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Paper Authors
V.Anusha, Radhika.Y, J.JyothiDeepika, Shravya.Ch, RadhaKrishna Karne, Ms.T.Swathi

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A Study on Vehicular Ad-Hoc Network (VANET)

V.Anusha[1], Radhika.Y[2], J.JyothiDeepika[3], Shravya.Ch[4], RadhaKrishna Karne[5] Ms.T.Swathi[6]

[1,2,3,4,6]UG Scholar, Department of ECE, Balaji Institute of Technology & Science, Narsampet, Warangal, Telangana, India

[5]Assistant Professor, Department of ECE, Balaji Institute of Technology & Science, Narsampet, Warangal, Telangana, India

Abstract:- Vehicle ad hoc networks (VANETs) are a type of mobile ad hoc network (MANET) application that has the ability to increase traffic safety and give travellers comfort. VANETs have recently surfaced to draw attention to of experts in the wireless and mobile fields communication. Their architecture sets them apart from MANET difficulties, traits, and applications. Although,regarded as a unique instance of a mobile ad hoc networks,A key characteristic of VANETs is their capacity to influence people's life-or-death choices Because of the unique qualities, from a topology that is very dynamic to intermittent connection, There are many difficulties facing VANETs, among them the following: conflicting privacy needs and various application QoS requirements and security concerns.

Keywords: *Vehicular AdhocNetwork(VANET), Road side unit(RSU),On board unit (OBU), Resource Command Processor(RCP), Vehicle to vehicle(V-V), Vehicle to Infrastructure(V-I) and Vehicle to Road side unit (V-R), Intelligent Transport System(ITS).*

I.INTRODUCTION

Some of the most significant developments in the vehicular industry and in our society are being driven by information and communication technology [1]. The previous two mobile communications have altered our way of living for decades. Thus enabling information sharing anytime, anywhere. Vehicles using such mobile communications systems is anticipated to become true in the following years. This fresh information-sharing model for automobiles and Various uses for safety will be made possible by infrastructure [2]. Many individuals use vehicles and other private vehicles on a regular basis today. The largest issue with the expanding use of private transportation is the rise in mortality from traffic accidents; the costs and associated risks have been acknowledged as a severe issue facing contemporary society.

The vehicular communication network (VANET), which permits information sharing between cars, is a crucial part of an ITS. A VANET is a unique instance of a Mobile Ad Hoc Network (MANET), in which moving vehicles having wireless and computing capability can impromptu form a network. Even in areas without communication infrastructure, such as cellular phone base stations or wireless network access points, direct wireless communication between vehicles enables data transmission [3].

II. VANET ARCHITECTURE

Through a wireless technology called WAVE, vehicles can communicate with one another or with RSUs. With the help of safety applications, this kind of communication gives drivers and travellers access to a wide variety of information that improves road safety and makes driving more comfortable. The device hosting the application is referred to as the provider, and the device using the application is referred to as the user. The application may be located in the RSU or in the OBU [4]. Each vehicle has an OBU and a collection of sensors to gather the data, process it, and deliver it as a message to other vehicles or RSUs through the wireless network.

The three types into which the primary system components are divided are as follows:

i. On Board Unit (OBU)
ii. Application Unit (AU)
iii. Roadside unit (RSU)

i. ON BOARD UNIT

An OBU is a WAVE device that is typically mounted on a vehicle and used to communicate with RSUs or other OBUs. It has a resource command processor (RCP), a read/write memory for storing and retrieving data, a user interface, a unique interface for interacting with other OBUs, and a network device for short-range wireless communication based on IEEE 802.11p radio technology. On board system has to provide a human machine interface (HMI) compatible with the driving. It makes it possible for users to both input information into the system and use the services. To broadcast internal data and gain access

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to external services, the Vehicle Ad-Hoc Network - VANETS Communications with Externals Elements are required [5]. For the sake of meeting the criteria for contact with all external parts, it might support a variety of wireless communications technologies.

ii. APPLICATION UNIT

The AU is a device installed inside the car that utilises the applications offered by the provider while utilising the OBU's communication skills [6-8]. The AU can run Internet-based safety software or be a standard device like a personal digital assistant (PDA).
The AU and OBU may be housed together in a single physical unit and connected to each other by wired or wireless means. It makes sense to distinguish between the AU and the OBU. The only means of communication between the AU and the network is through the OBU, which is in charge of all networking and mobility tasks.

iii .ROAD SIDE UNIT

The RSU is a wave device that is typically fixed to the side of the road or in certain locations, including at intersections or close to parking spaces. The Road Side Unit connects to the internet and gives the user security information, preventing accidents. Only the information can be accessed by the authenticated user. Pseudonyms, mix zones, silent periods, and ad hoc anonymity are the methods employed.

