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A Review On Vehicle-2-Vecicle Communication System Using DSRC Protocol

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Abstract**—**The Dedicated Short-Range Communication (DSRC) protocol is used in Vehicle-to-Vehicle (V2V) communication systems. This review paper Explains and investigates the developments and difficulties in this field. As a key technology for facilitating effective and dependable vehicle-to-vehicle communication, DSRC has become increasingly important, providing prospects for improved traffic control, road safety, and intelligent transportation systems [4]. This study investigates the essential elements, protocols, and architectures used in V2V communication systems based on DSRC, along with their uses and possible ramifications for future transportation networks, through a thorough examination of the body of existing literature. It also provides a critical assessment of the scalability, security, and performance of DSRC-based V2V systems, pointing out weaknesses and outlining potential directions for further study and advancement. This review seeks to provide a thorough knowledge of the state-of-the-art in V2V communication systems using DSRC by integrating ideas from numerous studies. It also highlights opportunities for further exploration and improvement in this quickly expanding subject.

Keywords— DSRC, V2V Communication, Traffic control & Road Safety.

I. Introduction

Advancements in the field of intelligent transportation systems have been greatly stimulated by the introduction of Vehicle-to-Vehicle (V2V) communication systems that employ the Dedicated Short-Range Communication (DSRC) protocol. With the use of this rapidly developing technology, cars can communicate vital information in real time, improving traffic flow, road safety, and the driving experience as a whole. V2V communication systems based on DSRC have the potential to transform how cars communicate with their surroundings and with each other, which might have a significant impact on lowering traffic accidents, easing congestion, and accelerating the advancement of autonomous driving technology [5]. But like any emerging technology, there are issues and complications to be aware of, which calls for careful consideration and study. In order to promote a deeper understanding of this game-changing technology and its implications for the future of transportation, this paper aims to provide a thorough overview of the state-of-the-art in V2V communication systems using DSRC. It does this by examining key components, protocols, applications, performance metrics, security considerations, and future research directions.

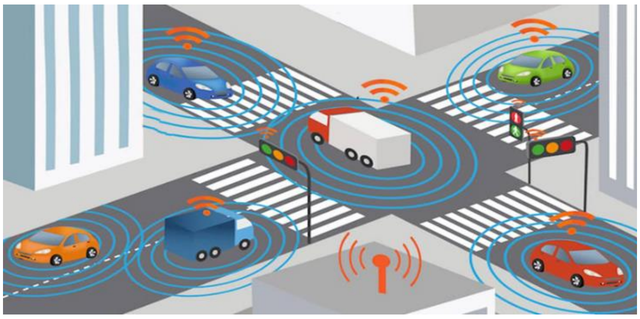

Figure 1.1 V2V Communication Illustration for road safety

A. *Background and Motivation*

To construct safer and more effective transportation systems, the automobile industry has seen a paradigm change in recent years toward smart and connected vehicles. In this evolution, vehicle-to-vehicle (V2V) communication is a key technology that allows cars to communicate with other vehicles in the vicinity to share vital information like position, speed, and status [6]. Vehicles are able to predict possible hazards and respond to them quickly thanks to this shared data, which helps to prevent accidents. The urgency of addressing road safety issues, lowering the number of traffic accidents, and building a networked automotive ecosystem that can adjust to changing traffic conditions is what spurred this development.

B. *Problem Definition*

Vehicle-to-vehicle (V2V) communication is essential for improving road safety because it allows cars to communicate with other surrounding vehicles in real time about their position, speed, and status. Vehicles function somewhat in isolation without this communication system, unable to share vital information that might avert crashes or mishaps. Vehicle-to-vehicle (V2V) communication is necessary to enable collaborative awareness among cars, which makes it difficult to predict and react to quickly changing traffic situations [13]. This restriction may cause people to react to possible threats more slowly, reduce overall road safety, and pass up the chance to use cutting-edge technologies to prevent accidents in the rapidly developing field of intelligent transportation systems.

