To validate these developed solutions, a versatile development environment is required (Figure 2). When targeting the scalability issues, a network simulator is an indispensable tool. However, the vehicular nature of the ad hoc networks leads to specific mobility and connectivity patterns which highly influence the performance of the routing protocols. Therefore, the static network simulator should be connected to a vehicular traffic simulator. Experience learned that simulations should always be combined with real life testing. For these tests, we fortunately have access to the IBBT iLab.t Wireless Lab, an indoor test facility that consists of approximately 200 embedded PC's. The final part of the research environment is a small scale testbed for testing in real vehicles. It is based on the same embedded PC's as the Wireless Lab, but extended with additional hardware for easy use in vehicles. The glue binding the different components of the development environment together is the Click Modular Router. The IPv6 based VANET routing protocols are all implemented in Click, and can be run on both the Wireless Lab and the small scale vehicular testbed. On the other hand, without modifying the source code, the same implementation can be tested on the NS-2 network simulator, which is coupled to the vehicle traffic simulator SUMO through the open source TraNS framework. This way, all specific aspects of VANET protocols can be comprehensively tested with minimum overhead.

References

[1] Trace project, *Review of crash effectiveness of Intelligent Transport Systems*, D4.4.4-D6.2, 2007

[2] Eichler, S, *Performance evaluation of the IEEE 802.11p WAVE communication standard* in Proceedings of the Vehicular Technology Conference (Baltimore, 2007)

[3] Kosch, T, Adler, C, Eichler, S, et al, *The scalability problem of vehicular ad hoc networks and how to solve it*, Wireless Communications, IEEE, Volume 13, Issue 5, October 2006, pp. 22-28