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A Review on Vehicle to Vehicle Communication

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ABSTRACT: Vehicle to Vehicle(V2V) communication is a promising technology that is going to make all our traffic lives much easier with lesser traffic jams and lesser road accidents. This technology is essentially nearby vehicles talking to each other, which minimizes the risk of collisions. V2V takes place using a Dedicated Short-Range Communication (DSRC) which ensures fast transmission. The vehicle is embedded with some set of components. At first, the signal from the antenna is passed through the GPS receivers where it provides vehicle position and time to DSRC radio and Electronic Control Unit(ECU). The ECU runs safety applications and distributes the information to all the In-vehicle components and the Driver-Vehicle Interface would generate warnings to the driver in order to avoid collision. The messages used for communication are stored in the memory which is also equipped with security certificates. Broadcasting of vehicle details to other vehicles, however also poses privacy risk. This is a problem since this can lead to security being breached and data being collected against will for unauthorised purposes. V2V has a standard security measure such as Security Credentials Management Systems (SCMS) to counter such threats. This paper attempts to review the basic understanding of V2V, briefs about the vehicle components and highlights the various crash scenarios of collisions, their safety applications and discusses about the security measures involved.

KEYWORDS: Vehicle to Vehicle, Dedicated Short-Range Communication, Driver-Vehicle Interface, Security Credentials Management System.

I. INTRODUCTION

Vehicle-to-vehicle (V2V) communications consists of a wireless network where automobiles convey information about what they are doing. This data mainly consists of speed, location, direction of travel, braking, and loss of stability. One important factor to be considered for vehicular communication systems is safety and eliminating the excessive cost of traffic collisions[5].

Vehicle-to-vehicle technology uses Dedicated Short-Range Communications (DSRC). DSRC works in 5.9 GHz band with bandwidth of 75 MHz[1]. In V2V communication messages have a range of more than 300 meters and can detect dangers occurred by traffic, terrain, or weather. V2V is a crash avoidance technology, which relies on communication of information between nearby vehicles to potentially warn drivers about dangerous situations that would lead to a crash. For example, V2V could help warn a driver that a vehicle which is moving ahead is braking and they need to slow down, or let a driver know that it's not safe to proceed through an intersection because another car (unseen by the driver) is quickly approaching. In V2V communication every vehicle is embedded with some indispensable equipment such as On-Board Unit (OBU) for exchanging information with Road Side Unit(RSU) or with other OBUs, Global Positioning System (GPS) to obtain the locations of the vehicle, sensors and computing devices. The technology behind V2V communication allows vehicles to broadcast and receive omni-directional messages (up to 10 times per second),

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creating a 360-degree “awareness” of other vehicles in proximity. Those vehicles equipped with appropriate software (or safety applications) can use the messages from surrounding vehicles to determine potential crash threats as they develop[2].



Fig.1.1 Crash avoidance through V2V communication



Fig.1.2. Future of Driving with V2V technology

V2V technology has a wide range of applications and its range exceeds the capabilities of systems with ultrasonic sensors, cameras, and radar – in some cases, by nearly twice the distance, allowing more time to warn drivers. Moreover, these radio messages can “see” around corners or “through” other vehicles addressing, for example, scenarios such as those where an oncoming vehicle emerges from behind a truck. In those situations, V2V communications can detect the threat much earlier than radar or camera sensors. Additionally, V2V technology can combine with existing radar and cameras to provide even greater benefits than approaching alone. This combined approach would improve system accuracy, becoming a foundation for realizing automated vehicles on the Nation’s roadways. The U.S. Department of transportation states that 21,000 out of 43,000 road accidents occurs due to roadway departures and intersection related accidents. This number can be brought down by using local warning systems through vehicular communications[5].

II. VEHICLE COMPONENTS OF A V2V SYSTEM[3]

1.Dedicated Short-Range Communication (DSRC): Dedicated Short-Range Communication (DSRC) is a wireless communication technology which is designed to allow automobiles in the intelligent transportation system (ITS) to communicate with other automobiles or infrastructure technology. DSRC technology operates at 5.9GHz band of the radio frequency spectrum and is effective over short to medium distances.

2.GPS Receiver: GPS is a system of 30+ navigation satellites circling Earth. We know the exact location where they are because they constantly send out signals. The GPS receiver on your phone listens for these signals. Once the receiver calculates the distance from four or more GPS satellites, it can figure out where you are.

