A TECHNICAL SEMINAR REPORT

ON

V2V COMMUNIATION

Submitted in partial fulfillment for the award of the Degree of

BACHOLER OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

2020-2024

SUBMITTED BY

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CERTIFICATE

This is to certify that technical seminar report "**V2V COMMUNICATION**" is successfully done by the following student of ELECTRONICS AND COMMUNICATION ENGINEERING department of our college in partial fulfillment of the requirement for the award of the B. Tech degree in the year 2023-2024.

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ACKNOWLEDGEMENTS

I hereby express my thanks and gratitude to Almighty, Parents, family members and friends, without their un-sustained support, I could not have done this technical seminar.

I am pleased to thank our Chairman **Sri Ch. Malla Reddy** for providing this opportunity and director **Sri G. Sudheer Reddy** for his constant support throughout the course.

I am very much thankful to our Principal **Dr. M.Ashok** for supporting us in all aspects and guiding in all walks of life.

I profoundly thank Head of the Department of Electronics and Communication Engineering **Dr. P. Sampath Kumar** who has been an excellent guide and also a great source of inspiration to my work.

I thank my coordinator **Dr. M.Sandhya Rani** for her valuable suggestions and technical guidance.

The satisfaction and euphoria that accompany the successful completion of the task would be great but incomplete without the mention of the people who made it possible with their constant guidance and encouragement crowns all the efforts with success. In this context, I would like to thank all the other staff members, both teaching and non-teaching, who have extended their timely help and eased my task.

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ABSTRACT

Vehicle-to-Vehicle (V2V) communication has emerged as a pivotal technology in modern transportation systems, revolutionizing road safety and traffic efficiency. This abstract delves into the essence of V2V communication, highlighting its significance, underlying principles, and potential implications. V2V communication enables vehicles to exchange real-time information, encompassing location, speed, and trajectory, fostering an intricate network that mitigates collisions and optimizes traffic flow. Employing wireless communication protocols like Dedicated Short-Range Communication (DSRC) or Cellular Vehicle-to-Everything (C-V2X), V2V systems operate within a secure and low-latency framework.This abstract examines the multifaceted benefits of V2V communication including "reduced accidents, congestion, and emissions".

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CHAPTER-1

1.1 Introduction:

For a long time, vehicles have been relatively insular – they have received radio signals for audio entertainment for decades, more recently, have become 'connected' to enhance functionality such as navigation and provide some streaming services. However, advanced communication is becoming central to vehicle operation as automakers see this as a way of delivering enhanced road safety, increased efficiency / economy and an improved experience for driver and passengers – eventually leading to fully autonomous vehicles.As the sector is rapidly evolving, delivering these communication capabilities to vehicles presents a number of design challenges - negotiating the regulatory environment and selecting the optimum component solutions.

In fact, the vehicle communications sector is becoming so broad that it is often sub-divided into smaller sectors. The broadest is 'vehicle to everything' (V2X) which is generic for the whole sector while 'vehicle to vehicle' (V2V) and 'vehicle to infrastructure' (V2I) are the most common, and where the majority of development is taking place. Others are emerging including 'vehicle to people' (V2P) where vehicles and pedestrians will be able to have two-way communication.

V2V would be based around a peer-to-peer mesh network were each element of the network (a vehicle) is able to generate, receive and relay messages. With this approach, an expansive network can be created in populated areas without the need for expensive infrastructure. Typically, each vehicle would be able to transmit information about their speed, direction, location, braking and turning intent – although this list is likely to expand over time.

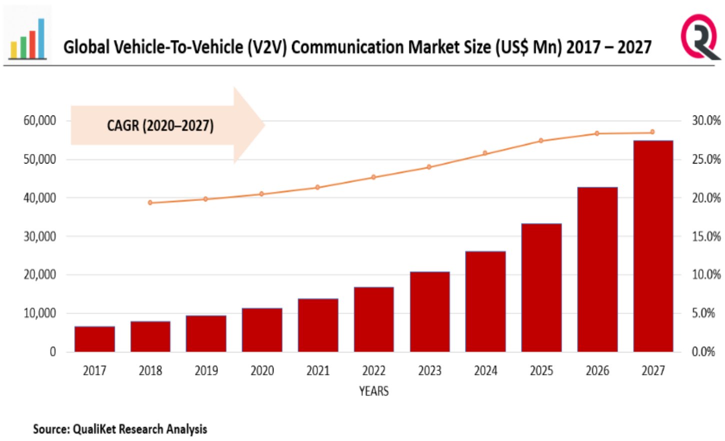


Fig 1.1: Market size of V2V Communication

1.2 History:

V2V communication has its roots in the early 2000s when the U.S. Department of Transportation (DOT) initiated research into vehicle-to-vehicle communication systems. The primary goal was to enhance road safety by enabling vehicles to exchange information in real-time. The DOT's efforts led to the development of the Dedicated Short-Range Communications (DSRC) technology, which operates in the 5.9 GHz band.

In 2014, the National Highway Traffic Safety Administration (NHTSA) proposed a rule to require V2V communication systems in all new light vehicles. However, this rule did not materialize due to concerns about technology standards and privacy issues.

