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WAVE: Wireless Access for Vehicular Environment

Miss Bhagyashri S.Kharate[*1], Prof. Sandip T. Dhagdi[2]
B.E-I.T (Final Year)[*1], Assistant prof. [2],
Jawaharlal Darda Institute of Engineering & Technology, Yavatmal (MS) INDIA
bhagyashri.kharategmail.com*, sandip.yml@gmail.com

Abstract*:* Vehicular environment impose a set of new requirements on today's wireless communication systems. The emerging Car-to-Car communication (C2C) technology , known as Wireless Access in Vehicular Environment (WAVE), enables vehicles on the roadway to communicate with each other and with roadside infrastructure. In addition to safety-relevant services, Vehicular safety communication applications cannot tolerate long connection establishment delays before being enabled to communicate with other vehicles encountered on the road. Similarly , non-safety applications also demand efficient connection setup with roadside stations providing services (e. g. digital map update) drivers may also need Internet access through C2C communication for infotainment services and car maintenance services, as specified in mobility and collaborative work in European vehicle . A management scheme is developed for the opportunistic wireless links between On-Board Units (OBUs) and Road-Side-Units (RSUs),as well as between OBUs and VCGs in vehicular communication.

Keyword: WAVE, IEEE standard 802.11,vehicular communication gateway, WAVE device.

I. INTRODUCTION

The emerging wireless vehicular communication technologies are intended to improve safety and comfort of transportation systems. The newly standardized Wireless Access in Vehicular Environments (WAVE) system is based on the IEEE Wireless Local Area Network (WLAN) technology. It is able to provide broadband Car-to-Car (C2C) and Car-to-Roadside (C2X) communications for both safety relevant and commercial applications.

Wireless Access for Vehicular Environments (WAVE) is an approved amendment to the IEEE 802.11 standard. WAVE is also known as IEEE 802.11p. WAVE is required to support the Intelligent Transportation Systems (ITS) applications in the short-range communications. Mobile communication is used to communicate with the On-Board Diagnostic (OBD), to gather breakdown information and to access web based services for repair information.

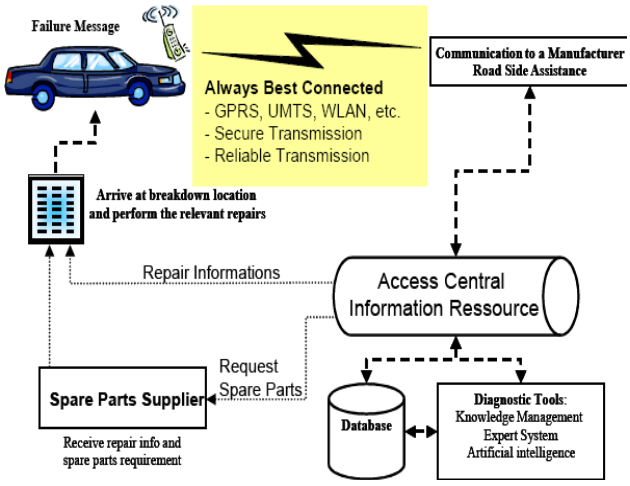

Figure 1.MYCAREVENT information flow

Figure 1 shows the information flow to conduct this service from vehicle failure to the restored mobility. Starting with the car reporting a failure, subsequent information is transmitted to a service provider using mobile communication. This error message is analyzed with an existing database, guidance and repair instructions are provided, and if necessary, a process to deliver additional spare parts is initiated. Transmitting the information enables the roadside assistance solving the problem.

This example shows that the ubiquitous Internet access is essential to the future automotive users. To solve the problem the MYCAREVENT consortium investigated the potential of various mobile devices and communication networks and designed an "always best connected" Vehicle Communication Gateway (VCG) for the roadside patrol and the driver. The VCG is able to seamlessly switch among multiple of available mobile communication networks, e.g. GRPS, UMTS or WLAN, and provide continuous, secure and always best data communication between the end user and the backend MYCAREVENT service portal. [1]

II. LITERATURE REVIEW

The IEEE 802.11p WAVE standardization process originates from the allocation of the Dedicated Short Range Communications (DSRC) spectrum band in the United States and the effort to define the technology for usage in the DSRC band.

In 1992, Unite States started to research the Dedicated Short Range Communication (DSRC). It is the wireless communication protocol for the vehicles. United States, Europe and Japan are the main countries of research and application for DSRC. From 2004, the concentration of DSRC has been migrating to the IEEE 802.11 standard group. At first DSRC is based on the IEEE 802.11a, which focus on the low overhead operations. DSRC standard is based on the Wireless Fidelity (Wi-Fi) architecture [1]. However, in order to support high-

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speed moving vehicle and simplify the mechanisms for communication group, IEEE working group dedicate more efforts on the WAVE, which is the core of the DSRC. WAVE ensures the traffic information collection and transmission immediate and stable, and keeps the information security.