C. *System Architecture*

Sr. No.	Components	Description
1.	Onboard Unit (OBU):	• DSRC Module: For fast, short-range vehicle-to-vehicle communication, include a DSRC communication module in the onboard unit. • Wi-Fi Module: Install a Wi-Fi module to increase communication range and allow further communication features. • Microcontroller (Raspberry Pi): To handle sensor data and control communication protocols, use a microcontroller (such as the Raspberry Pi) as the central processing unit.
2.	Communication Middleware:	• DSRC Communication Middleware: Create middleware to control the formatting, sending, and receiving of messages in DSRC communication. Put DSRC security procedures in place to ensure authentication and data integrity. • Middleware for Wi-Fi Communication: Create middleware that enables Wi-Fi communication while guaranteeing DSRC compatibility and smooth integration. Put Wi-Fi security measures in place to ensure safe data transfer.
3.	Data Processing and Fusion:	• Data Processing Unit: Use the microcontroller to process data from various sensors, including ultrasonic ones. Put data fusion, obstacle identification, and distance measuring algorithms into practice. • Calibration Logic: Put logic in place to adjust distance measurements according to the kind and positioning of sensors. Adapt calibration parameters dynamically to the speed and ambient circumstances of the vehicle.
4.	Accident Prevention Logic:	• Dynamic Following Distance Adjustment: Use algorithms to modify the following distance dynamically in response to real-time information, promoting safer and more adaptable driving.
5.`	V2V Communication Interface:	• DSRC Communication Interface: Provide interfaces for message encoding and decoding, signal strength monitoring, and collision detection in order to control DSRC communication. • Wi-Fi Communication Interface: Provide interfaces that provide secure transmission, low latency, and data integrity for Wi-Fi communication.
6.	User Interface (Optional):	• Driver Display: If appropriate, put in place a user interface that allows drivers to get feedback in real time on the state of V2V communication, any dangers, and suggested courses of action. • Driver Alerts: Use visual or audio alerts to warn drivers of impending accidents or when they should alter their driving style.
7.	Vehicle Control Unit:	• LED blinking, the motor being off, or any other kind of Integration with the vehicle's control unit will enable autonomous braking and acceleration adjustments based on V2V communication data and accident avoidance logic.
8.	Wireless Communication Infrastructure:	• DSRC/Wi-Fi Base Stations (Optional): To increase communication range and offer more data exchange capabilities, integrate with DSRC/Wi-Fi base stations in locations with infrastructure support.

Figure 2. System Architecture

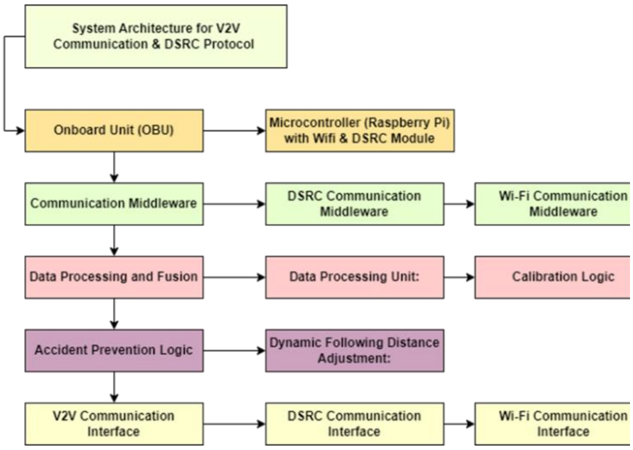

Figure 3. System Architecture

II. Literature Survey

A. Surveys

Ashar Ahmed and Bushra Aijaz et al. [1] the writers possess the transportation of the future is networked automobiles. When cars can "communicate" to one another or exchange information with one another regarding the traffic and road conditions, the road can become safer. Smooth communication between vehicles can be beneficial for road safety in the event of abrupt braking, uneven surfaces, slow-moving traffic, low visibility circumstances like fog, and—most importantly—traffic going the wrong way. Our research makes recommendations for possible uses of vehicle-to-vehicle (V2V) communication to raise road safety in Pakistan. We have examined one such signalized crossroads location on Karachi's main University route and have proposed a method for utilizing V2V technology to make this route safer for both cars and pedestrians. [1]