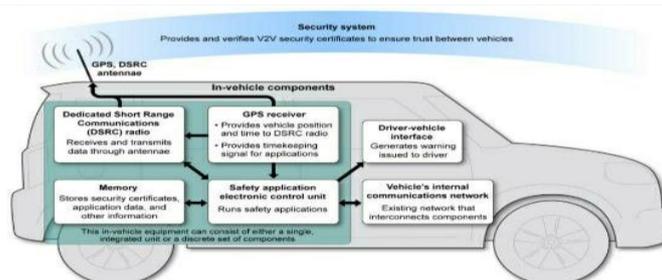


Fig.2.1 In-Vehicle Components of V2V System[3].

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3.Driver Vehicle Interface: Vehicle senses the collision approaching towards it and generates warning issued to driver.

4.Memory: It basically acts as a storage element where it stores security certificates, application data and other information.

5.Safety Applications and Electronic Control Unit: There are some of V2V safety application which has to be followed and has been briefly explained in the below subtopics. An electronic control unit is basically a device responsible for overseeing, regulating and altering the operation of a car's electronic systems. Each of the car's electronic features, such as an anti-lock braking system or electronic fuel injection setup, will typically be controlled by an ECU.

6.Vehicle's Internal Communication Network: It is an existing network that interconnects components.

III. VEHICLE CRASH SCENARIO

V2V technology communicates through radio signals, which are omnidirectional (i.e., offer 360 degrees of coverage). Communicating via these signals allows two connected vehicles to “see” each other at times whereas other vehicles that are only relying on their sensors are not able to detect the presence of another vehicle, let alone determine the other vehicle's heading, speed, or its operational status[2].

Some of the example of crash scenario and vehicle to vehicle application:

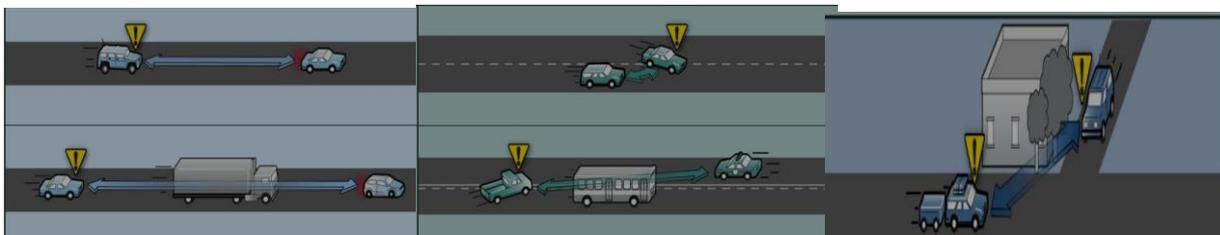


Fig.3.1

Fig.3.2

Fig.3.3

Fig.3.1 depicts the example of Rear end collision scenario, Fig 3.2 depicts the example of Lane change scenario, Fig 3.3 depicts the example of intersection scenario[3].

In Fig.3.1, the first case is called as Forward collision warning i.e moving towards a vehicle which is decelerating or stopped and the second is called as Emergency electronic brake light warning i.e moving towards a vehicle stopped in roadway but not visible due to obstruction[4].

In Fig.3.2, the first case is called as Blind spot warning i.e at the beginning of lane departure of one vehicle that could encroach on the travel lane of another vehicle travelling in the same direction and can detect vehicles not yet in blind spot and the second case is called as Do no pass warning i.e when one vehicle approaches onto the travel lane of another vehicle travelling in opposite direction and can detect moving vehicles.

In Fig.3.3, this case is called as Blind intersection warning i.e approaching onto the travel lane of another vehicle with whom driver is crossing paths at a blind intersection or an intersection without a traffic signal[6].

IV. SAFETY APPLICATIONS

There are three V2V safety applications that the agency believes are enabled by V2V alone and could not be replicated by any current known vehicle-resident sensor- or camera-based systems, as discussed below:

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1. Intersection Movement Assist:

IMA application warns the driver of a vehicle when it is not safe to enter an intersection due to high collision probability with other vehicles at stop sign controlled and uncontrolled intersections. This application can provide collision warning information to the vehicles operational systems which performs actions to avoid collisions. Figure 4.1 illustrates one possible IMA scenario[7].