In parallel, automakers and technology companies began conducting extensive research and development into V2V communication. Many prototype systems were tested, and real-world trials were conducted to demonstrate the technology's potential in preventing accidents, especially at intersections and in situations with limited visibility.

By the mid-2010s, V2V communication started gaining momentum in Europe and Asia as well, with various research projects and pilot programs. European initiatives like the Cooperative Intelligent Transport Systems (C-ITS) aimed to establish a harmonized framework for V2V and vehicle-to-infrastructure (V2I) communication.

In 2020, the landscape of V2V communication technology evolved further with the introduction of Cellular Vehicle-to-Everything (C-V2X) technology. C-V2X leverages cellular networks for communication between vehicles, infrastructure, and other connected devices, offering new possibilities and potentially overcoming some of the challenges faced by DSRC.

As of my last knowledge update in September 2021, V2V communication was still in a state of development and regulatory consideration, with various technological approaches competing for dominance in different regions. The future of V2V communication holds promise for improving road safety and traffic efficiency, but its widespread adoption and integration into vehicles will depend on continued research, standardization, and regulatory decisions.

CHAPTER-2

2.1 V2V Scope:

Vehicle To Vehicle mechanism is one of the main components in the Vehicular Ad Hoc Network (VANET) networks the main target of which is because of its importance in our daily lives to open direct communication between vehicles. United States is using a predefined band 5.9 GHz. IEEE 802.11p is used as a standard component in United States Vehicle To Vehicle current production implementation. VANET is considered as Mobile Ad Hoc Network (MANET) with some differences, like considering the vehicle as a node in the network, also the VANET network can include Dedicated Short-Range Communications (DSRC) which are used for V2V mechanism. Fixed components in the traffic systems are considered as Vehicle to Infrastructure.

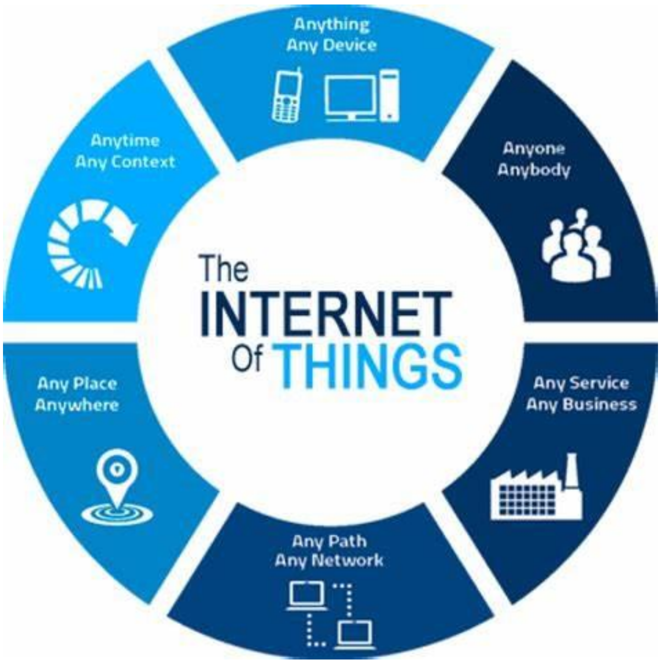


Fig 2.1: Scope of V2V Communication

2.2 Block Diagram:

In the block diagram, surrounding each vehicle are sensor modules, such as cameras, sensors, and radar, which capture real-time environmental data. This sensor data is vital for detecting obstacles, pedestrians, and other vehicles, contributing to the overall safety of the V2V system. The collected information is then processed by the onboard unit and shared with neighboring vehicles within the communication range.

Moreover, the V2V block diagram often includes a secure communication layer, highlighting the importance of encryption and authentication to prevent data tampering or unauthorized access. Additionally, the diagram may incorporate a cloud-based infrastructure, which can provide additional services like traffic management, route optimization, and remote monitoring.

