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A comprehensive survey on vehicular Ad Hoc network

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ABSTRACT

Vehicular ad hoc networks (VANETs) are classified as an application of mobile ad hoc network (MANET) that has the potential in improving road safety and in providing travellers comfort. Recently VANETs have emerged to turn the attention of researchers in the field of wireless and mobile communications, they differ from MANET by their architecture, challenges, characteristics and applications. In this paper we present aspects related to this field to help researchers and developers to understand and distinguish the main features surrounding VANET in one solid document, without the need to go through other relevant papers and articles starting from VANET architecture and ending up with the most appropriate simulation tools to simulate VANET protocols and applications.

1. Introduction

At the present time cars and other private vehicles are used daily by many peoples. The biggest problem regarding the increased use of private transport is the increasing number of fatalities that occur due to accidents on the roads; the expense and related dangers have been recognised as a serious problem being confronted by modern society. VANET provides a wireless communication between moving vehicles, using a dedicated short range communication (DSRC). DSRC is essentially IEEE 802.11a amended for low overhead operation to 802.11p; the IEEE then standardises the whole communication stack by the 1609 family of standards referring to wireless access in vehicular environments (WAVE). Vehicle can communicate with other vehicles directly forming vehicle to vehicle communication (V2V) or communicate with fixed equipment next to the road, referred to as road side unit (RSU) forming vehicle to infrastructure communication (V2I) (Olariu and Weigle, 2009; Moustafa and Zhang, 2009; Jiang et al., 2006).

These types of communications allow vehicles to share different kinds of information, for example, safety information for the purpose of accident prevention, post-accident investigation or traffic jams. Other type of information can be disseminated such as traveller related information which is considered as non-safety information. The intention behind distributing and sharing this information is to provide a safety message to warn drivers about expected hazards in order to decrease the number of accidents and save people's lives, or to provide passengers with pleasant journeys.

This field attracts researchers from different fields to develop VANET applications, protocols and simulation tools. Several challenges are facing researchers and developer. Therefore, several papers and articles have tried to cover these issues. Hartenstein and Laberteaux (2008) have investigated the communication and networking aspects of this technology and addressed the security and privacy issues. While, Li and Wang (2007) focus on the routing protocols of VANET and their requirements to achieve better communication time with less consumption of network bandwidth. Lin et al. (2010) investigate the categories of routing protocols in VANET and the idea behind each of them. In this paper, we present a key document which can provide detailed information to researchers and developer so as to understand the main aspects and challenges related to VANET. It covers different issues such as network architecture, communication domains, challenges, applications and simulation tools.

The rest of this paper is structured as follows. We start in Section 2 with describing the network architecture. Section 3 presents the communication domains in VANET. In Section 4, we discuss the wireless access technologies that can be used to establish the communication of the network. Section 5 presents the unique characteristics of VANET. Network challenges and requirements are discussed in Section 6. Section 7 will give a comprehensive explanation for the applications enabled by VANET communications. VANET simulation tools are given in Section 8 before we sum up our paper with a conclusion in Section 9.

2. VANET architecture

The communication between vehicles, or between a vehicle and an RSU is achieved through a wireless medium called WAVE.

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This method of communication provides a wide range of information to drivers and travellers and enables safety applications to enhance road safety and provide a comfortable driving. The main system components are the application unit (AU), OBU and RSU. Typically the RSU hosts an application that provides services and the OBU is a peer device that uses the services provided. The application may reside in the RSU or in the OBU; the device that hosts the application is called the provider and the device using the application is described as the user. Each vehicle is equipped with an OBU and a set of sensors to collect and process the information then send it on as a message to other vehicles or RSUs through the wireless medium; it also carries a single or multiple AU that use the applications provided by the provider using OBU connection capabilities. The RSU can also connect to the Internet or to another server which allows AU's from multiple vehicles to connect to the Internet (C.C. Communication Consortium; Ieee Trial-use Standard for Wireless Access in Vehicular Environments; Olariu and Weigle, 2009).