III. PROPOSE WORK

A. IEEE 802.11P STANDARD:

The IEEE 802.11p standard is mean to describe the functions and services required by WAVE-conformant stations to operate in a rapidly varying environment and exchange messages without having to join a Basic Service Set (BSS), as in the traditional IEEE 802.11 use case. And define the WAVE signaling technique and interface functions that are controlled by the IEEE 802.11 MAC.

In order to support various safety and commercial applications in vehicular environments, the IEEE 1609 and IEEE 802.11p [3] task groups developed an IEEE 802.11 WLAN based C2C/C2X communication system, known as Wireless Access in Vehicular Environments (WAVE). This system works on the 5.9GHz ITS frequency band regulated by FCC in the U.S. and by ETSI in Europe. The system diagram of WAVE is illustrated in Figure 2, where the IEEE 802.11p standard specifies the Physical layer (PHY) and the basic MAC layer. All upper layers in WAVE system are regulated by the IEEE 1609 standard family.

The IEEE 802.11p PHY is based on the Orthogonal Frequency Division Multiplexing (OFDM) technology providing up to 27Mb/s data rate out of 1 0MHz bandwidth. The typical communication distance in WAVE system is from 300m to 1 000m, as required by direct C2C and C2X data exchange[9].

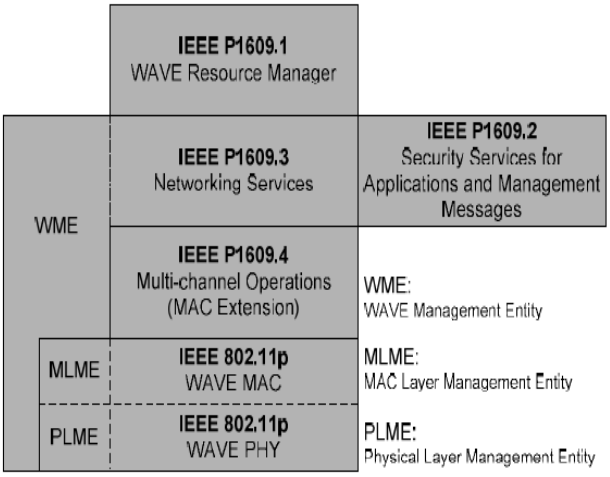

Figure 2. Protocol stack of WAVE system

Owing to the high dynamic feature of VANET, usually vehicles can only perform opportunistic data exchange with limited communication duration. Therefore, unlike in traditional IEEE 802.11 networks, the Basic Service Set (BSS) in WAVE system is reformed into WAVE BSS (WBSS) which can be established in a fully ad-hoc manner, where no association or authentication is required between communicating OBUs and RSUs.

The WBSS is defined based on WAVE service, e.g. the Internet access service. A WAVE device can take a role of the service either as the service provider or as the service user

a. It is the duty of a service provider to periodically broadcast the information of services that can be overheard by potential users in range. The service information, e.g. service profile, channel number and routing information, are composed into the WAVE Service Advertisement (WSA) information element, which is carried by the WAVE Announcement (WA) frame at 802.11p MAC layer and periodically broadcast on CCH.
b. At the service user side, when a service user receives a WSA frame from a service provider and the service matches its requirement, the service user will locally decide to join in the WBSS. In the next SCH interval, it will switch to the SCH channel as specified in the WSA to perform the service. In case the service uses IP as the network protocol, in contrary to pure broadcast services, an additional handshake are required between the service provide and the service user to establish the data link.
c. Exchange of service data is performed on the dedicated SCH channel as indicated by the service provider.
d. In WAVE system there is no explicit handshake process required to terminate the WBSS when the user is leaving the range of the provider

B. Vehicular Communiction Gateway:

The main idea of MYCAREVENT VCG is to incorporate several communication systems such as GPRS, UMTS and WLAN and to provide the gateway users “always best connected”

In vehicular communication gateway several communication media are envisaged. A dynamic network selection chooses the most suitable communication medium according to Quality of service (QoS) criteria. Moreover, this could also be combination of two or more parallel communication technologies for better QoS support. It describes a classical gateway design, except that many different technologies can be used to attach to the gateway as the central point of communication. Mobile devices, such as the roadside patrol’s laptop, driver’s PDA or other C2C OBUs will be able to connect to the gateway. The functions mobility management (MM), encryption, authentication, QoS mapping, enhanced reliability and routing . Thus, the gateway offers an advanced and flexible communication service, through which the Car-side users can enjoy the encrypted and reliable communication within the range of VCG. Opportunistic internet access is also possible for occasionally passing by OBUs, if an efficient service discovery and link management scheme can be used between the VCG and the OBUs