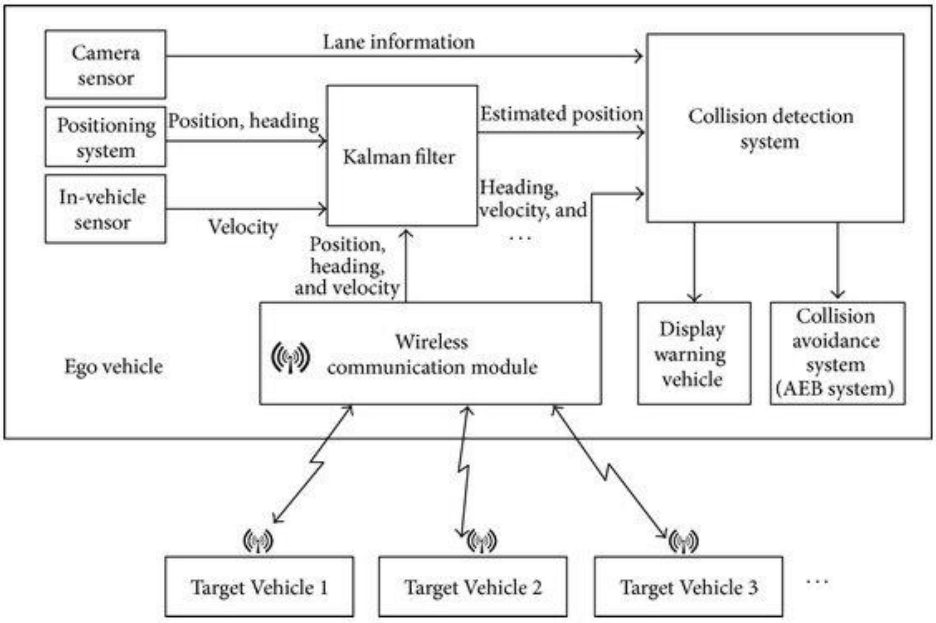


Fig 2.2: Block Diagram of V2V Communication

2.3 V2V Standard Communication Model:

Dedicated Short-Range Communication is the most reliable communication model in Vehicle to Vehicle to supply wireless communications features for ITS programs within a 1 KM range at standard speeds of the highway. Table 1 provides a comparison of Existing Communication Technologies for V2V Communication from many perspectives (Characteristics, Efficiency, etc.)

Communication technologies	Communication protocols	Range	Characteristics
Zigbee	IEEE 802.15.4	100 m	Low-cost、low-power
UWB	IEEE 802.15.3a	10 m	Strong anti-interference ability
Wi-Fi	IEEE 802.11a/b/g	76~122 m、305 m	High data transfer rate
MmWave	IEEE 802.11ad/ IEEE 802.15.3c	10 m	High transmission quality
Infrared	IEEE 802.11	10 m	Reliable、mature and easy to master
DSRC	IEEE 802.11p	1000 m	High data transfer rate
bluetooth	IEEE 802.15.1	10 m	Low-power、good communication security

Table 2.3: Comparison between Existing Communication Technologies

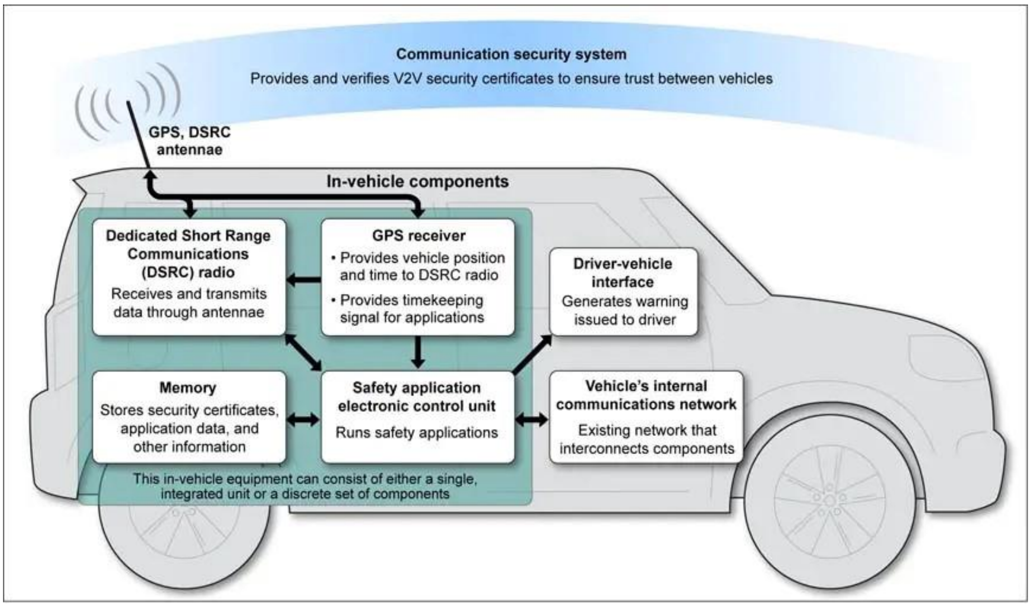
2.4 V2V Security :

A well-established infrastructure is used for applying continuous security services and securing the critical data related to the Vehicle-To-Vehicle networks.

It demonstrates that security infrastructure techniques are essential for Vehicle-To-Vehicle performance. During the last decade, some researches recommended and tested a method related to performance that able to support the Vehicle-To-Vehicle nodes in a message's acceptance or refusal.

Vehicle-to-vehicle (V2V) security is a critical component of the rapidly evolving landscape of connected and autonomous vehicles. As cars become increasingly interconnected, the exchange of information between vehicles through V2V communication systems is becoming more prevalent. These systems allow vehicles to share data related to their speed, position, and other essential parameters, enhancing safety and traffic efficiency. However, ensuring the security of these communications is of paramount importance. V2V security measures are designed to protect against potential cyber threats, such as hacking attempts or malicious interference, which could have severe consequences for road safety.

By implementing robust encryption, authentication, and intrusion detection mechanisms, V2V security aims to create a trustworthy network of vehicles, where data exchanged between them remains confidential and uncorrupted, ultimately promoting safer and more reliable transportation systems. The ongoing development and standardization of V2V security protocols will be instrumental in building public trust in this technology and realizing its full potential for improving road safety.



Sources: Crash Avoidance Metrics Partnership and GAO.

