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A Study of DSRC Radio Testbed under Heavy Channel Load

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Abstract**—**Dedicated Short Range Communication (DSRC) is a key enabling technology for the next generation of communication-based safety applications. One of the important problems for DSRC deployment is maintaining high performance under heavy channel load. Many studies focus on congestion control mechanisms for simulating hundreds of physical radios deployed on vehicles. The U.S. department of transportation's (DOT) Intelligent Transportation Systems (ITS) division has a plan to chosen prototype on-board devices capable of transmitting basic "Here I am" safety messages to other vehicles. The devices will be used in an IntelliDrive safety pilot deployment of up to 3,000 vehicles. It is hard to log the information of 3,000 vehicles. In this paper we present the designs and issues related to the DSRC Radio Testbed under heavy channel load. The details not only include the architecture of DSRC Radio Testbed, but also describe how the Radio Interfere System is used to help for emulating the congestion radio environment.

Keywords**—**DSRC, UDP, WAVE, Radio Testbed

I. Introduction

THE US Federal Communication Commission (FCC) has allocated 75 MHz of spectrum in the 5.9 GHz band for Dedicated Short Range Communication (DSRC) amoung vehicles, and between vehicles and roadside infrastructure[1,2]. The primary purpose is to enable safety applications that can prevent accidents. DSRC radio technology is standardized in IEEE 802.11p[3,4], IEEE 1609.3[5], and IEEE 1609.4[6].

Automotive Research Testing Center (ARTC) aggressively attends vehicle research and test to accumulate a lot of technologies and test experiences related to vehicles. In 2009, ARTC had involved in inter-vehicle communication project. Inter-vehicle communication integrates information, communication and vehicle to provide more comfortable and safer driving environment. The main inter-vehicle communication includes inter-vehicle communication (V2V) and vehicle-roadside communication (V2R) in, where V2V indicates communication between On Board Unit (OBU) and on board unit (OBU), and V2R indicates communication between on board unit (OBU) and road side equipment (RSE). The main components of inter-vehicle communication are OBU, RSE and vehicles.

Automotive test-bed, where occupies 119 hectares and provides nine test roads and auxiliary facilities to develop components, motorcycles, automobiles, commercial vehicles and military vehicles as well as testing regulations, is world-class automotive test-bed. RSE is planned to build in automotive test-bed, and OBU is installed in a testing vehicle to test V2V and V2R. Dedicated short range communications (DSRC) will be used for inter-vehicle communication. Owing to short range and fast speed for dedicated short range communications, more distributed RSE will be installed to cover the whole automotive test-bed. In addition, vehicles with OBU need to perform mobile communication test. Therefore, the range includes the whole automotive test-bed. Because inter-vehicle communication has the characteristics of equipment distribution, large range and high mobility test, the perfect information management system will be required to collect and manage monitoring data from testing equipment as well as achieve more efficient automotive test-bed.

In [7] techniques have been proposed to configured a testbed with DSRC radios in a laboratory setting and demonstrate two important results that together suggest a strategy for investigating congestion control. First, it shows that the NS-2 simulator accurately models the MAC and PHY associated with an IEEE 802.11 hardware implementation. Second, it shows that a technique in which one radio emulates N vehicles can produce results quite similar to the case in which a larger number of distinct vehicles exit. It has two important results. First, it shows that for an indoor office environment where LOS is available, the NS-2 simulator accurately models the MAC and PHY associated with an actual 802.11 implementation. Second, it shows that a technique in which one radio emulates N vehicles can produce results quite similar to the case in which a larger number of distinct vehicles exit.

II. System Architecture

A. System Configuration

The research platform is built on three DSRC WAVE Boxes and one PC. And the test campus is located in general performance test track of ARTC proving ground in Fig. 1. This example is simulated metropolitan area in DSRC signals broadcasting. The application usually uses DSRC signals to provides driving assistance information (about vehicle accidents, obstacles in the road, etc) and traffic information (a map of the surrounding area, the presence of traffic jam).

The test track will be divided into several segments every 10 meters. To transmit DSRC signals with different packets speed, packet sizes and packet length, the commander plays a role with packet slicing and power control programs. The receiver is used to receive packets from transmitter, and furthermore, the jammer is the key research tool for emulating N vehicles. The DSRC receiver is used to check transmitting data and packet availability.