Liu Cao, Hao Yin, Jie Hu & Lyutianyang Zhang et al. [2] The performance of vehicle-to-vehicle (V2V) communication using the Dedicated Short Range Communication (DSRC) application in periodic broadcast mode is the main topic of this article.. With the assumption of perfect PHY performance, (PDR) and mean delay based on the IEEE 802.11p standard in a fully linked network are examined using an analytical model and a fixed point technique. Using the capabilities of V2V communication, we develop the Semi-persistent Contention Density Control (SpCDC) technique to improve the DSRC performance. We use Monte Carlo simulation to verify the analytical model results. The simulation findings show that under extreme vehicle load conditions, the packet delivery ratio in the SpCDC scheme surpasses 10% in comparison to IEEE 802.11p. Meanwhile, the mean reception latency has dropped by more than 50%, increasing traffic safety.[2]

Vithanage W.G et al. [3] The acronym "DSRC" stands for Dedicated Short-Range Communications, a wireless technology that integrates with the Intelligent Transportation System to enable communication between automobiles and roadside infrastructure units. DSRC provides more advanced features than other wireless technologies such as Wi-Fi, GSM, WiMAX, and so on. This paper describes the properties, functions, and applications of DSRC intelligent modes of transportation (ITS).

Particular Short-Range Phone Essentially, long-range RFID communication using microwave technology is what wireless technology is. The International Standardization Organization's (ISO) transport and control system unit is in charge of implementing and overseeing the DSRC standards. The USA 900 MHz, Japan ARIBSTDT75, and Europe ENV Series are the three global DSRC standard camps. [1] It is recommended that the 5.8 GHz frequency spectrum be made exclusive to the DSRC by the Wireless Management Congress. DSRC Wireless technology allows an automobile to stay connected to other cars, improving road safety and driving enjoyment.

In order to facilitate ITS applications, the US (FCC) allocated in 1999 the frequency band ranging from 5.85 to 5.925 GHz of the spectrum for wireless communications to be used by the (DSRC) systems. This was mandated by ITS as wireless connection was necessary for data transfer between cars and between infrastructure and vehicles. A study on the use of the 5.9 GHz spectrum for ITS applications was released by the FCC in 2003. This research made use of the (ASTM) E2213-03 standard, which enables communications and information sharing between cars and roadside units. This ASTM standard employs (OFDM) with an 8//sec symbol period, based on the IEEE 802.11a standard [14].

ASTM made several changes to the IEEE 802.11a standard to allow for fast-moving vehicles [15]. The principal aim of the DSRC standard's establishment was to improve car safety applications. In 2006, the FCC changed the rules to restrict Vehicle-to-Vehicle collision prevention systems to using solely DSRC technology.

In 2008, the FCC changed the required standard for operation in the 5.9 GHz spectrum from ASTM E2213-03 to IEEE 802.llp. The IEEE 802.lip employs the same OFDM technique as IEEE 802.11a, while having a 10 MHz channel width as opposed to IEEE 802.lla's 20 MHz channel width.Both IEEE 802.11p and IEEE 802.11a use the same modulation; however, each IEEE 802.lip modulation level results in half the data speed since IEEE 802.lip employs a 10 MHz channel width and half the duration of each symbol. These improvements to IEEE 802.11a have the advantage of improving the reliability of IEEE 802.lip in scenarios involving extremely brief communication and scenarios where multipath shifts rapidly, such as in automobile environments. Furthermore, because to high speeds, the standard Wireless Local Area Networks (WLAN) technique would not be practical in some road conditions. Through the protocol of Broadcast message IEEE 802.lip Enables Communication of message between surrounding automobile or vehicles in aligned scenarios without any requirement of Network using a two way WLAN Connection. [16]

B. Technical Features

High-speed wireless communication is possible with dedicated short-range technologies. Since DSRC has the lowest latency and the maximum transfer rate available. This technology can handle a wide range of other communications demands for transportation systems, such as intelligent parking systems, electronic toll collecting (ETC), and more, in addition to connecting vehicles to other vehicles and infrastructure. During a communication process, it can establish a connection very rapidly and reliably. Wi-Fi and GSM (Global System for Mobile Fidelity) are less sophisticated than DSRC in terms of capability. DSRC is regarded as the more reliable wireless technology since it shares many of the same features and performance metrics as WiMAX but is less complex and costly.

