A Literature Review on Dedicated Short Range Communication for Intelligent Transport

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Abstract— WAVE/DSRC technology provides various standards for the wireless access in vehicular environment i.e. IEEE 802.11 and IEEE 1609 family. The wireless network is the integration of all type of networks. The vehicular ad hoc network is the sub class of mobile ad hoc network. In vehicular ad hoc network vehicles are serving as nodes and it offers certain intelligent activities. It is an intelligent network of vehicles, called Intelligent transport System. It provides safety, driver assistant services and comfort to the road users. It also includes all type of communication in vehicles between Vehicle to Vehicle and Vehicle to Infrastructure.

Keywords— ITS, VANET, MANET, V2V, V2I

I. INTRODUCTION

In recent years, continuous progress in wireless communication has opened a new research field in computer networks. It aimed at increasing data networks connectivity to different environments, where wide solutions are impracticable. Now a day’s wireless ad hoc networking is an emerging research area, focused on providing dedicated short range communication. There are two distinct approaches for enabling wireless mobile units to communicate each other.

Firstly the infrastructure networks, in that emerging mobile network are based on cellular concepts. In this all the devices are connected to a central node which is the acting agent for all communication and realized on good infrastructure support, examples are GSM, UMTS etc. Secondly we have infrastructure less approach, which is commonly known MANET. It is a collection of wireless nodes that can be dynamically set up, anywhere anytime without using a pre existing networks infrastructure.

The wireless network is the seamless integration of all types of Networks. The Vehicular ad hoc Network (VANET) is the sub class of Mobile ad hoc network (MANET) [1]. It helps in Inter Vehicle Communication (IVC). IVC network exhibits very different characteristics from other MANETs. Specifically, the constraints on vehicle movements, varying driver behaviour, and high mobility cause rapid topology changes, frequent fragmentation of the network, a small effective network diameter, and limited utility from network redundancy [2]. Ad hoc networks support the growing number of wireless products that can be used in different vehicles [3]. It is a technology simulating ad-hoc networks, wireless LAN (WLAN) and cellular technology to achieve intelligent Inter Vehicle Communication (IVC) and Roadside to Vehicle Communication (RVC). The car 2 car communications consortium developed the C2C-CC project in Europe, and the related projects including E-safety support [4]. In ITS, each vehicle takes on the role of sender, receiver and router to broadcast information to the vehicular networks or transportation agency, which then uses the information to ensure safe, free flow of traffic [5] [6]. For communication to occur between vehicles and roadside units (RSU’s), vehicles must be equipped with some sort of radio interface or onboard unit (OBU) that enables short range wireless ad hoc networks to be formed. Vehicles must be installed with GPS and DGPS receiver for smooth transportation and communication [1] [2]. Various protocols related to communication are used to perform the tasks. The paper is organized as follows: Section II provides the overview and architectural details of the WAVE/DSRC. It also contains the review of the literature. Section III presents the detail study of the Wave Short Message Protocol (WSMP). Section IV explains the vision of Indian Automotive Networks. It discusses the need of DSRC for the Indian Intelligent Transport System. Finally Section V presents the conclusion of the survey followed with Acknowledgement and References.

II. WAVE/DSRC

A. Overview

WAVE used in inter vehicle, vehicle to roadside, and routing based communication rely on very accurate and up to date information about the surrounding environment, which in turn, require the use of accurate positioning systems and smart communication protocols for exchanging information [7]. For vehicle communication, various standards i.e. WAVE 1609, IEEE 802.11p, IEEE 802.11a, and IEEE 802.11e are used that supports wireless communication between V2V and V2I [8] [9]. WAVE uses dedicated short range communication (DSRC) for high data transfers and low communication latency in small communication zones. A dedicated spectrum (Bandwidth) is given for short term communication [3]. The current DSRC standards deployed in the USA, Europe and Japan are shown in the Table 1.
TABLE I: DSRC Standards [10]

<table>
<thead>
<tr>
<th>Features</th>
<th>JAPAN (ARIB)</th>
<th>EUROPE (CEN)</th>
<th>USA (ASTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Half-duplex</td>
<td>Half-duplex</td>
<td>Half-duplex</td>
</tr>
<tr>
<td>(OBU)/Full duplex (RSU)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio Frequency Band</td>
<td>5.8 GHz band</td>
<td>5.8 GHz band</td>
<td>5.9 GHz band</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>80 MHz</td>
<td>20 MHz</td>
<td>75 MHz</td>
</tr>
<tr>
<td>Channels</td>
<td>Downlink: 7 Uplink: 7</td>
<td>Down-link: 7 Up-link: 5</td>
<td>Down-link: 5 Up-link: 7</td>
</tr>
<tr>
<td>Channel Separation</td>
<td>5 MHz</td>
<td>5 MHz</td>
<td>10 MHz</td>
</tr>
<tr>
<td>Data Transmission rate</td>
<td>Down/Up-link 1 or 4 MBits/s</td>
<td>Down-link: 500 Kbits/s Up-link: 250 Kbits/s</td>
<td>Down/Up-link 3-27 Mbits/s</td>
</tr>
<tr>
<td>Coverage</td>
<td>30 meters</td>
<td>15-20 meters</td>
<td>1000 meters (max)</td>
</tr>
<tr>
<td>Modulation</td>
<td>2- ASK, 4-PSK</td>
<td>RSU: 2-ASK OBU: 2-PSK</td>
<td>OFDM</td>
</tr>
</tbody>
</table>