RSU communication has three main functions and procedures are as follows:

i. Extending the communication range of ad hoc network and also providing Internet connectivity to OBUs

Here, the communication range can be increased by redistributing the information to additional OBUs, sending the information to additional RSUs to forward it to additional OBUs in the new RSU range, and also providing internet connectivity to the OBUs when a vehicle is too far away to communicate directly with another vehicle (V2V).

ii. Running safety application

This programme uses infrastructure to vehicle communication (I2V) and serves as an information source to offer information regarding low bridge warnings, accident warnings, or work zones.

III. WIRELESS ACCESS TECHNOLOGY IN VANET

Today, a variety of wireless access technologies are available that can be used to deliver the radio interface that cars need in order to connect with one another via V2V communication or with RSUs via V2I communication. These communication technologies enable a variety of safety and non-safety applications, which are meant to increase traffic efficiency, road safety, and driver and passenger comfort. A central infrastructure is utilised by several of these systems to manage connections between nodes.

The wireless access technology in VANET is broadly classified into three categories based on their ranges as follows:

i. Long range
ii. Medium range
iii. Short range

Cellular and Wi-MAX technologies are both applicable to long-distance communication. The idea behind the cellular system is to make use of the finite frequency that is currently allocated to the service.A cellular system standard known as the Global System for Mobile (GSM) that offers a maximum data rate of 9.6Kbps and is categorised as second generation (2G). Frequency division multiple access (FDMA) and time division multiple access (TDMA) techniques are both used by GSM. The original Worldwide Interoperability for Microwave Access (WiMAX), or IEEE 802.16-2004, was adopted by IEEE in the year 2004. WiMAX, or IEEE 802.16e, is an update to that standard. IEEE 802.16e is suited for applications requiring these qualities, such as multimedia, video, and voice over internet protocol (VoIP) applications, because it offers a fast data rate, large transmission range, and excellent quality of service (QoS).

In the VANET context, WAVE and DSRC can be utilised for medium-range communication. The US Federal Communications Commission (US FCC) allotted a 75 MHz licenced spectrum at a 5.9 GHz band in 1999 specifically for use in vehicle-to-vehicle and vehicle-to-infrastructure communication in the US. Dedicated Short-Range Communication (DSRC), commonly known as IEEE 802.11p, is designed for automobile ad hoc networks (VANETs). At the moment, this is the only standard that supports direct V2V communication.
By facilitating low latency, spatially local, and high mobility communications, DSRC/WAVE systems

eliminate the drawbacks of wireless infrastructure. For Intelligent Transportation Systems (ITS), which are a part of the Federal Highway Administration's Vehicle Infrastructure Integration initiative, DSRC/WAVE supports vehicle-to-vehicle and vehicle-to-infrastructure communications.

The Dedicated Short Range Communications (DSRC) spectrum band was assigned in the United States, and subsequent work to specify the technology to be utilised in this band resulted in the IEEE 802.11p standard (WAVE). The control channel (CCH) and the service channel are the two different types of channels in DSRC, and they both have a 10 MHz width (SCH). The SCHs are available for both safety and non-safety use, but the CCH is solely permitted for safety communications.

IV.VANET COMMUNICATION TYPES

Due to both the speed of the vehicles and the nature of radio propagation, a vehicular network is very dynamic.
Vehicles travel at high relative speeds, averaging 50 km/h in urban areas and exceeding 100 km/h on highways. Due to the cars' swift ability to join or leave the network, topological changes occur frequently and quickly. The development of algorithms and protocols for vehicle networks must take into account the variety of nodes in terms of speed and mobility.

Consider how the vehicles differ in their speeds and tend to follow an inconsistent mobility paradigm. In VANET communication types or domain are categorised into three types as follows:

i. Vehicle to vehicle (V2V)
ii. Vehicle to infrastructure(V2I)
iii. Hybrid Architecture
iv. Road side unit to Road side unit (RSU2RSU)

i. Vehicle to Vehicle

Vehicle to vehicle (V2V) communication enables direct vehicular communication without depending on a permanent infrastructure support and is mostly used for dissemination and safety-related applications. An OBU plus one or more AUs, which may be wired or wireless, make up this domain. In order to run one or more sets of application providers utilising the OBU's communication capabilities, the OBU offers a communication link to the AU.