Fig 2.4 : Security System

CHAPTER-3

3.1 DSRC:

Dedicated Short-Range Communications is a wireless connection based on mutual way communication. Usually, the range capability is from short to medium which permits the transmission of critical information. The concerned authorities are using a predefined band already reserved for the VANET and approximate variety of 1 KM for use through Intelligent Transportation Systems (ITS) mobility applications and vehicle protection . Vehicle To Infrastructure and Vehicle To Vehicle programs are making use of the Dedicated Short-Range Communication which may additionally have the capacity to seriously reduce the number of the fatal styles of crashes through actual time advisories alerting drivers to pressing risks–like swerving to the road edge closely, cars stopped in advance, impacted lanes all through integration, the existence of nearby cars and communications gadgets.

Dedicated Short-Range Communication has become evolved with a major goal of authorizing technology that assists programs for communication and safety between cars and infrastructure to reduce collisions. Dedicated Short-Range Communication is the current exclusive wireless connection with short-range that offers:

- Privacy and Security: Dedicated short-range communication supplies privacy and authentication for safety messages.
- Safety Programs Prioritization: Urgent safety programs are also in a high priority rank more than other programs.
- Flexibility: Dedicated short-range communication ensures that it can combine one or more network methodologies (V2V and V2I) in the same network for safety programs.
- High Accuracy when Required: It is expected that Dedicated Short-range communication works in a very tough work conditions in order to provide high accuracy for the safety programs like high speed vehicles and climate conditions.
- High Acquisition of Network: All connections (new and existent) should be established in an instant mode for safety programs.
- Low Latency: All transmitted data in the VANET should not face any delay by any mean in all vehicular safety programs.
- Particular certified bandwidth: This bandwidth is mandatory to be reserved for safety programs related to vehicles in order to provide secure and reliable communications.

DSRC operates in the *5.9 GHz* frequency band and is designed to support low-latency, high-reliability communication. It is used in applications such as:

V2V Communication: DSRC allows vehicles to communicate with each other, sharing information about their speed, position, and other important data. This can improve safety by enabling collision avoidance and warning systems.

V2I Communication: Vehicles equipped with DSRC can communicate with roadside unit (RSU)/infrastructure, such as traffic lights and road signs. This can be used for traffic management, congestion reduction, and other purposes.

V2X Communication: This term encompasses all forms of communication between vehicles and the surrounding environment, including both V2V and V2I communication.

DSRC technology has been used in various pilot projects and initiatives to improve road safety and traffic efficiency. However, it has faced competition and challenges from emerging technologies like Cellular Vehicle-to-Everything (C-V2X) that utilize cellular networks for V2X communication. The choice between DSRC and C-V2X depends on regulatory decisions, industry standards, and the specific needs of the transportation system in a given region.

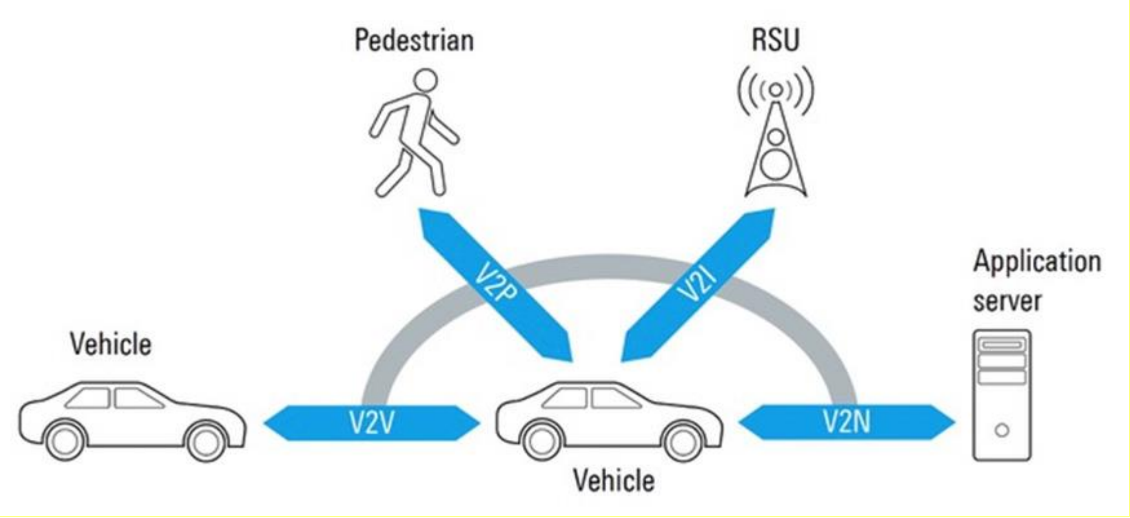


Fig 3.1: Types of V2V Communications

3.2 WAVE (Wireless Access Vehicular Environment):

WAVE can be a superset of DSRC as it supports the traditional characteristics of DSRC but has some remarkable advantages. WAVE supports a longer operational range (over 1 km depending on environmental conditions), higher data transfer rates, and allows peer-to-peer communications.

WAVE is an adaptation of the IEEE 802.11a protocol and has received a tentative designation of 802.11p within this wireless interface standards family. The official IEEE 802.11 Work Plan predictions indicate that the approved amendment of the 802.11p standard will be published in April 2009. Within the IEEE 802 context, “Wireless Access in Vehicular Environments” (WAVE) refers to what was previously called Dedicated Short-Range Communications (DSRC).