	DSRC	Wi-Fi	GSM	WiMAX
Delay	<50ms	Seconds	Seconds	/
Mobility	>60m/h	<5m/h	>60m/h	>60m/h
Data Transfer Rate	3-27 Mb/s	6-54 Mb/s	<2Mb/s	1-32 Mb/s
Communicatio n Distance	<1000m	<100m	<10km	<15km
Communicatio n Bandwidth	10MHz	20MHz	<3Mhz	<10MHz
Communicatio n Band	5.86~ 5.925 GHz	2.4GHz, 5.2GHz	800MHz, 1.9GHz	2.5GHz
IEEE Standards	802.11P (WAVE)	802.11a	N/A	802.16e

Figure 3. Wireless Communication Technologies Comparison

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C. Communication and Technical mechanism

The following three components make up the dedicated short-range communication technology mechanism in its entirety.

- On-Board Unit (OBU)
- Roadside Unit (RSE)
- Protocols for communication

There are numerous kinds of OBU equipment available. The majority of fast-moving automobiles are outfitted with OBUs. RSUs are positioned on the road's shoulder. The data-link layer, application layer, and physical layer are the three main levels that make up the tiered architecture of DSRC protocols (Figure) [4]. Once more, the data link layer is separated into two layers: LLC (Logical Link Layer) and MAC (Medium Access Control), depending on how each layer is used. Because of the minimal overhead in the OS of the protocol, which lowers delays, the real-time features of this straightforward protocol architecture

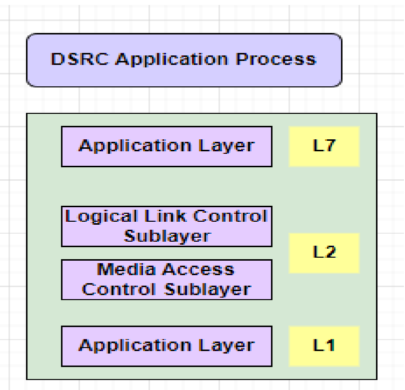

Figure 4. Communication and Technical mechanism

D. Network architecture

Every day, the number of roadside collisions is sharply increasing. Consequently, as a safety feature in all future cars and on all highways, DSRC technology will be widely employed to address this issue. The system determines which network model applies.

This paper covers the architecture of the Vehicle Infrastructure Integration network model. Geographic routing and IPv6 protocol integration have changed over time. The automobile may use all of the available internet protocol-based apps and connect to the internet either directly or through multi-hop connection thanks to this integration.

The department of road development, the department of traffic management, and other governmental organizations send traffic data to the drivers and infrastructure elements via Ethernet technology. Most corporate companies, including infrastructure components, can broadcast this information for public consumption using Ethernet technology. After then, the data is sent to the car's OBD, which the drivers are free to utilize however they see suitable.

When a driver drives their automobile to the toll station, toll stations can collect information based on vehicle to infrastructure communication. The infrastructure unit installed in the toll and the on-board computer installed in the vehicle communicate with one another to do this. Prior to recording the toll information in this phase, the system searches the database for the customs information. Vehicle-to-vehicle (V2V) communication is used to notify surrounding vehicles of accidents. This information is also distributed across different regions as needed. [8]

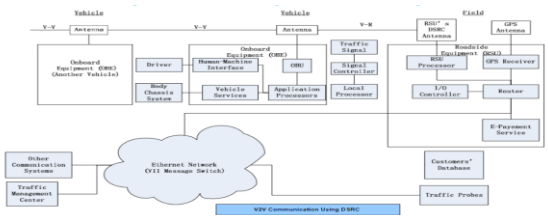

Figure 5 Network architecture

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E. Services from V2V and V2I