B. Architecture

The Federal Communications Commission (FCC) has provided 5.85 - 5.925 GHz band to DSRC, which has 75 MHz spectrum for use by Intelligent Transportation Systems (ITS) vehicle safety and mobility applications [11]. Their spectrum is divided into seven 10 MHz channels. Figure 1 shows the DSRC spectrum and their channels.

IEEE is developing the wireless access in vehicular environment (WAVE) standard for DSRC. The DSRC stack incorporates a number of protocols and corresponding standards. Figure 2 shows overall WAVE architecture.
It includes IEEE 802.11p (MAC and PHY standards) and IEEE standards 1609.1 to 1609.4 [18] [19]. At the MAC layer IEEE 802.11p is based on IEEE 802.11e, which has been augmented with QoS support. At the physical layer 802.11p is the same as 802.11a except that 802.11p is operated with 10 MHz bandwidth instead of 20 MHz for 802.11a. [20].

C. Review

As we have discussed that, WAVE/DSRC defines various standards for the wireless access in vehicular environments, e.g. IEEE 802.11 and IEEE 1609. It helps us to develop scalable, robust, low-latency and high throughput technologies for safety applications that will significantly reduce collisions and save lives and property loss [21] [22] [23]. In paper [24] the comparative analysis of DSRC and IEEE 802.11 over vehicular ad hoc networks is performed. In this two different models of DSRC is proposed i.e. preemptive and non preemptive. It also measures the reliability metrics both in network and application levels for different mobility scenarios. Operational concept of 5.9 GHz DSRC based vehicular safety communication has been presented in [25]. The overall DSRC communication architecture in the draft IEEE 1609 standard contains two parallel stacks i.e. one for TCP/IP-based communications and the other one for safety messaging [26]. Yi Wang et al. [27] presented the performance evaluation of IEEE 802.11p WAVE for V2V and V2I communication. Author provides an NS-2 simulation study of the proposed IEEE 802.11p MAC protocol focusing on vehicle-to-infrastructure communication. Evaluation of the IEEE 802.11p MAC method for Vehicle-to-Vehicle Communication is also presented in paper [28] for highway scenario with periodic broadcast of time critical packets.

Wei Yen Lin et al. [29] compared the IEEE 802.11a and 802.11p for V2I communication. In this author proposed the WAVE protocol for future traffic system. IEEE 802.11p is modified from IEEE 802.11a, and both are based on OFDM. Author investigated the performance difference between both standards for V2V and V2I communication through real world experiments. P. Vetrivelan et al. [30] proposed that VANET is a technology for implementing Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications. The proposed work is implemented using NS-3 and SUMO. A comparative study of radio propagation and mobility models in vehicular ad hoc networks is carried out in [31]. In this author have highlighted the need of adequate radio propagation and mobility models for VANET i.e. Free Space, Two Ray Ground, Shadowing, Ricean and Nakagami models. Most of these radio propagation models are now bundled with network simulator NS-2, NS-3 and some simulation tools are also available for VANET like MOVE, TraNS and Veins that can help researchers to check the performance of routing protocols using these proposed and appropriate models for VANET. Shie Yuan Wang et al. [32] presented NCTUIns as a novel network simulator and emulator that directly uses real-life applications and Linux protocol stack to generate simulation results. In its 5.0 release, NCTUIns provides a complete implementation of the IEEE 802.11p and 1609 standards for wireless vehicular networks. With continuous improvements, NCTUIns has become a very valuable tool for researching advanced ITS wireless vehicular networks.

III. WSMP

WAVE is comprised of two protocol stacks: the standard Internet Protocol (IPv6) and the WAVE short message protocol (WSMP). WSMP allows applications to directly control physical layer characteristics used in transmitting the messages, e.g., channel number and transmitter power. WSMs (WAVE short messages) are delivered to the corresponding application at a destination based on the Provider Service Identifier (PSID). Author performs experiments using WAVE short messages to send and receive packets [29].