The first international conference on WAVE is scheduled on (December 8-9, 2008), in the USA. The following figure illustrates the WAVE prototype:

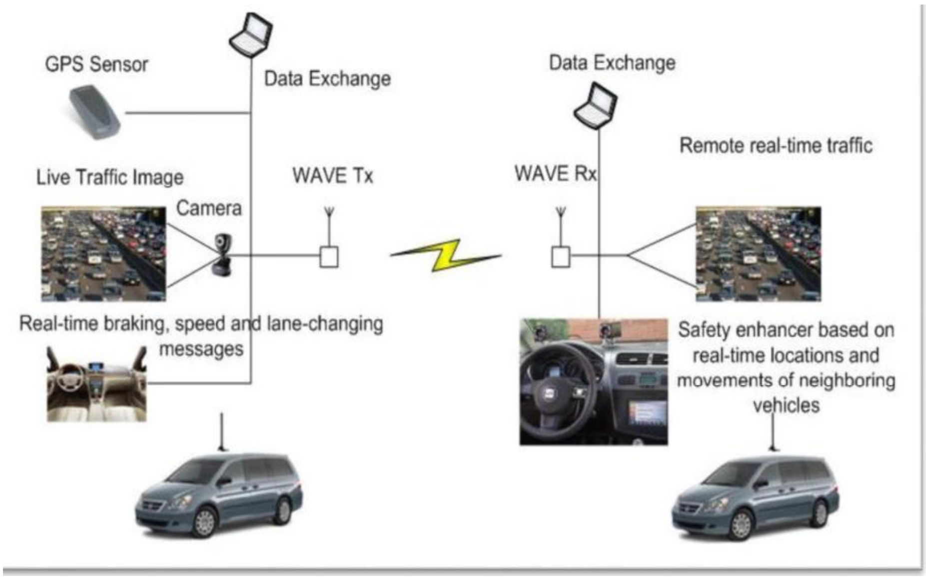


Fig 3.2: WAVE Prototype

3.3 CLAM (Continuous Air interface Long and Medium range communications) :

CALM is a framework that defines a common architecture, network protocols and air interface definitions for all types of current and (expected) future wireless communications. These air interfaces are designed to provide parameters and protocols for broadcast, point-point, vehiclevehicle, and vehicle-point communications.

CALM is being developed by Working Group 16 of the Technical Comittee 204 of the International Standards Organization (ISO)

These standards are designed to enable quasi-continuous communications between vehicles and service providers, or between vehicles. In particular, for medium and long-range high-speed V2I transactions, the functional characteristics of such systems require contact over a significantly longer distance than is feasible or desirable for DSRC, and often for significantly longer connection periods.

The following communication modes will be supported by CALM:

• Infrared

• GSM (until 3G cellular technology)

• DSRC

• IEEE 802.11 evolutions such as WAVE

• IEEE 802.16e (Mobile WiMax)

• Millimetre-wave (62 GHz)

• Satellite

• Bluetooth

• RFID

Some applications will have the need that communication sessions set up in an initial communications zone may be continued in following communication zones. CALM establishes the network protocols to support the handover of a session conducted between a landside station and a mobile station to another landside station using the same media or a different media, in whatever way is optimum for the application.

CALM also supports safety critical applications, such as those examined within VSC. In such cases, a handoff between media is unlikely as the messages will be short and quick. However, the CALM architecture allows for messages to be sent simultaneously on several media to improve quality of service.

