Chapter 14
Experience Developing a Vehicular Network Based on Heterogeneous Communication Technologies

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ABSTRACT

This chapter describes the experiences and findings deploying a vehicular network architecture supporting different communication technologies. This approach has been developed taking into account key issues regarding mobility and security. These two aspects have been provided by means of the NEMO and IKEv2 protocols, respectively. In addition, thanks to the EAP protocol, transported by IKEv2, an extensible authentication method can be used to implement an access control mechanism. This work also focuses on how the terminal is aware of the surrounding environment in order to boost the handoff processes among heterogeneous networks using the IEEE 802.21 protocol. Apart from the description of the on-board system architecture, a WiMAX/WiFi deployment has been set up at the infrastructure side to validate the development of the mobility and security environment designed for vehicular networks.

DOI: 10.4018/978-1-4666-0209-0.ch014
INTRODUCTION

The world of wireless communications has undergone exponential evolution in recent years. The “wireless” concept is growing in importance day by day, together with new mobility and security needs which arise in this context. Wireless communication devices move within a determined coverage range and communicate my means of an air medium, which is exposed to any other terminal in the surroundings. This is the reason why extended security mechanisms are needed. Moreover, these devices are usually provided with extended network capabilities using several technologies simultaneously, such as WiFi, Bluetooth, 3G, Wi-MAX, etc., each one covering a range of scenarios determined by its particular features regarding communication range, latency, throughput or jitter. Vehicular networks present a challenging field where mobility and security through several communication mediums are key issues.

In this kind of heterogeneous scenario in which more than one technology is present, deciding when to switch from one communication technology to another (i.e. inter-technology or vertical handover) is quite complex, even more so considering high mobility vehicular scenarios. To make the best decision each time, the information gathered from the surrounding wireless infrastructure must be evaluated, taking into account many parameters obtained from the different information sources, i.e. network layer, communication transceivers, and user preferences. Here is where the 802.21 (IEEE Std. 802.21, 2008) protocol can be greatly useful, supporting the handoff process between two communication technologies. Cross-layer multi-parameters can be used together with techniques such as fuzzy logic, neural networks, and pattern recognition, among others, to decide the feasibility of the handover.

Apart from link-level issues, a change in the (physical) point of attachment to a network may cause changes at network-layer level if a new IP address is assigned (inter-domain handover). Mobility at network layer is one of the main aspects to take into account in vehicular networks (Stephan & Michele, 2009). In this work, NEMO (Network Mobility) (Devarapalli, Wakikawa, Petrescu, & Thubert, 2005) is used to cope with this requirement. This protocol is an evolution of MIPv6 (Johnson, Perkins, & Arkko, 2004), where the new concept of “mobile router” is introduced. By using NEMO, a mobile equipment acts as router for a mobile network and allow mobile network nodes to maintain their IP address despite changing the mobile router attachment point in visited networks. As explained in the rest of the chapter, NEMO is used to support network mobility in the proposed vehicular network.

Among the various technologies applicable for medium-range communications, the IEEE 802.16 standard (IEEE Std. 802.16, 2004) presents a communication media that can be quite useful in vehicular networks. Commonly known as WiMAX, it was originally devised for point-to-point scenarios to provide connectivity to small isolated populations or buildings belonging to the same company. But nowadays, the appearance of the 802.16e extension (IEEE Std. 802.16e, 2005) allows deploying wide-range wireless infrastructures for mobile scenarios. 802.16e is placed midway between WiFi (IEEE Std. 802.11g, 2003) and 3G (3G/UMTS Evolution, 2006), with coverage ranges in the order of several kilometers. This kind of wireless infrastructure can be more suitable for vehicular networks than common WiFi, due to the large distances a vehicle can travel in a short period of time.

Operators have considered WiMAX technology as a business opportunity, using licensed frequency bands. However, it is possible to use license-free frequency bands for WiMAX-based infrastructures. As a proof of concept, a pilot WiMAX infrastructure has been deployed at the University of Murcia using these license-free bands. The Espinardo Campus has been chosen as a testbed area within the University of Murcia.