Sr. No.	Main uses of V2V and V2I communication services are to transmit information for:
1.	Roadside beacons
2.	Traffic signals/controls
3.	Toll collections
4.	Petrol pumps and charging centers (for electric vehicles)
5.	Digital signage
6.	Safety Applications such as red light violations, overloading or crossing speed limits
7.	eCall (911 in USA and 112 in Europe)
8.	Infotainment
9.	Maintenance
10.	Navigation

Table 1. Services from V2V and V2I

When paired with appropriate road infrastructure, V2V safety applications will also make a wider range of safety and mobility applications possible; as such, V2V acts as the entry point for more extensive ITS applications. The following are examples of vehicle-to-vehicle (V2V) safety applications that are made possible only by V2V and cannot be duplicated:

- Vehicle-resident sensor- or camera-based systems.
- Assistance with Intersection Movement
- Left Turn Assistance
- Electronic Emergency Brake Light
- Infrastructure-related gadgets
- Devices based on infrastructure that facilitate V2

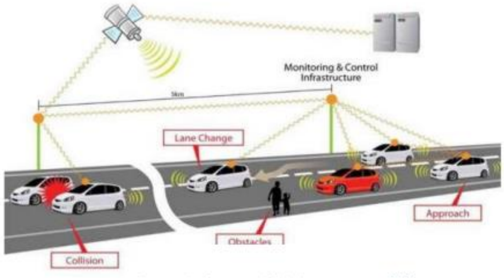


Figure 6. Illustration Services from V2V and V2I

F. Safety application

By enabling vehicles to exchange vital information in real-time, vehicle-to-vehicle (V2V) communication systems that use the Dedicated Short-Range Communication (DSRC) protocol have completely changed applications related to road safety. Numerous features are included in these safety apps with the goal of raising driver awareness, reducing the likelihood of collisions, and boosting overall traffic safety. Cooperative Collision Warning (CCW) systems are one of the main safety applications made possible by V2V communication and DSRC. These systems let vehicles to identify possible collision dangers and promptly alert drivers by exchanging data, including vehicle position, speed, and direction, via vehicle-to-vehicle (V2V) communication. By giving drivers alerts and advisories based on the analysis of surrounding traffic circumstances, CCW systems can dramatically lower the frequency of rear-end collisions, lane-change crashes, and intersection-related accidents.

Intersection Collision Warning (ICW) applications are also supported by V2V communication systems that use DSRC. Since junctions account for a large percentage of traffic accidents, ICW systems use V2V communication to identify and alert drivers to possible collisions. Vehicles can anticipate and avert collisions connected to intersections, including those caused by failure to yield or red-light violations, by sharing information about their positions, velocities, and intended trajectories. ICW systems improve situational awareness among drivers and offer preventative safety measures to lessen the likelihood of collisions, particularly in intricate urban driving situations with heavy traffic and a variety of road user behaviors.

Emergency Electronic Brake Lights (EEBL) applications are also made possible by V2V communication systems based on the DSRC protocol. These applications improve safety by warning drivers of impending emergency braking events even when they are out of their line of sight. cars equipped with EEBL systems communicate their brake condition and deceleration information to other cars in the vicinity. This enables following vehicles to anticipate warnings and adjust their course in order to prevent rear-end collisions. These devices offer an extra degree of safety assurance to drivers and passengers in situations where visibility is restricted because of things like bad weather, blocked vistas, or nighttime driving circumstances.

`Road safety tactics have undergone a paradigm shift as a result of safety applications in V2V communication systems that use the DSRC protocol. These applications offer proactive and cooperative approaches to accident prevention and mitigation. These applications have the potential to drastically lower the human and financial costs associated with traffic accidents by utilizing real-time data interchange and cooperative awareness among cars, opening the door for safer and more effective transportation networks'.