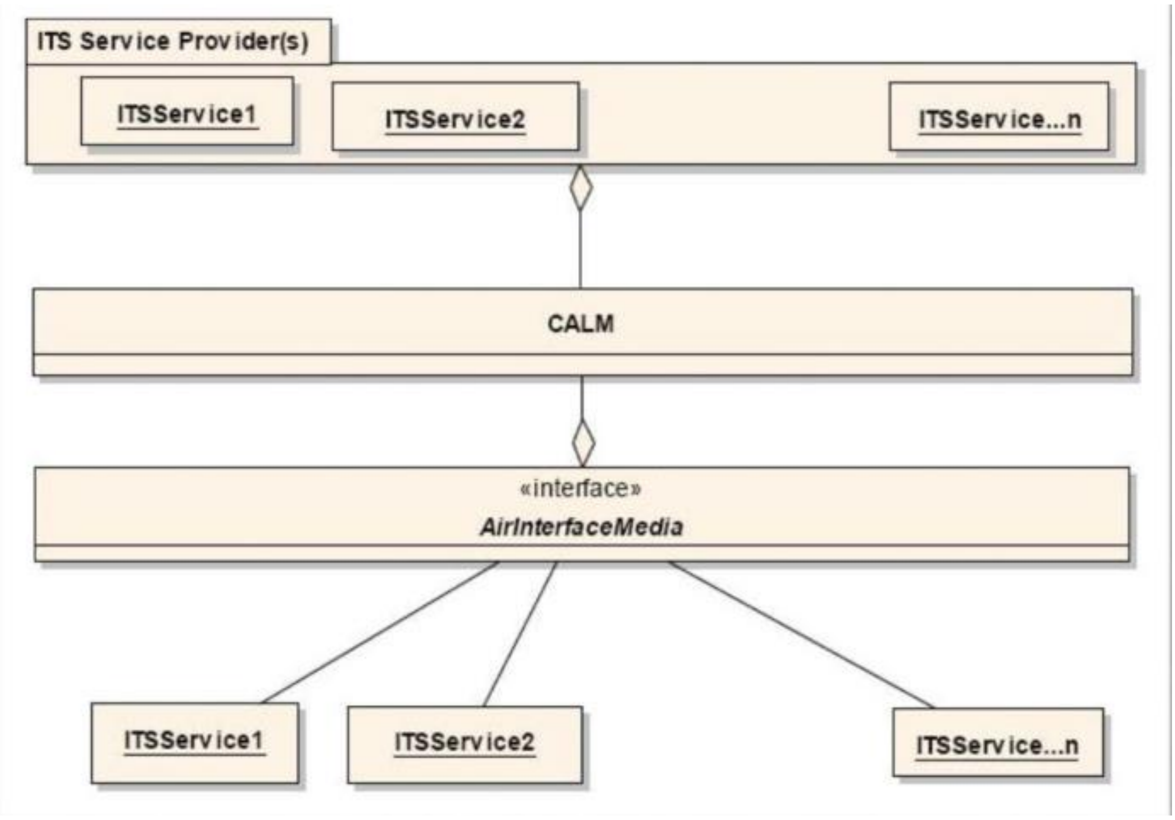


Fig 3.3: CLAM Architecture

3.4 V2V Protocol Design :

The general Steps to design a new V2V protocol are as the following:

- Identify the objective
- Gather the Information
- Study the current V2V protocols (Pros and Cons foreach one)
- Study the standard V2V communication model" If Available" Study Protocol Specification
- Design Protocol Interfaces
- Handling Constraints
- Implementation Phase
- Prototype version for testing purposes
- Testing Phase
- Validation Phase
- UAT Phase

An ad-hoc network is a network with either no infrastructure or a minimal infrastructure. An ad-hoc network is composed of nodes that come together to form a network. An ad-hoc network is selforganizing. Each node can function as a network router, data source, or data destination. Thus, when several (two or more) nodes come together into an ad-hoc network, they become capable of communicating with one another and therefore relaying information.

- ➢ It activates the program of mutual impact warning to use the techniques of service segregation with other programs.
- ➢ It also demonstrates a technique to eliminate excessive critical messages, making use of the flow effect of classic emergency events.

