Comparison between DSRC and other Short Range Wireless Communication Technologies

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***Abstract*—DSRC (also known as IEEE 802.11p or WAVE) is a medium/short-range RF communication technology designed specifically for in-vehicle environments that provide high-speed, real-time, accurate, and reliable connectivity between vehicles and vehicles, vehicles, and roadside infrastructure. The single/two-way voice, image and data communication services support vehicle public safety, traffic management, in-transit information release, commercial freight management and non-stop charging services, which can significantly improve the safe operation efficiency of road traffic. It consists of a series of protocols and standards that work very similar to RFID technology. This study presents a compares DSRC with several other commonly used short-range wireless access technologies in terms of transmission rate, spectrum characteristics, and communication modes.**

Keywords—VANET, V2V, IEEE 802.11p, WAVE, DSRC

I. INTRODUCTION

Vehicle self-organizing networks have the general characteristics of wireless mobile ad hoc networks. For example, vehicle-vehicle communication networks are temporarily built without relying on pre-arranged fixed infrastructure. Vehicle-to-vehicle communication systems require less infrastructure support, and each vehicle node can implement data collection as a terminal system and It can also be used as a relay route to implementing multi-hop forwarding [1, 2, 3, 4, 5, 6] it also has problems inherent in wireless networks, such as hiding/exposing terminals, channel congestion, etc. [7]. However, compared to MANET/WSN, VANET has the following different characteristics [8, 9]:

1) The scale of the network

The large-scale self-organizing network of vehicles is mainly reflected in two points: 1 The number of VANET nodes is not huge, including vehicle nodes (such as private cars, public transportation, freight vehicles) and roadside nodes (such as traffic signs, traffic lights, etc.); 2 The VANET node distribution area is also very extensive (such as in a city center or on a highway).

2) Network density changes quickly and at any time

Network density depends on the Spatio-temporal distribution of VANET nodes (especially vehicle nodes). Traffic in remote areas is a sparse network, and in the case of traffic congestion, it is an intensive network. For example, in a two-way six-car road section with a length of 1 km, if the vehicle safety distance is 70 m, there is a near

70 vehicles are driving on this section; when traffic congestion occurs, if the vehicle spacing is only 5 m, there will be more than 1,000 vehicles in the same section [10].

3) The particularity of vehicle node motion

Vehicle nodes can only perform high-speed, limited constrained motion along with the road network. For example, the speed of vehicles on highways is generally not less than 70 km/h, but the relative motion speed between vehicles can be as high as 300 km/h; Vehicles must also comply with relevant traffic rules (such as red) while driving.

The lights stop at the green light, speed limit or line travel, etc.). Therefore, the motion of the vehicle nodes can be predicted in a short time, and the propagation of traffic information between VANET nodes is also highly directional. At present, researchers agree that the IVC network built in the highway scene has a one-dimensional

The IVC network built in urban road scenes has two-dimensional features [11].

4) Network topology changes frequently

Due to the high speed of vehicle node motion and the fact that the network is highly susceptible to driver behavior (such as changing lanes or driving directions) and message content, the network topology formed by wireless links between nodes changes dramatically and frequently. For example, the node communication distance is 250 m,

In a two-way motion scenario with an average speed of 130 km/h, the probability of communication link duration between nodes not exceeding 15 s is only 57% [12].

5) Frequent topology changes lead to frequent network splitting

Even though VANET is widely deployed, network fragmentation often occurs when traffic density is high, causing many link paths to fail before they are officially used. To this end, by increasing the communication distance of nodes and realizing information forwarding by means of reverse motion vehicles, network splitting can be effectively reduced [13].

6) Node has no obvious hardware constraints

VANET nodes generally have external power supplies to provide energy, so unlike the sensor nodes, there is no obvious power supply constraint. Therefore, single-hop communication distance can be appropriately increased under the premise of satisfying network connectivity. For example, VANET nodes can communicate up to 1 km.