2.1. On board unit (OBU)

An OBU is a wave device usually mounted on-board a vehicle used for exchanging information with RSUs or with other OBUs. It consists of a resource command processor (RCP), and resources include a read/write memory used to store and retrieve information, a user interface, a specialised interface to connect to other OBUs and a network device for short range wireless communication based on IEEE 802.11p radio technology. It may additionally include another network device for non-safety applications based on other radio technologies such as IEEE 802.11a/b/g/n. The OBU connects to the RSU or to other OBUs through a wireless link based on the IEEE 802.11p radio frequency channel, and is responsible for the communications with other OBUs or with RSUs; it also provides a communication services to the AU and forwards data on behalf of other OBUs on the network. The main functions of the OBU are wireless radio access, ad hoc and geographical routing, network congestion control, reliable message transfer, data security and IP mobility (C.C. Communication Consortium; Ieee trial-use standard for wireless access in vehicular environments; Olariu and Weigle, 2009).

2.2. Application unit (AU)

The AU is the device equipped within the vehicle that uses the applications provided by the provider using the communication capabilities of the OBU. The AU can be a dedicated device for safety applications or a normal device such as a personal digital assistant (PDA) to run the Internet, the AU can be connected to the OBU through a wired or wireless connection and may reside with the OBU in a single physical unit; the distinction between the AU and the OBU is logical. The AU communicates with the network solely via the OBU which takes responsibility for all mobility and networking functions (C.C. communication Consortium; Olariu and Weigle, 2009).

2.3. Roadside unit (RSU)

The RSU is a wave device usually fixed along the road side or in dedicated locations such as at junctions or near parking spaces. The RSU is equipped with one network device for a dedicated short range communication based on IEEE 802.11p radio technology, and can also be equipped with other network devices so as to be used for the purpose of communication within the infrastructural network (Figs. 1–3).

According to C.C. Communication Consortium, the main functions and procedures associated with the RSU are:

1. Extending the communication range of the ad hoc network by re-distributing the information to other OBUs and by sending the information to other RSUs in order to forward it to other OBUs.

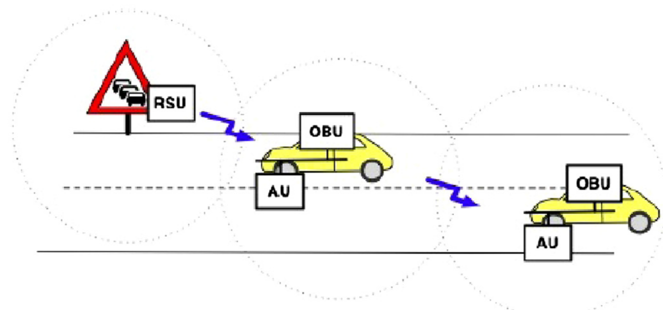

Fig. 2. RSU work as information source (running safety applications) (C.C. Communication Consortium,).

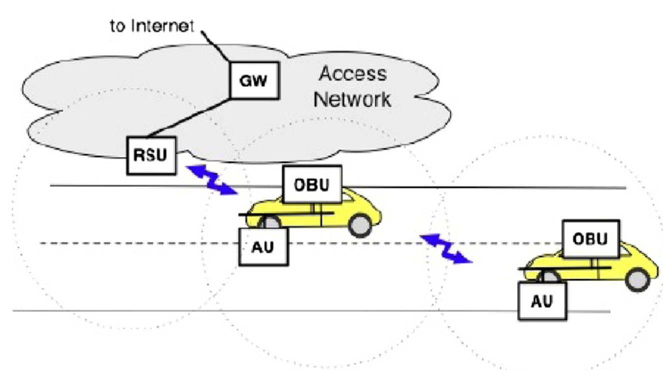

Fig. 3. RSU provides internet connectivity to the OBUs (C.C. Communication Consortium,).

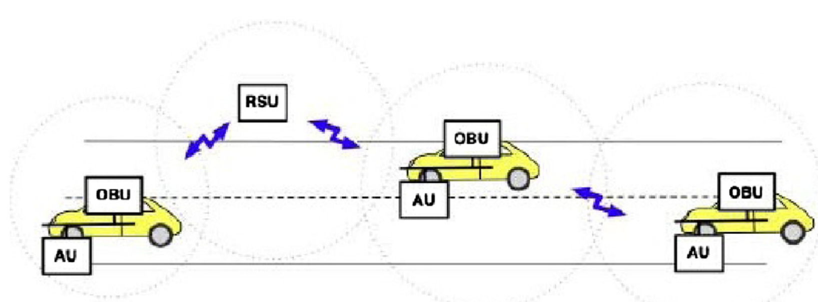

Fig. 1. RSU extend the range of the ad hoc network by forward the data of OBUs (C.C. Communication Consortium,).