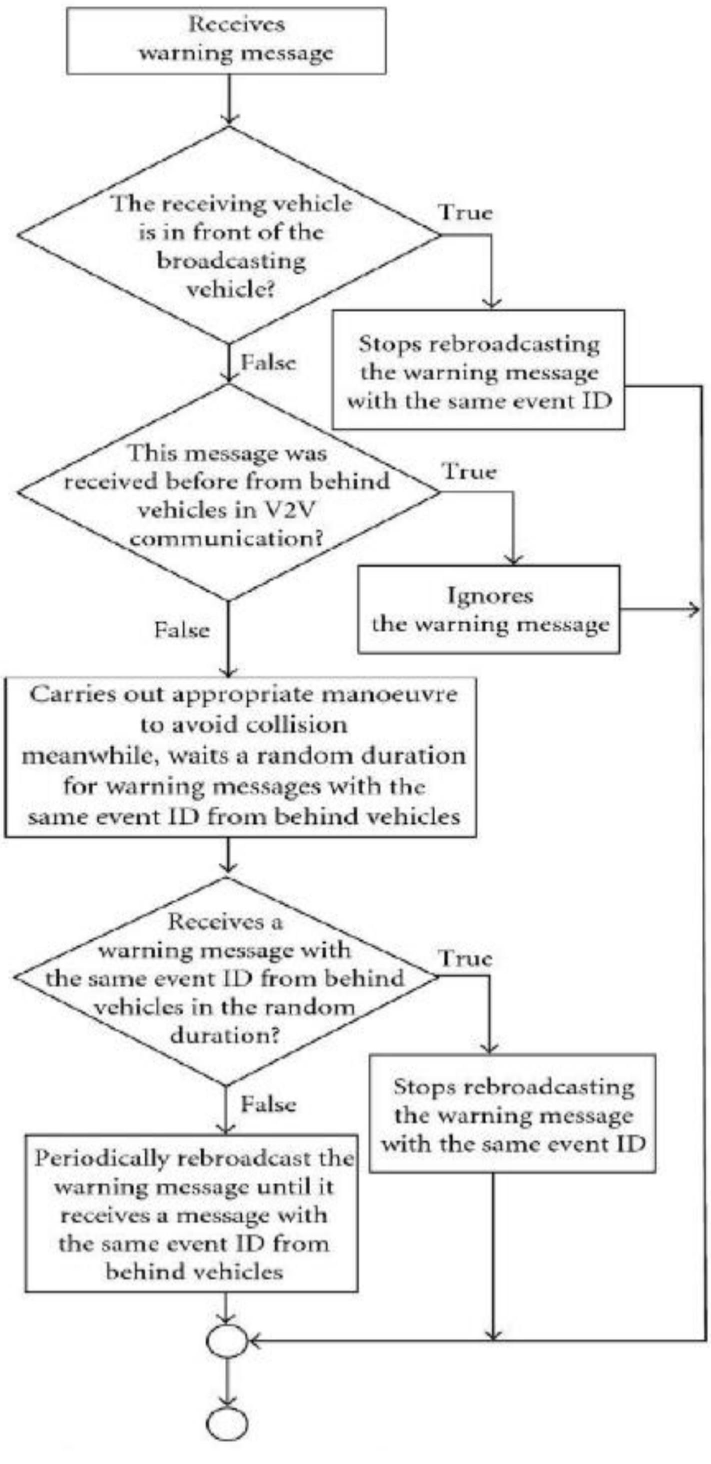


Fig 3.4: Flowchart of V2VCommunication Protocol

CHAPTER-4

4.1 V2V Implementation Enhancements :

This direction is very important as it links between the theoretical and real life, as it implements a V2V on some cities like a prototype in order to develop a road-map for V2V/V2Ideployments and business models and realistic deployment strategies to speed-up the market penetration, then to enforce the harmonization of V2V global standards.

The output and conclusion for this study have discussed the cooperative collision Avoidance performance vulnerability to unstable communication channels. Also, these results were used to describe and justify the essential requirements for prioritizing the information based on its criticality in the safety programs.

The main components:

- Nodes
- Server
- V2V
- V2I

In the general infrastructure, the locations of vehicles are identified through the global positioning system GPS. The event log is transmitted to the traffic management server through the mobile operators GSM/GPRS/3G/4G/5G system that are connected to Internet.

4.2 The Main Components:

NODES:

Node means vehicle in our hardware design, each node should support GSM/GPRS/3G/4G/5G Module, GPS Module and WIFI Module. GSM module support data communication through GPRS or 3G/4G. GPRS allows GSM operators to launch wireless data services, such as e-mail and internet access.

GPS module is used on incidents in a variety of ways, such as:

- To determine position locations.
- To navigate from one location to another.
- To create digitized maps.
- To determine distance between two points.

SERVER:

It is a web app and installed it on a local PC (to simulate a server which represent traffic center), to capture the event login the ITS network through the 3G mobile connection.

The web application on the server is based on a GUI layer and Backend layer including a small DB to store the event details inside it based on the date, event name, event type, and the sender. The web application is developed in house to provide the exact and required results, also it provides us with a room for expansion to add new features in the future work.

V2V:

The communication will be through the WIFI communication between nodes to simulate the real-life events. WIFI and GPS based vehicle location and tracking system will provide effective, real time vehicle location, mapping and reporting this information value and add by improving the level of service provided. A GPS-based vehicle tracking system will inform where your vehicle is and where it has been, how long it has been.

The system uses geographic position and time information from the Global Positioning Satellites. The system has an ”On-Board Module” which resides in the vehicle to be tracked. The system uses geographic position and time information from the Global Positioning Satellites. The system has an” On- Board Module” which resides in the vehicle to be-tracked

This data is then used to enhance road safety by alerting drivers to potential hazards, such as sudden braking or vehicles in blind spots, and can even assist in preventing accidents altogether. V2V also has the potential to improve traffic flow and reduce congestion, leading to fuel savings and a more sustainable transportation system. As V2V technology continues to advance and become more widely adopted, it has the potential to revolutionize the way we drive and make our roads not only safer but also more efficient and environmentally friendly.

V2I:

The communication will be through the GPRS/3G/4G/5Gmobile communication between nodes and traffic management server to capture the log events. It provides the information gathering and sharing of information on vehicles by the traffic management server. Moreover, it features the processing, computing, sharing and secure release of information on to information platforms. Based on this data, the system can effectively guide and supervise the proposed ITS.

Vehicle-to-Infrastructure (V2I) communication complements Vehicle-to-Vehicle (V2V) technology, ushering in a new era of smart transportation systems. V2I enables vehicles to communicate with the surrounding infrastructure, such as traffic lights, road signs, and even the road itself. This connectivity opens up a world of possibilities, as it allows for real-time data exchange with infrastructure elements, providing drivers with vital information about traffic signal timings, construction zones, and road conditions ahead.

With V2I, drivers can make more informed decisions, optimizing their routes and driving habits, leading to improved traffic management and reduced congestion. The integration of V2I into the transportation ecosystem is a crucial step towards achieving safer, more efficient, and environmentally conscious roadways, as it paves the way for intelligent transportation systems that can revolutionize the way we travel and interact with our urban environments.