Wireless communication bandwidth is typically several thousand kbps. In addition, the in-vehicle mobile terminal currently adopts a high-performance embedded system with a 32-bit microprocessor as the core, and the computing power and storage capacity are greatly improved, so the production cost is also high, the life cycle of the node and the vehicle. The life cycle is roughly equivalent [14].

7) Nodes have rich external auxiliary information

With the popularity and wide application of Global Positioning System (GPS) and Geographic Information System (GIS), VANET nodes can not only obtain accurate instantaneous motion information such as position, velocity, and acceleration but also obtain geographic information in the area where the node is located. (Such as road network distribution, etc.),

If combined with onboard lidar (LIDAR) and CCD vision sensing devices, the VANET node can also sense its surroundings in real-time. Therefore, VANET nodes use geographic area-based addressing mechanisms more [15].

8) Different transportation applications have different quality of service requirements

VANET is committed to improving road safety, transportation efficiency, driving comfort and environmental protection. Most transportation applications have stringent requirements for network quality of service (QoS), such as packet delay, delay jitter, and available bandwidth. Packet loss rate, etc., and not the same traffic application has different requirements for network service quality. For example, applications related to driving safety allow a delay of only 20 to 200 ms [16], and applications related to driving efficiency have low latency requirements (generally seconds), while applications for multimedia information services require A lot of network bandwidth.

The biggest difference between VANET and MANET/WSN is fast-changing but predictable network topology, frequent network fragmentation, node hardware performance (energy saving is no longer the primary challenge facing VANET), location-based homing Different from the routing mechanism and the quality of network service requirements, these are also unique features of VANET, which play an important role in the design and implementation of the entire network system. In view of this, the research results for MANET/WSN cannot be directly applied to the emerging VANET system.

II. PERFORMANCE COMPARISON BETWEEN DSRC AND OTHER SHORT-RANGE WIRELESS COMMUNICATION TECHNOLOGIES

At present, the DSRC/WAVE standardization system with European CEN/TC278, American ASTM/IEEE, and Japan ARIB/TC204 as the core have been basically formed in the world. They are mutually incompatible and each has different application areas but from the microwave. Spectrum perspective it is obvious that the DSRC technology for ITS applications basically selects the 5.8~5.9 GHz RF band, mainly because the microwave signal in this band has good spectral characteristics and propagation characteristics, such as high-speed data transmission (6~27 Mbps).), the communication distance is up to 1000 m, and it is less affected by the weather, so it is especially suitable for the vehicle environment. In addition, in order to avoid unnecessary delays and interferences caused by other non-safety related applications for high priority driving safety-related applications, the frequency band is free to use the frequency band but must apply for a license before use [17, 18] This is also completely different from 900 MHz, 2.4 GHz and 5.0 GHz. Use of the ISM band. The 915 MHz band was also used in the early days, and the main differences between them are shown in Table 2.

TABLE1: 915 MHZ VS. 5. SYSTEM PERFORMANCE COMPARISON

Radio frequency band	5.9 GHz	915 MHz
Data rate	6~27 Mbps	500 kbps
Communication type	Car/car communication	Vehicle communication
Communication distance	<1 km (nominal 300 m)	<30m
Signal uplink	<2W	<4mW
main application	Vehicle safety communication, internet access	No parking fee
system requirement	Based on IEEE 802.11a	Customized chips and software
Communication mode	Request response / point to point mode	Request response method
Spectrum bandwidth	75 MHz	12 MHz
Number of channels	7 (requires a license before use)	1 (use does not need to apply for a license)
Power downlink	<2W	<10w
Source of interference	Certain radar or satellite Communication uplink	900 MHz mobile communication Spread spectrum radio, radar, etc.

