

Chapter 14

QoS in Vehicular Communication Networks

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ABSTRACT

Vehicular communication networks (VCNs) have emerged as a key technology for next-generation wireless networking. DSRC/WAVE as a leading technology for VCN provides a platform for Intelligent Transportation System (ITS) services, as well as multimedia and data services. Some of these services such as active safety and multimedia services have special requirements for QoS provision. However, when providing QoS, the VCN characteristics are the cause for several new issues and challenges, especially when vehicles travel at high speeds of up to 200 km/h. These issues are addressed in the context of roadside networks and vehicular ad hoc (unplanned) networks (VANETs), including vehicle-to-vehicle (V2V) and vehicle-to-roadside (V2R) communications. Accordingly, plenty of solutions for provisioning QoS in VCNs have been classified in regards to VANETs and roadside networks, on the one hand, and to layer-2 and layer-3, on the other hand. Consequently, several QoS solutions, including medium access and routing protocols, are presented and discussed. Additionally, open research issues are discussed, with an objective to spark new research interests in the presented field.

INTRODUCTION

Vehicular communication networks (VCNs) have emerged as a key technology for next-generation wireless networking. Several national and international organizations (IEEE, ASTM, ISO, etc.), public transport authorities (US Department of Transporta-

tion and equivalent transport authorities in Europe and Japan, etc.), and vehicle manufacturers (DaimlerChrysler, BMW, GM—General Motors, Renault, Toyota, etc.) have been corporately working on the development of standards for VCNs. Accordingly, various projects are underway (AKTIV, COOPERS, etc.) or were completed just recently (FleetNet, ASV 4, VSC, etc.). Several consortia (C2C-CC, VSCC, etc.) were set up to explore the potential of VCNs

DOI: 10.4018/978-1-61520-680-3.ch014

(Hartenstein & Laberteaux, 2008). These projects are funded substantially by national governments and involve several constituencies, including the automotive industry, the road operators, tolling agencies, and other service providers.

While the adoption of vehicle manufactures for information technology address safety issues mainly, environmental and comfort issues of vehicles have accelerated the development process of VCNs (Hartenstein & Laberteaux, 2008). The increasing demand for broadband wireless services for Intelligent Transportation Systems (ITS) technologies, besides the wide use of IEEE 802.11, has led to adoption of the DSRC/WAVE - Dedicated Short Range Communications (DSRC) in accordance with IEEE 802.11p and IEEE 1609 Wireless Access in Vehicular Environments (WAVE) standards (Federal Communications Commission [FCC], 2004; DOT-HS810591, 2006). Furthermore, several national and regional governments contribute licensed spectrum for vehicular wireless communication, generally in the 5.8/5.9 GHz band and at least in Japan, the 700 MHz band (Stibor, Zang, & Reuerman, 2007). For instance, the U.S. Federal Communications Commission (FCC) has allocated 75 MHz of Radio Spectrum at 5.9 GHz band for DSRC (FCC, 2004).

Since VCNs form the basis for supporting not only the ITS-services, especially public-safety-related applications, but also a wide range of future multimedia and data applications, such as audio/video as well as e-maps and road/vehicle-related services (Su & Zhang, 2007), vehicles are envisaged to become a part of the Internet in the near future, either as mobile endpoints, as mobile backbone routers, or as mobile sensors (Kutzner et al., 2003). Thus, VCNs must support QoS for a number of applications and services, especially real-time applications addressing safety and VoIP services (Bossom et al., 2008). However, the dynamic architecture of the VCN, especially within the access level network, in which vehicles can move with speed of even more than 200 km/h, forms the main challenge for adopting the already

existing QoS-models and solutions. To investigate related issues and solutions, this chapter deals with QoS-mechanisms, protocols and models for VCNs and concentrates on DSRC/WAVE as the leading technology for vehicular communications (Berger, 2007).

This chapter presents a detailed investigation of the current state-of-the-art of QoS-mechanisms, protocols and models for DSRC/WAVE-based VCNs and related solutions. Furthermore, open research issues in all protocol layers are also discussed, with an objective to spark new research interests in this field. The rest of this chapter is organized as follows. First of all, we briefly describe the specifications of DSRC/WAVE and related network architectures, as well as real-time applications and their QoS requirement. Then, the main issues and challenges for adopting QoS in VCNs are addressed. After that is done, we will classify the considered solutions in accordance with roadside networks and vehicular ad hoc networks, on the one hand, and with layer-2 and layer-3, on the other hand. Consequently, we present several QoS solutions, including medium access and routing protocols, to reflect the state of the art in this field. Finally, we summarize our chapter in the last section.

DSRC/WAVE: Background and Network Architecture

The DSRC/WAVE specifies using IEEE 802.11p for physical and MAC layers, while using IEEE 1609 for the upper layers. The IEEE 1609 family of WAVE defines the architecture, communications model, management structure, security mechanisms and network access for wireless communications in the vehicular environment. Additionally, IEEE 1609 family consists of four (trial-use) standards: 1609.1 for specifying the services and interfaces of resource manager applications; 1609.2 for defining security services for applications and management messages, including message format and processing; 1609.3 for

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