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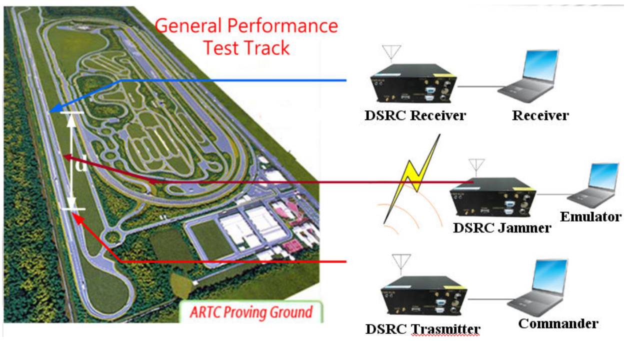

Fig. 1 System operation Testbed

B. System Requirements

The DSRC devices is developed by Industrial Technology Research Institute whether the receiver and jammer device located in roadside, but transmitter device located in vehicle. Beside, all DSRC device will be set to converter mode.

As show in Fig. 2, the frequency spectrum of DSRC is divided into seven wide channels (10MHz). Channel 178 is the control channel (CCH), which is restricted to safety communications only. CCH is a unique channel shared with all WAVE devices and used for control communication. The two channels at the edges of the spectrum are reserved for future advanced accident avoidance applications and high powered public safety usages. The remainder is service channels (SCH) which are available for both safety and non-safety usage, and SCH is used for normal data communication. In resource management, security services, network services and medium access control, the hardware is based on IEEE 802.11p standard to WAVE protocol or IEEE 1609.1 to 1609.4.

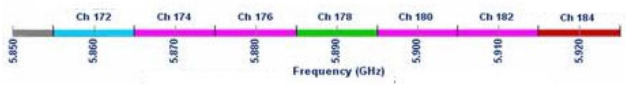

Fig. 2 DSRC frequency allocation

C. Protocol Requirements

The communication protocol of the DSRC device which set to converter mode is User Datagram Protocol (UDP)[8]. The UDP is one of the core members of the Internet Protocol Suite, the set of network protocols used for the Internet. With UDP, computer applications can send messages, in this case referred to as datagram, to other hosts on an Internet Protocol (IP) network without requiring prior communications to set up special transmission channels or data paths. The protocol was designed by David P. Reed in 1980 and formally defined in RFC 768. UDP uses a simple transmission model without implicit handshaking dialogues for providing reliability, ordering, or data integrity. Thus, UDP provides an unreliable service and datagram may arrive out of order, appear duplicated, or go missing without notice. UDP assumes that error checking and correction is either not necessary or performed in the application, avoiding the overhead of such processing at the network interface level. Time-sensitive applications often use UDP because dropping packets is preferable to waiting for delayed packets, which may not be an option in a real-time system.[1] If error correction facilities are needed at the network interface level, an application may use the Transmission Control Protocol (TCP) or Stream Control Transmission Protocol (SCTP) which are designed for this purpose.

III. Development of DSRC Radio Testbed

A. To set the DSRC device to converter mode

First, we need to set three DSRC device into converter mode. We can use putty via Ethernet to set the DSRC device to converter mode and the arguments in Fig. 3.

User can use *cvt* to set the related arguments of converter.

cvt *<action>*.

The *<action>* is described as follows:

- Add a converter rule

  cvt add *<device> <waveport> <psid> <ip> <udpport>*

  <device> - wave0 | wave1 (wireless device)

  For example:

  # cvt add wave0 52001 68 192.168.10.10 55555

  # cvt add wave0 66666 123 192.168.1.10 3838

  #cvt add wave0 8000 90 192.168.0.20 6000

Fig. 3 Arguments for converter mode

B. UDP send & receiver program

In The Vehicle Safety Communications (VSC) project[9], More than 75 application scenarios were identified and analyzed resulting in 34 safety and 11 non-safety application scenario descriptions. Finally, we choice 13 scenarios and 4 non-safety scenarios in Fig.4. The transmitted frequency is between 1 Hz and 5 Hz. For packet size, we have researched on compensated modeling[10]. The Factors and its levels is in table I.

TABLE I
FACTORS AND ITS LEVELS

Control Factors	Levels		
	Level 1	Level 2	Level 3
A. Bit Rate(Mbits)	3	12	27
B. Power Density(dBm)	12	15	18
C. Packet Size(bytes)	64	256	1024
D. Number of Packets	1000	6000	10000

We find that the packet size in 256 bytes has a good communication performance.