In July 2003, the US Federal Communications Commission (FCC) allocated a spectral bandwidth of 75 MHz to the DSRC, located between 5.850 and 5.925 GHz. To meet the needs of different types of applications, this band is divided into eight different channels [19]: a 10 MHz bandwidth control Channel (5.885~5.895 GHz, CH178), six 10 MHz bandwidth service channels (where CH172 belongs to the vehicle-to-vehicle communication service channel, the vehicle communication service channel includes CH174/176/180/182 and the intersection cooperative communication service channel CH184) and a reserved channel with 5 MHz bandwidth (see Figure 7). The control channel is mainly used for the broadcasting safety-related broadcast beacons and the issuance of service announcements, and other non-safety related traffic information is processed and transmitted in the service channel. In the DSRC system, the vehicle communication bandwidth is chosen to be 10 MHz (instead of the 20 MHz bandwidth in the WLAN system), the main reason is in order to reduce the interference between orthogonal frequency division multiplexing (OFDM) symbols caused by multipath propagation.

TABLE 2. PHYSICAL NETWORK STANDARDS OVERVIEW

Technical Standard	Appropriate for Outdoor Network	Speed (Mbps)	Indoor Range Signal (Mtr).	Frequency Band (GHz)	Approximate Outdoor Range Signal (Mtr).	Mobility support (≈km/h)
DSRC (802.11p)	High	3-27	30	5.8-5.9	1000	40-150
WiMax (802.16)	High	1-3Gbps	NR	2.3, 2.5 & 3.5	≈50km	60-250
GPS	Medium	-	-	1.575	-	-
Wi-Fi (802.11b)	Low	11	30	2.4-2.5	100	40-150
Wi-Fi (802.11g)	Low	6-54	35	2.4	140	40-120
Wi-Fi (802.11n)	Low	254	70	2.4/5	250	40-120
Wi-Fi (802.11a)	Low	25-54	30	5.1-5.8	45	40-120
Bluetooth (802.15.1)	Very low	1-24	10	ISM band 2.4–2.48	100	20-30

Unlike the US DSRC specification, the European Telecommunications Standards Institute (ETSI) proposes to allocate a total of 70 MHz between 5.855 and 5.925 GHz to the European DSRC system, where the 10 MHz bandwidth control channel center frequency is at 5.900 GHz (CH180). In addition, 5.875~5.905 is specified for road safety and traffic management applications.

GHz (3 × 10 MHz, mainly used for inter-vehicle communication), 5.905~5.925 GHz (2 × 10 MHz, mainly used for inter-vehicle communication) for high-priority driving safety-related applications, and stipulates 5.855~5.875 the available bandwidth of 20 MHz for GHz is primarily for non-safety related traffic applications [20].

Japan tends to allocate 80 MHz bandwidth for its DSRC communication in the 5.8 GHz band (5.770~5.850 GHz). Although the ISO/TC204 Technical Committee of China has also proposed to allocate the 5.8 GHz band to smart transportation short-range communication to the Radio Management Committee of the Ministry of Communications, for the current specific application, the main implementation is ETC charging service.

Summary Table 3 compares DSRC with several other commonly used short-range wireless access technologies in terms of transmission rate, spectrum characteristics, and communication modes. It can be seen that each radio system has its own technical performance and application fields.

It provides high-speed and high-reliability Internet access but does not support applications with high real-time requirements. Telecom networks (such as GSM/CDMA) are mainly for voice services, so they can provide low latency. Real-time support, but poor reliability; dedicated communication systems (such as DSRC) are application-related networks that can be used to make efficient target systems only when they are close to the application; however, radio broadcasts are difficult to provide high-reliability, low-latency real-time. The reliability of communication services is usually guaranteed by relay forwarding.

III. Conclusion

The IEEE 802.11p also said to be a Dedicated Short-Range Communication (DSRC), which is meant for vehicular ad-hoc networks (VANETs). Currently, DSRC is the only standard with support for direct vehicle-to-vehicle (V2V) communication. The original DSRC standards are more application-specific standards containing the whole protocol stack with a physical (PHY), a MAC and an application layer, which are found in Europe, Japan and Korea. DSRC is meant for hot spot communication like electronic toll collection systems. DSRC specifically designed automotive use which is a protocol for short to medium range wireless. DSRC provides high bandwidth DSRC gives high bandwidth communication between vehicles (V2V) or they can also communicate between a roadside unit and vehicles (V2I or I2V). By the entire vehicle V2V concept relies on the continuous broadcast of information, which permits each vehicle to connect the entire neighbor vehicle in real-time. This message is also known as a packet where information is transmitted at regular intervals. To tell the neighbors about the vehicle profile the packet is generated and broadcasted consecutively.

