Chapter 71
WLAN Systems for Communication in Transportation Systems:
Towards the Benefits of a Cooperative Vehicular Approach

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ABSTRACT

Vehicular Ad-Hoc Networks (VANETs) are wireless networks primarily meant to enforce vehicular safety. The incumbent international VANET solution is based on an adaptation of WLAN to the 5.9 GHz band and to the vehicular environment: it is universally known as IEEE 802.11p. One of the main reasons for the success of IEEE 802.11p lies on the functional requirement of a decentralized solution, that is, one able to work in the absence of infrastructure. While Filed-Operational Tests are being developed world-wide and new VANET applications, not restricted to safety, are being developed, new requisites are emerging. Some limitations of the IEEE 802.11p are coming to light as well: stakeholders must be aware of them to prevent misleading conclusions on reliability and, most importantly, improper solutions for the safety which the protocol is aimed at.

INTRODUCTION

The communication systems adopted by transportation systems can be classified according to their role; for instance, a possible distinction can be made between communications which are restricted on-board and others spanning multiple vehicles. Wireless is basically used for vehicle-to-vehicle communications – when possible, cables are still considered much more reliable. In recent years, wireless has been intensively investigated for transportation. In particular, focusing on the automotive field, cooperation between cars has been proposed with the main goal of enforcing safety; wireless is considered the main enabler of this approach. The rationale behind it is to let vehicles exchange information (such as position, speed, obstacles, etc.) so as to prevent possible

DOI: 10.4018/978-1-4666-8473-7.ch071

accidents, or to allow timely reaction to ones which have already occurred.

For instance, *eCall* is a European initiative whose aim is rapid assistance to drivers involved in a collision anywhere in Europe, as suggested by the European Commission (2011). The project involves deploying a hardware black box, to be installed in vehicles, collecting on-board data - for instance airbag and impact sensor information, GPS coordinates – and forwarding it to local emergency agencies (by dialing 112), in case of an accident. The project is also supported by the European Automobile Manufacturers Association (ACEA) and ERTICO; implementation is expected by 2015. In North America, a similar service is available from OnStar Service, a subsidiary of General Motors. Their new service, called Advanced Automatic Crash Response (AACR), is designed to assist emergency response efforts. The example of eCall is particularly interesting because it demonstrates how much the international community can work jointly and in a concerted way towards a common goal when safety is concerned: at present, 22 EU Member States formally declared their support for a Europe-wide eCall system.

Based on the experience of eCall, one could think that mobile networks can be used for the collection of additional information about other vehicles and roads, contributing to the prevention of accidents. This adheres to the idea of the telematics horizon, a concept which has been explored by several research projects: the extension of a vehicle's field of vision, providing the driver with information spanning hundreds of meters, much beyond the natural visual horizon. In principle, UMTS and WiMax would be two candidates: they both support mobility (even at vehicular speeds) and have migrated to a data-oriented paradigm (rather than a voice one). However there are some non-negligible aspects which hinder their application. First of all they require an expensive and capillary coverage. This means that, in order to have a reliable service, all the roads would have to be covered by a mobile infrastructure. Furthermore, mobile services are expensive and it is not clear who should pay for them: if a subscription were required, it would probably not be mandatory; on the other hand, if not mandatory, only a few cars would be equipped, so the safety service, which is intrinsically based on the concept of cooperation, would not work. The other alternative would be for the infrastructure to be paid for by governments, but this would hardly be sustainable economically. From a technical point of view, safety services require real-time delivery, roughly within 100ms: given the set-up time of a call, the strict end-to-end delay would imply that each car were always connected – so as to skip the call set-up. The main drawback would be on the scalability of the mobile network: it could hardly manage the number of subscribers of a metropolitan area.

Altogether this led to the conclusion that a wireless network with infrastructure would not be the most appropriate solution for vehicular safety communications. The other possible paradigm is that of *Ad-Hoc Networks*. In the following sections, after a brief introduction to Vehicular Ad-Hoc Networks (VANETs) and Services, the main phenomena affecting VANETs will be covered. Based on this preliminary analysis, the incumbent international solution will then be discussed, highlighting its strengths and weaknesses.

VEHICULAR AD-HOC NETWORKS

The paradigm of ad-hoc networks requires that wireless devices communicate with each other directly: hence, wireless nodes, which are in the respective radio ranges, mutually discover and communicate in peer-to-peer fashion, without involving any central coordinators. While the infrastructure mode (with the so called *access points* - AP) is the most common way in which WiFi is used, the ad-hoc mode is already included in WiFi IEEE 802.11 (2007).

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