C. Wave Devices:

Two architectures of Internet access in vehicular environments using WAVE technology,

a. Wave Rsu Solution:

In the WAVE system, the roadside infrastructure, i.e., RSUs usually have connection to the IP backbone and can act as the Internet access service providers for passing by OBUs. The

Internet access will be a WAVE service provided on SCHs. This solution is also known as drive-thru Internet in [8], where the original IEEE 802.11 WLAN technology is used.

b. MYCAREVENT VCG solution:

The second solution integrates WAVE C2C/C2X communications with the MYCAREVENT VCGs. As for safety reason all WAVE OBUs have to self-organize into VANET on the roadway and keep communicating with each other. Some of these vehicles that have VCG equipped may operate as the Internet access gateways of the autonomously formed VANET. The VCGs, in this case, on the one hand connect to the Internet service provider through UMTS, GPRS or WiMAX, while on the other hand provide Internet access using the WAVE C2C communication to other surrounding vehicles. For example a broken vehicle located outside the RSU range may have opportunity to get Internet access via the passing by VCGs. Wireless Internet access through MYCAREVENT VCG.

The common point of these two architectures is that WAVE C2C users have to detect the opportunistic Internet access services provided by either RSUs or VCGs, and perform data communication within the limited duration in VANET.

IV. APPLICATION

For now, some applications based on the IEEE 802.11p standard are on the market, but some projects are testing yet with few vehicles. The application can be separated into three aspects.

A. Safety-oriented:

Car-to-car communication (C2C) can be used to provide a global view of the traffic that the driver could not be able to have by himself. For example, by exchanging of information such as position and speed, a driver can see on a screen in his car, all vehicles around. This is very useful if the weather prevents a good visibility, like fog or rain, and in a turn or at an intersection. A driver can also be advertised of a traffic jam or a traffic collision. This is also very useful especially if the driver have a bad visibility . For an emergency vehicle, because it has to arrive the destination without delay, it can broadcast a message to the cars around it and make a place for itself. Car-to-infrastructure communication (C2I) can be used, for example, to allow an emergency vehicle to pre-empt a red light on its way, and then have green light all along its path or at the intersection, the traffic light sends the light information to the cars that are in its communication scope. It assists drivers better know about the conditions of the intersection to avoid traffic collision.

B. Traffic control-oriented:

Some other applications are not related to the safety, but by exchanging information about position we can have a global view about the density of the traffic and used it to regulate the traffic. For example the traffic jam advertiser, enumerated for safety purpose, is also a traffic control oriented application in a way that the user knows about a traffic jam further and then can choose a other way .We can also imagine a “smart red light” that could collect information about number of cars waiting and how long time they have been wait, and then change its status based on that. The infrastructure can also supply the localization map for the drivers and make a suggestion of appropriate path to the destination and avoid traffic jam .The Electronic Toll Collection (ETC) has been applied in some Europe countries. ETC charges the road price for reducing the congestion. The system can recognize the car by car’s identification by the equipment based on the WAVE technology without stopping the cars. The antenna is installed on the gantry can communication with the on-board equipment, which is on the car.

C. User-oriented:

Some previous applications could be also in this section, such as the traffic jam advertiser or the smart red light, because they can avoid the driver to wait too long time in a traffic jam or at a red light. But the comfort-oriented applications are more service that the users could enjoy themselves in their cars like download movies or music or upload some documents to their friends. Actually having access to the Internet can summarize comfort applications.

V. CONCLUSION

WAVE is a short-range communication technology that is based on IEEE 802.11p. This paper is mainly based on the study of the basic technologies of the WAVE. And Starting from a typical Internet access application on the roadway for car maintenance, in this article we studied the solution for providing Internet access to automotive users through WAVE C2C/C2X wireless communication. Two architectures of providing Internet access to drivers using OBU to RSU communication and using OBU to VCG communication are presented.

In this work we conducted an early attempt toward using WAVE C2C/C2X communication for providing general IP services to automotive users.

During the study, we realize that most of the challenging issues are results from the movement of vehicles and the dynamic network topology. To deal with these problems, the ability of environment awareness is required at each of the OBU. For the future work, we would like to enhance the current WAVE protocol with mobility awareness and use the acquired information to further improve the channel access efficiency.

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