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TABLE.3 PERFORMANCE COMPARISON BETWEEN DSRC AND OTHER SHORT-RANGE WIRELESS COMMUNICATION TECHNOLOGIES

	DSRC-ETC	**DSRC-IVC**	**WLAN**	**IR**	**WiMAX**	**GSM/GPRS**	**UMTS**
Technical standard		IEEE 802.11p	IEEE 802.11a/b/g	ISO 21214	IEEE 802.16	GSM	3GPP
Antenna type (MHz)	Roof antenna	Roof antenna	Roof antenna	Directional antenna	Smart Antenna (MIMO)	Roof antenna	Roof antenna
Spectrum range (MHz)	5795~5815 (early: 902~928)	Europe: 5855~5925 United States: 5850~5925 Japan: 5770~5850	11a: 5 GHz (UNII) 11b/g: 2.4 GHz (ISM)	800~1000 nm	2~66 GHz can be User choice	Europe: 900/1800 United States: 850/1900	Europe: 900/2100 United States: 850/1700/1900
Channel bandwidth	4 × 5 MHz or 2 × 10 MHz	Control channel: 1 × 10 MHz Service channel: 6 × 10 MHz	20 MHz	4 independent channels	-	124 × 200 kHz 8-time slots/carrier frequency	5 MHz
Equivalent omnidirectional Radiated power	≤33 dBm	Roadside node: ≤44.8 dBm Vehicle node: ≤33 dBm	17 dBm/MHz ≤ z30dBm	-	Depending on the frequency range used	(MS) ≤ 2W(850/900) ≤1W(1800/1900)	Power Control
Data rate (kbps)	Downstream:500 Upstream: 250	3000~27,000 Typical rate: 6000	802.11a/g : ≤54,000 802.11b： ≤11,000	1000~2000	≤70,000 Typical rate: 10,000	(GPRS) Downstream: 60~80 Upstream: 20~40	Car environment: 384
Communication distance(m)	3~15	≤1000	Access point Coverage	1~100 Typical distance: 7	Access point Coverage Maximum: 50 km	Base station Coverage Maximum: 35 km	Dependent on base station coverage maximum:2km
Connection establishment time(ms)	5~12	Self-organizing	-	10	Connection delay Support for handoff	Network access time: 10 s Support for handoff	Network access time: 2.12 s Support for handoff
System response time(ms)	10	Depending on the specific implementation	Depending on the specific implementation	10	Depending on the specific implementation	500~700	200~300
Channel access mechanism	TDMA	EDCA(~802.11e)	CSMA	TDMA	OFDMA	TDMA	CDMA
Priority or QoS support	No priority QoS support	4 service levels No real-time support	Priority support No QoS/RT support	CALM~IR support 8 Different priorities	QoS depends on it Distance to AP	No QoS support	QoS depends on it Distance to BS
Communication mode	Directional duplex asymmetry Broadcast, no P2P	Omnidirectional duplex symmetry Broadcast/unicast/multicast	Omnidirectional duplex symmetry Broadcast, no P2P	Directional duplex symmetry Broadcast/unicast/multicast	Omnidirectional duplex asymmetry Limited broadcast, no P2P	Omnidirectional duplex asymmetry No broadcast, no P2P	Omnidirectional duplex asymmetry Limited broadcast, no P2P
system requirement	Roadside equipment	GPS (but not mandatory)	Access point device	Line-of-sight directional antenna	Access point device	Base station equipment	Base station equipment
Main source of interference	DSRC-IVC	DSRC-ETC WLAN 5GHz	DSRC-IVC	Visible light, rain, snow	Depends on use Frequency range	Reserved frequency band	Reserved frequency band

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