G. DSRC Communication between CAV & UAV

The automotive sector has successfully employed the Dedicated Short Range Communication (DSRC) protocol for a wide range of communication applications. Employed DSRC communication for a Vehicle-to-Infrastructure (V2I) algorithm, enabling a CAV with a DSRC modem to receive Signal Phasing and Timing (SPaT) messages broadcast by a traffic light and utilize them to save fuel usage. Created and tested a Cooperative Adaptive Cruise Control (CACC) model that makes use of DSRC communication for car-following applications, as well as a Hardware-in-the-Loop (HIL) simulator for testing automated driving algorithms. [2]

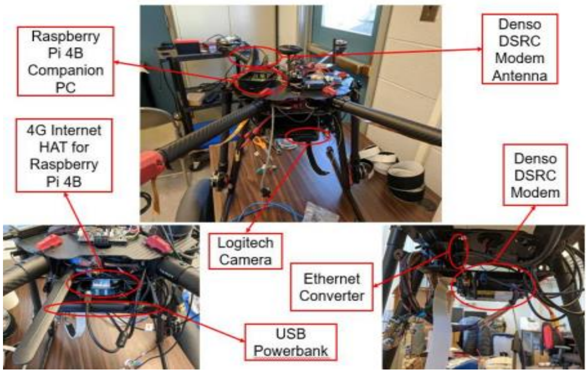


Figure 7. UAV platform equipped with hardware.

H. Analytical modal for making v2v communication using DSRC protocol with raspberry pi controller

Signal Propagation Model:

$$Free - space\ path\ loss\ model\ PL\ (d) = 20\ log10(d) + 20log10(f) + K$$

where:

PL(d) is the path loss at distance

d (in meters),

f is the frequency of operation (in Hz),

K is a constant that depends on environmental factors.

$$Received\ Signal\ Strength\ (RSS):$$

$$RSS = Pt - PL(d) + Gt + Gr$$

where:

- $P\ t$ *is the transmitted power (in dBm),*
- $G\ t$ *and* $G\ r$ *are the transmitter and receiver*

$antenna\ gains\ (in\ dB)$.

Packet Error Rate (PER) – Determine the bit-rate-to-noise ratio (SNR) and the modulation algorithm (BPSK, QPSK, etc.) to determine the peak bit rate (PER).

Data Rate – Determine the achievable data rate based on the modulation scheme, channel bandwidth, and PER.

Channel Access and Latency – DSRC uses IEEE 802.11p for MAC layer protocols. Analyze the contention-based channel access mechanism, including back off procedures, to estimate latency and throughput.

Transmission Range – Define the transmission range based on the maximum allowable path loss and the power constraints of the Raspberry Pi controller and DSRC transceiver.

Throughput – Estimate the throughput based on the achievable data rate, channel access protocol efficiency, and packet error rate.

Interference Analysis - Examine possible 5.9 GHz band sources of interference, such as Bluetooth or Wi-Fi enabled devices, and assess how they affect the efficiency of V2V communication.

Energy Consumption – Model the energy consumption of the Raspberry Pi controller and DSRC transceiver during transmission and reception, considering factors such as duty cycle and idle power consumption.

System Reliability and Security – Consider reliability metrics such as packet delivery ratio and end-to-end delay, as well as security mechanisms such as message authentication and encryption.

III. Application, Advantages & Disadvantages, Conclusion & Future Scope

A. Advantages & Disadvantages

Sr. No.	**Advantages**	**Disadvantages**
1.	• Improved Road Safety • Traffic Efficiency • Enhanced Driver Assistance • Support for Autonomous Vehicles • Environmental Benefits	• Infrastructure Deployment • Spectrum Allocation • Privacy and Security Concerns • Standardization and Interoperability • Vulnerability to Cyber Attacks