4.3 V2V vs V2I :

Aspect	V2V Communication	V2I Communication
Definition	Communication between vehicles.	Communication between vehicles and infrastructure (e.g., traffic signals, road-side units).
Purpose	Enhance vehicle safety, collision avoidance, and traffic efficiency.	Improve traffic management, provide real-time information to vehicles, and support autonomous driving.
Participants	Vehicles communicate directly with each other.	Vehicles communicate with fixed infrastructure components.
Communication Range	Typically shorter-range, usually within a few hundred meters.	Can have longer-range communication, covering larger areas.
Use Cases	Collision avoidance, emergency warnings, cooperative adaptive cruise control.	Traffic signal prioritization, real-time traffic updates, autonomous vehicle guidance.
Network Complexity	Simpler network topology with peer-to-peer communication.	More complex network involving infrastructure components like traffic lights and roadside units.
Data Exchange	Primarily involves vehicle state data (e.g., speed, position).	Involves traffic information, road conditions, and signals from infrastructure.
Security Implications	Focused on preventing malicious interference and securing peer-to-peer communication.	Requires securing data transmission to and from infrastructure, including protecting against potential cyber threats.

4.4 Consumer Demand :

Every year, there are about 34,000 traffic fatalities in the US. Studies showed that 60% accidents were avoidable with ½ sec prior warning [14]. Furthermore, V2V can affect > 82% non-impaired crashed over 16% for V2I. A recent study showed that more than 80% of drivers would like to have some advanced V2V safety warning systems . As such, there is an immediate consumer demand for V2V warning systems and insurance company rate discounts could cause additional impetus.

Features	Acceptance Ratio
EEBL: Emergency Electronic Brake Lights	91.4 %
FCW: Forward Collision Warning	90.5%
BSW/LCW: Blind Spot/ Lane Change Warning	90.9%
LTA: Left Turn Assist	83.8%
IMA: Intersection Movement Assist	95.5%
DNPW: Do Not Pass Warning	88.6%

Fig 4.4: Driver's acceptance as a function of safety feature

CHAPTER-5

5.1 Advantages :

Vehicle-to-Vehicle (V2V) communication offers a wide range of advantages that can significantly improve road safety, traffic efficiency, and overall transportation systems. Here are some key benefits:

1. Enhanced Road Safety: V2V systems can provide real-time information about the speed, location, and actions of nearby vehicles. This enables vehicles to detect potential dangers, such as sudden braking or vehicles in blind spots, and issue warnings to the driver, reducing the risk of accidents.

2. Collision Avoidance: V2V technology can assist in collision avoidance by predicting and preventing potential collisions. When a vehicle senses a high-risk situation, it can automatically take corrective actions, such as applying brakes or steering, to avoid accidents.

3.Reduced Congestion: V2V can optimize traffic flow by coordinating vehicle movements and suggesting the most efficient routes. This leads to reduced congestion, shorter commute times, and lower fuel consumption.

4.Traffic Management: V2V systems can transmit information to traffic management centers, allowing for real-time traffic monitoring and control. This information can be used to adjust traffic signal timings, manage road closures, and improve overall traffic management.

5.Emergency Services Support: In the event of an accident or emergency, V2V can automatically notify emergency services, providing critical information about the location, severity of the incident, and the number of vehicles involved. This accelerates response times and can save lives.

6.Eco-Friendly Driving: V2V can promote eco-friendly driving by providing information on optimal driving speeds and routes that minimize fuel consumption and emissions.

7.Improved Transportation Efficiency: V2V can help optimize transportation systems by reducing traffic bottlenecks, improving public transit coordination, and promoting the use of shared mobility services.

8.Infrastructure Cost Savings: V2V can reduce the need for costly infrastructure upgrades by improving traffic flow and safety without requiring major road construction projects.

9. Autonomous Vehicle Integration: V2V is a critical component for autonomous vehicles, as it enables them to interact with human-driven vehicles, pedestrians, and the surrounding environment. This technology is essential for the safe deployment of self-driving cars.

10. Flexibility and Scalability: V2V systems can adapt to changing traffic conditions and can be easily scaled to accommodate a growing number of connected vehicles, making them a flexible solution for future transportation needs.

5.2 Future Scope :

The future of Vehicle-to-Vehicle (V2V) communication is exceptionally promising, with numerous opportunities for further development and integration within our transportation systems. V2V technology is poised to play a pivotal role in shaping the future of automotive safety and efficiency.

V2V also holds significant potential in reducing traffic congestion. By allowing vehicles to communicate and coordinate with each other, traffic flow can be optimized, minimizing the stop-and-go patterns that contribute to gridlock. This, in turn, will lead to fuel savings, reduced emissions, and a more sustainable approach to transportation.

Moreover, V2V can be integrated into smart city initiatives, creating a harmonious connection between vehicles and urban infrastructure. Traffic signals, road signs, and even infrastructure sensors can communicate with vehicles, providing real-time information about traffic conditions, detours, and parking availability, making urban mobility more efficient and less stressful.

5.3 Conclusion :

Vehicle to Vehicle communication can be a real game changer, because of its importance on our daily lives, it is a major challenge but it will be resolved with time. It includes a lot of points of interest to declare and develop, starting from the protocol design to obtain a standard communication model, then to go through the performance evaluation to have stable KPIs. After that to explore the implementation phase for commercial usage with zero percent failure, and finally to discover the integration mechanisms to release a full automated ITS solution ready to use for the real life.

Vehicle to Vehicle communication real life implementation till now requires RSUs in order to have accurate results and full safety for the society, but due to lack of resources in some of the developing countries most of them don’t have well established infrastructure and on the other side, the accidents and loss of lives are increasing exponentially year by year.

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