Safety		Non safety	
03	Approaching emergency vehicle warning	14	Enhanced route guidance and navigation
07	Cooperative collision warning	16'	GPS correction
08	Cooperative FCW	30	Map downloads and updates
11	Curve speed warning	32	Point of interest (POI) notification
12	Emergency electronic brake lights	-	—
13	Emergency vehicle signal preemption	-	—
22	Intersection collision warning	-	
26	Lane change warning	-	—
27	Left turn assistant	-	—
34	Pre-crash warning	-	—
38	Stop sign movement assistance	-	—
40	Traffic signal violation warning	-	—
44	Work zone warning	-	—
13 scenarios		4 scenarios	

Fig. 4 Safety & non-safety scenarios

To combine all information, we deign a form to adjust packet size, packet number and frequency as show in Fig. 5.

Fig. 5 UDP Transmitter program screen

For to receive the data from transmitter, we need a UDP server program as show in Fig. 6. When the program is running, it listen the Ethernet port to get the data. From the received packet number, we can calculate the packet loss rate. For example, we transmit 1000 packet number and the receiver only gets 9872 packets then the packet loss rate will be 98.72%.

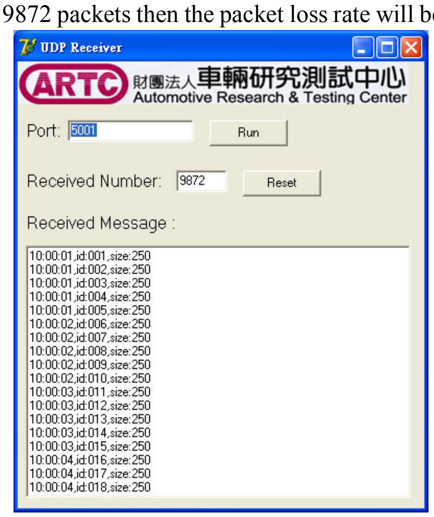

Fig. 6 UDP Receiver program screen

C. *DSRC jammer*

For to interfere the communication between DSRC transmitter and DSRC receiver, we design a jammer. The jammer is used a DSRC WAVE Box and a PC. The DSRC WAVE Box also need to set to converter mode and need a PC to send the data for interfering. In reference paper[7], it shows that a technique in which one radio emulates N vehicles can produce results quite similar to the case in which a larger number of distinct vehicles exit. So we use one PC to simulate many cars to interfere the communication. The factors in this PC have car number, frequency, packet size and interval. The factors frequency and interval can determine the density of an interfering transmitter. The factors Average and Continue are for interfering data sending timing. If you choice Average then the interval time of data sending will be frequency divide car number. So maybe you have found the car number and frequency have a limit.

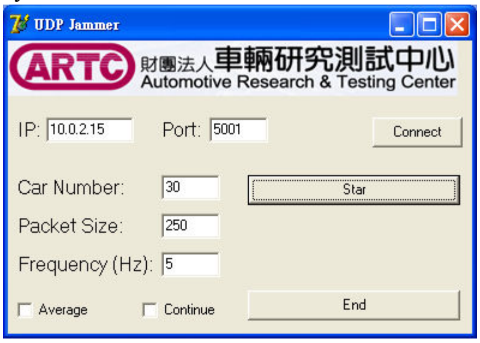

Fig. 7 UDP Jammer program screen

IV. Issues and Challenges

A. *DSRC Transmission delay*

Because the DSRC transmitter data is from PC, the transmission time between DSRC transmitter and PC is not fixed. The communication rate in Ethernet is 100MHz, so maybe we can ignore the communication time. But it still need to do more experiment to calculate the time.

B. *The rule of counting received packet number*

We do not fix the length of WSM(Wave Short Message), so we do not know the data from PC to DSRC transmitter which is separate how many segments. We think the better method to count received packet number is identified the header and length when the data from PC to DSRC transmitter. And the DSRC receiver will check the complete message format, then it accumulate.

C. *The distance for DSRC jammer*

We fix the jammer between the DSRC transmitter and DSRC receiver and we also fix the transmission power. That is not real. Because the car can move and the transmission power is changeable. We think in the commission area we do not care the transmission power. If you want to simulate the real word, we suggest you can dynamic to adjust the car number.

V. Conclusion

We present the designs and issues related to the DSRC radio testbed under heavy channel load. In this paper, we can understand the issues needed to consider for the design of the DSRC radio test under heavy channel load, providing the designers for reference in the future not only to solve problems but also help to setup a testbed for testing DSRC radio under heavy channel load. Taguchi method is a good method and it has proved to determine the optimal conditions necessary for DSRC communication, greatly increasing the availability with optimal parameters in transmitting and receiving packets.

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