B. Application

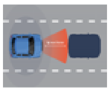
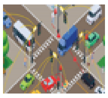
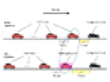
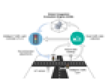
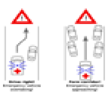
Sr. No.	Components	Description	Icons
1.	Collision Avoidance Systems:	Vehicle-to-vehicle (V2V) communication allows cars to share real-time data on their trajectory, position, and speed. This data is utilized to support collision avoidance systems by identifying possible collision dangers and promptly alerting drivers. By warning drivers of impending hazards, these systems can assist avert lane changes, rear-end collisions, and other mishaps.	
2.	Intersection Safety:	By enabling cars to exchange information about their approach, speed, and intentions, DSRC-enabled V2V communication systems can increase safety at intersections. Vehicles can coordinate their movements, foresee possible conflicts, and negotiate right-of-way with the use of this information, which lowers the likelihood of intersection-related incidents including T-bone crashes and pedestrian accidents.	
3.	Cooperative Adaptive Cruise Control (CACC):	Cooperative Adaptive Cruise Control systems, in which cars independently modify their speed and following distances depending on input from neighboring vehicles, are made possible by V2V communication. CACC systems can lessen traffic jams, increase fuel efficiency, and improve traffic flow by requiring a safe and uniform gap between vehicles.	
4.	Traffic Congestion Mitigation:	Vehicles can communicate real-time traffic information, such as road closures, accidents, and congestion, thanks to DSRC-based V2V communication systems. By optimizing traffic flow and rerouting cars on the fly, this data can lessen congestion and cut down on travel times for all users of the road.	
5.	Emergency Vehicle Warning:	Emergency vehicles like ambulances, fire trucks, and police cars can broadcast their location, status, and intended path to other vehicles in the vicinity by using vehicle-to-vehicle (V2V) communication. This expedites response times and may even save lives by allowing other drivers to cede the right-of-way, clear the route, and allow emergency vehicles to pass quickly.	
6.	Road Weather Condition Alerts:	When a vehicle has DSRC installed, it can communicate with other vehicles regarding roadside weather conditions including rain, fog, or ice. By using this information, drivers can be made aware of potentially dangerous road conditions in advance, allowing them to modify their driving style and lower their chance of weather-related collisions.	
7.	Platooning:	Platooning—a coordinated group of vehicles traveling close together—is made possible by V2V communication. The lead vehicle manages the group's speed and trajectory. Platooning can boost traffic capacity, lower aerodynamic drag, and enhance fuel efficiency for all participating vehicles by maintaining close spacing and coordinated movements.	

Figure 8. Applications of V2V Communication system

C. Conclusion

In conclusion, this review paper has provided a comprehensive overview of Vehicle-to-Vehicle (V2V) communication systems utilizing the Dedicated Short-Range Communication (DSRC) protocol. Through an examination of key components, protocols, applications, performance metrics, security considerations, and future

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research directions, it is evident that DSRC-based V2V communication systems hold immense potential for revolutionizing road safety, traffic management, and intelligent transportation systems. Despite significant advancements and promising applications, challenges such as spectrum availability, interoperability, cyber security, and regulatory frameworks remain to be addressed. Nevertheless, with continued research, innovation, and collaboration across academia, industry, and policymakers, DSRC-based V2V communication systems are poised to play a crucial role in shaping the future of transportation, ultimately leading to safer, more efficient, and sustainable mobility solutions.

D. Future Scope

Looking towards the future, several key modifications and advancements can be envisaged for Vehicle-to-Vehicle (V2V) communication systems utilizing the DSRC protocol. First, integration with emerging technologies such as 5G and beyond, as well as the potential transition to alternative communication standards like C-V2X, could offer enhanced performance, reliability, and scalability. Additionally, leveraging artificial intelligence and machine learning techniques for intelligent data processing and decision-making within V2V systems could improve contextual awareness and predictive capabilities, thereby further enhancing road safety and traffic efficiency. Moreover, exploring novel communication paradigms such as hybrid communication architectures, cooperative sensing, and edge computing integration could enable V2V systems to adapt to dynamic and heterogeneous environments more effectively. Furthermore, efforts towards standardization, harmonization of regulations, and collaboration among stakeholders will be crucial to fostering widespread deployment and interoperability of V2V communication systems, ultimately realizing their full potential in creating safer and more connected transportation ecosystems.

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