Yasser L. Morgan [33] provides the information that WSMP is used to carry routine emergency and safety information on CCH and SCH which is critical to the DSRC public safety applications. Evaluation of multi channel schemes for vehicular safety communications is proposed in the paper [34]. IEEE 1609.4 defines an alternating access channel switching scheme to enable a DSRC device to support applications concurrently on different channels. In this paper author proposes three alternative approaches i.e. Dedicated Safety Radio, Capability Bit, and Intension Bit for DSRC V2V safety communication in a multi-channel environment, all of which accommodate single and multi-radio vehicles, all of which allow at least some vehicles to utilize an “always on” safety channel, and all of which perform better than the Basic 1609.4 Safety Model. The alternative approaches and the basic IEEE 1609.4 approach are evaluated via NS-2 simulations [18] [19]. In a similar type of paper [35] author provides an overview of IEEE 1609.4 over 5.9 GHz Dedicated Short Range Communication (DSRC) spectrum. It contains results from software simulations conducted to study vehicle safety communications under stressful but realistic conditions. These results confirm concerns for the currently proposed scheme and provide a motivation for updating and revising the standard. The IEEE 1609.4 Multi-Channel Operation protocol supports the co-existence of safety and non-safety (infotainments) applications over the Dedicated Short Range Communication (DSRC) channels at the 5.9 GHz band [36].

Mei Wen Li et al. [37] proposed to develop a protocol on top of WSMP to build a reliable session for the message exchanges between RSU and OBU. Authors of paper [38] proposed WAVE architecture that supports a Control Channel (CCH) and Multiple Service Channels (SCH). The CCH is used to transmit Wave Short Messages (WSMs) and announce WAVE services, and the SCH are used for application interactions and transmissions over IP. In this importance of channel utilization efficiency and synchronization between multiple wireless nodes is evaluated. IEEE WAVE protocol suite provides the communications services to applications in vehicular networks, by way of promising support for two protocol stacks: the Wave Short Message Protocol (WSMP) and IPv6. The paper [39] reviews and analyses the main challenges in providing proper IPv6 operation for WAVE networks. In the article [40] author proposed that in WAVE, the WAVE Short Message Protocol (WSMP) provides broadcast services but does not define unicast / multicast services that require mobility management to track the locations of the vehicles. The WAVE short message protocol adequately
The number of vehicles has been growing at an average pace of 10.16% per annum over the last five years [42]. Due to this there is a need to develop an Intelligent Transport System (ITS) for the Indian Automotive Networks. In Indian automotive scenario ITS plays an important role. According to the National Highways Authority of India (NHA), Indian road network is around 33 lakhs Km, which is 2nd, largest in the world. The details of the Indian Automotive Network are given in table 2.

TABLE II: Indian Automotive Network [42]

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Length (KM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressways</td>
<td>200</td>
</tr>
<tr>
<td>National Highways</td>
<td>79,243</td>
</tr>
<tr>
<td>State Highways</td>
<td>1,31,899</td>
</tr>
<tr>
<td>Major District Roads</td>
<td>4,67,763</td>
</tr>
<tr>
<td>Others</td>
<td>26,50,000</td>
</tr>
</tbody>
</table>

The Indian Automotive Networks deal with the Dedicated Short Range for communication, security etc. ITS used in inter vehicle, vehicle to roadside, and routing based communication rely on very accurate and up to date information about the surrounding environment, which in turn, require the use of accurate positioning systems and smart communication protocols for exchanging information [9]. The ITS uses dedicated short range communication (DSRC) for high data transfers and low communication latency in small communication zones. DSRC is the only short-range wireless alternative that has the following visions:

- Designated licensed bandwidth
- Fast network acquisition
- Low latency, Security, Privacy
- High reliability when required
- Priority for safety applications, and
- Interoperability

IV. VISION

The number of vehicles has been growing at an average pace of 10.16% per annum over the last five years [42]. Due to this there is a need to develop an Intelligent Transport System (ITS) for the Indian Automotive Networks. In Indian automotive scenario ITS plays an important role. According to the National Highways Authority of India (NHA), Indian road network is around 33 lakhs Km, which is 2nd, largest in the world. The details of the Indian Automotive Network are given in table 2.

V. CONCLUSION

The DSRC is used for short range communication. This paper presents the review of the WAVE/DSRC technology. It also provides the information about the work already done. In this paper we reviewed different simulation tools that focused on WAVE/DSRC. In VANET, we have to deal with the vehicle movements, driver behaviour and high mobility of the vehicles. In future we intend to work on protocols which can be effectively used for dedicated short range communication among vehicle to vehicle and vehicle to infrastructure. We will evaluate such protocol for different Radio Propagation and Mobility Models using different network tools and simulator. Selecting appropriate Mobility Model for the short range communication ensures safety and, free flow of traffic for different automotive scenario in future.

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