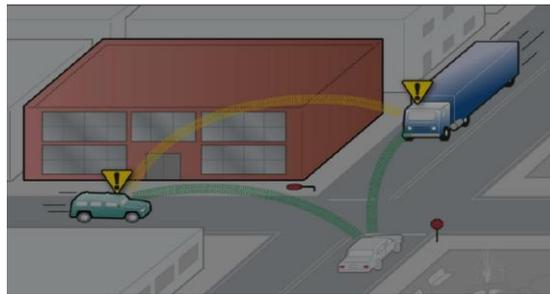


Fig.4.1

Fig.4.1 depicts the Example of V2V Intersection Movement Assist Warning Scenario

In this scenario, the truck and sports utility vehicle are on the urge of colliding because the drivers are unable to see one another approaching the intersection and the stop sign is disabled. Both drivers would receive warnings of the collision, allowing them to take necessary actions to avoid it[3].

2. Left Turn Assist:

LTA warns the driver of a vehicle, when they are entering an intersection, not to turn left in front of another vehicle traveling in the opposite direction. This system monitors upcoming traffic using two radar sensors in front of the vehicle. If a collision with upcoming vehicle is imminent, the system will stop the turn in time by performing an automatic emergency braking system[8].

3. Emergency Electronic Brake Light:

Emergency Electronic Brake Light is used to target the position accuracy and time-critical problems in the distribution of warning messages among vehicles which is employed with camera sensors and Dedicated Short Range Communication(DSRC) protocol. It is particularly useful when the drivers line of sight is disturbed by other vehicles or due to weather conditions.

4. Forward collision Warning:

Forward Collision Warning (FCW) system is an advanced safety technology that monitors a vehicles speed, the speed of the vehicle in front of it, and the distance between the vehicles. If the vehicles get too close due to speed of the rear vehicle, the FCW system warns the driver through voice and visual interface of the risk of an impending rear-end collision with a vehicle ahead in traffic in the same lane and direction of travel[9].

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5. Blind Spot Warning and Lane Change Warning:

Blind Spot Warning (BSW) notifies the driver that a vehicle in an adjacent lane is positioned in the driver's "blind spot" zone. If a driver attempts a lane change when another vehicle is in his or her blind spot, Lane Change Warning (LCW) warns the driver that a vehicle is present in or approaching the "blind-spot" zone[7].

6. Do-Not-Pass Warning:

Do-Not-Pass Warning (DNPW) warns the driver that it is not safe to pass a slower-moving vehicle when vehicles are approaching from the opposite direction[7].

V. SECURITY

By design, the V2V system will not collect, broadcast, or share personal information between vehicles, nor does it permit tracking of specific drivers or their vehicles. V2V-enabled vehicles only exchange generic, unnamed and safety information. This system is designed with several layers of security and privacy protection to ensure that drivers can rely on messages sent from other vehicles, and that NHTSA[3] and vehicle manufacturers can identify defective V2V equipment without collecting or using any personal information about specific vehicles or drivers. Design engineers need to implement strong security measures that provide identity while managing privacy.

The V2V security system consists of three primary components such as:

1. A message authentication proposal is required which is designed to enhance confidence in the authenticity of V2V messages and secure the exchange of safety data.
2. V2V enabled devices, which transmit and receive safety messages and ensure that each incoming message is checked to detect and avoid misbehaviour.
3. A misbehaviour reporting requirement to share signatures misconfigured, or malicious vehicles enabling other vehicles to block V2V messages from misbehaving vehicles[10].
4. Authentications are needed for messages to be trusted. A Security Credentials Management System (SCMS) is the entity that issues, distributes, and revokes security credentials for devices operating in the system.
5. Devices should have valid certificates in order to communicate. V2V devices that transmit and receive DSRC messages, communicate with the SCMS for digital security credentials that provide message authentication.
6. Occasionally, devices should securely receive new authentications via communications network, which facilitates two-way encrypted communications between an SCMS and a device (and, potentially, roadside infrastructure)[11].

Functioning of a vehicle, its safety and privacy is dependant on the functions of the interconnected components. Security by design is fundamental and the need to address privacy during development of the interconnecting system is very important. Harmful attacks must be assumed before hand such that risk an impact can be minimised. A systemised approach to the design and system is essential to ensure security is achieved and it is done in the best interest of the consumers.

VI. CONCLUSION

V2V holds a plethora of possibilities in the near future. With its short-range communication protocol and many other components acting together, it has the scope of transforming the current technology. V2V will help reduce traffic congestion, accidents and time taken to travel. Drivers will be able to see and detect objects beyond their vision and this in turn will help to take better decisions on the road. However, it also has various protocols which has been proposed to eliminate the threat of privacy being breached. When V2V unlocks its full potential, it will revolutionize the whole world.

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