Vehicular Ad Hoc Networks
Research and Standardization in Europe

Dr. Andreas Festag

NEC Laboratories Europe, Network Division

Kurfürstenanlage 36, D-69115 Heidelberg, Germany

Ad hoc networks in general allow for a wide range of application, ranging data networking in home environments and personal area networks to city mesh networks and airborne ad hoc networks. Among these, vehicular ad hoc networks (VANETs) for vehicle-to-vehicle and vehicle-to-infrastructure communication have received particular attention in the past years. For other scenarios, a break through from research and development to widespread deployment and commercial operation seems to be far away. Due to the joint efforts of many parties – vehicle manufactures and suppliers, governments and research organizations, and the society at large – for safer, cleaner and smarter roads, vehicular communication represents a use case for sustainable deployment of ad hoc technology. Considering 180 million vehicles in Europe, VANETs will potentially deploy ad hoc networks in an enormous scale.

VANETs enable vehicles to directly communicate with other vehicles and allow for real-time interaction among them. For example, a vehicle may periodically provide status information, such as position, speed and heading. By that a driver knows if a car is on a conflicting course. Or a car may disseminate an accident warning triggered by its airbag sensor to all vehicles in a geographical area of its vicinity. Ad hoc networking can provide timely information about the road traffic situation in general and about neighboring vehicles in particular beyond a driver's range of vision. Moreover, drivers and passengers can benefit from infotainment applications, for example local information, inter-car games and messaging and data access.

One obstacle to introduce VANETs for road safety in Europe was the lack of a dedicated frequency spectrum. Compared to North America and Japan, the process for frequency allocation is considerably complex and time consuming since all European countries and their national authorities are involved. Today, major steps are taken after few years of work for frequency regulation and re-deployment: analysis of spectrum requirements, request for the proposed spectrum, study of compatibility aspects, and recommendation of policies for harmonized spectrum usage. A decision by the European Commission to designate the spectrum is expected mid of this year and will be implemented by the EU countries after few months. Eventually, the frequency bands 5875–5905MHz for road safety, additional 20MHz above this band as future extension, and 5855–5875MHz for non-safety will be available. The allocated frequency of 50MHz and optional the additional 20MHz are similar to the 75MHz ITS band in North America.

Significant technical developments for vehicular ad hoc networks in Europe are carried out in collaborative research projects, on national and European level. Among the various initiatives, this newsletter highlights three R&D projects – NoW – Network on Wheels, GeoNet and COMeSAFETY.

- The German R&D project 'NoW – Network on Wheels' (http://www.network-on-wheels.de) has completed the development of a communication system based on WLAN and ad hoc technology and integrates safety and infotainment applications in a single system. The project has studied enhancements of ad hoc networking based on geographical addressing, improving efficiency and reliability of data transmission and

information dissemination, data security and anonymity aspects. Started in 2004, the final project presentation in May 2008 demonstrated a consolidated technical basis, which serves as reference for planned field. One of the main outcomes of the project is a prototype software platform for car-to-car and car-to-infrastructure communication (http://c2x-sdk.neclab.eu). It provides the protocol stack and an open API and offers a toolkit for application design, implementation and testing.

- The EU project GeoNet (http://www.geonet-project.eu/), started in February 2008, implements a reference system for vehicular ad hoc networking using concepts for geographical addressing and routing. Particular focus lies on integration of GeoNetworking with IPv6 and solutions for IP mobility support. In GeoNet, a vehicle is regarded as a mobile network, where the NEMO protocol handles Internet connectivity of the nodes in the mobile network with intermittent access to roadside units. For wide deployment of the project results, it is planned to provide the GeoNet implementations to other R&D projects.

- 'COMeSAFETY' (http://www.comesafety.org/) is a support activity, which coordinates the European research and standardization efforts for vehicle-to-vehicle and vehicle-to-infrastructure communication as the basis for cooperative intelligent road transport systems. In close cooperation with all stakeholders, the project is defining a common European architecture that harmonizes current activities and represents a framework for future deployment of the systems. A common European ITS architecture will fasten the technical developments and consequently the future deployment of the systems.

A major driving force for vehicular communication based on WLAN technology in Europe is the Car-to-Car Communication Consortium, C2C–CC (http://www.car-to-car.org), a consortium of car manufacturers, suppliers and research institutes. The C2C-CC assimilates developments from various European R&D projects, creates system and protocol specifications, and provides a framework for system prototyping. In 2007, the C2C-CC made a substantial step forward and published its 'manifesto' describing the main concepts of the system, covering system and protocol architecture, use cases and communication protocols. A core concept of C2C-CC's networking approach is based on wireless ad hoc and multi-hop communication utilizing geographical addressing and routing. Currently, the consortium is planning a major event for October 2008 demonstrating first interoperability among cars from different car manufacturers and suppliers of on-board and roadside units. The event will showcase real-live demonstrations of safety applications for tangible ad hoc networks.

The European Telecommunications Standards Institute, ETSI, has recently created a new Technical Committee TC ITS in order to develop standards and specifications for ITS services. The TC ITS is organized in five working groups: WG1 - User & Application requirements, WG2 - Architecture and cross layer issues, WG3 - Transport and Network, WG4 - Media and related issues, and WG5 - Security. The working groups have already agreed on a number of work items for various aspects of vehicular communication including media, networking, security and safety applications. In WG3, the current focus is on specification of ad hoc networking based on geographical addressing and routing. In order to allow for use of different media, the specification distinguishes between media-independent and media-dependent network functions. The specifications are backed by other work groups, which specifically address media and security issues, such as a European profile standard of IEEE 802.11 for ITS. The technical committee is developing a road map for standardization developments for the coming years in order to achieve a complete set of standards ranging from communication architecture to protocol specifications together with formal test procedures.

For future vehicular communication, ad hoc networking based on WLAN technology plays a crucial role. It enables direct and rapid communication among vehicles and from vehicles to infrastructure networks. One of the core concepts is ad hoc routing based on geographical positions. The technical base is being built in national and European R&D projects, the Car-to-

Car Communication Consortium further adopted the technical concept and promotes its specification, and the recently founded ETSI technical committee ITS creates protocol specifications and test procedures. All three measures ensure a sustainable deployment of vehicular ad hoc networking in Europe. A missing pillar is a field tests on a large scale. Such Field Operational Trials (FoT) for cooperative systems will start in 2008: SIM-TD is a German project, which equips hundreds of cars and roadside units. Similar activities are under preparation in many countries across Europe, such as VOLTAIRE in France. Also, the project PREDRIVE-C2X starts in mid 2008 in order to prepare trials on a European basis and develop appropriate methodologies. All trials have two main objectives: (i) validation of ad hoc networks under realistic conditions. (ii) Provide an evidence for the positive effect of ad hoc networking on road safety. If both are achieved, vehicular ad hoc networks for road safety and infotainment in Europe foresees a bright future and wide-scale deployment.