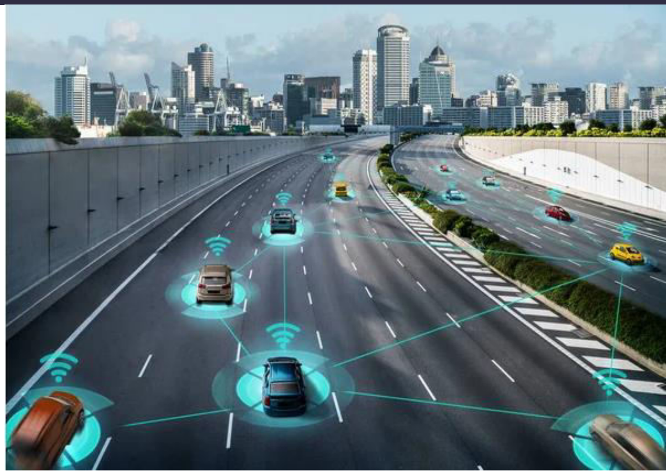

Figure.1.: V2V Communication Model

ii. Vehicles to Infrastructure

A vehicle can interact with the roadside infrastructure through in vehicles to infrastructure, mostly for information and data collection purposes. On VANET, it is also known as Ad Hoc domain. Through a network of OBUs, which connects vehicles to one another, vehicles can communicate with one another entirely distributedly with decentralised coordination. If a direct wireless link is provided between two vehicles, they can interact with one another directly, constituting a single hop vehicle to vehicle communication (V2V). Data is forwarded from one vehicle to another until it reaches the destination point using a specific routing protocol when there is no direct link between them, creating multi-hop vehicle to vehicle communication. By transmitting, receiving, and transferring data from one node to the RSU to perform particular applications, the car communicates with an RSU to extend the range of communication. This is known as vehicle to infrastructure communication (V2I).

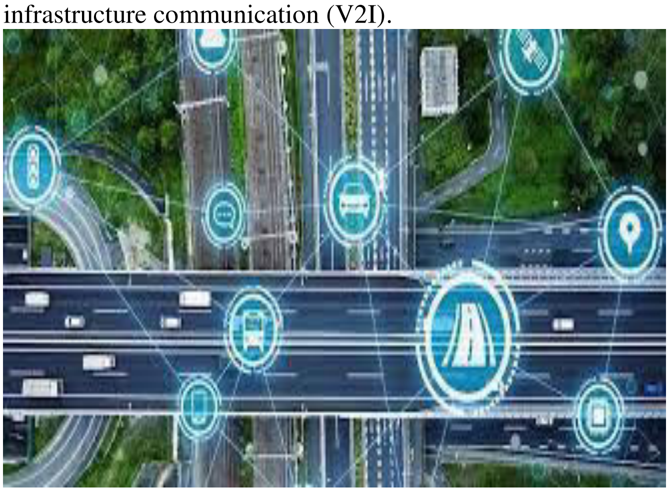

Figure.2.: V2I Communication Model

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iii. Hybrid Architecture

The OBU can access the infrastructure network through the RSU by connecting to it or to the Internet [1]. In this situation, it's likely that the AUs are authorised by the OBU to connect to any host on the internet. OBU can also communicate with other hosts over cellular radio networks for purposes other than safety (GSM, GPRS, UMTS, HSDPA, WiMax and 4G). Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications are combined (V2I). Depending on the distance, a vehicle can communicate with the roadside infrastructure in this situation either in a single hop or multi-hop fashion, i.e., whether it can or cannot access the roadside unit directly[9]. It makes it possible to connect distant cars or the Internet over vast distances.

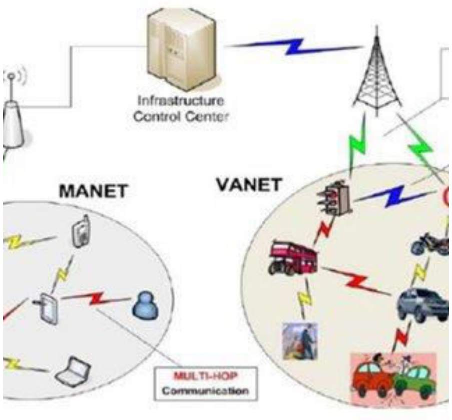

Figure.3.: Hybrid VANET Communication Model

iv. Road Side Unit to Road Side Unit

RSU to RSU (R2R) provides for direct communication between two RSUs in close proximity and is typically used when a critical safety message, information about a significant traffic jam, or VVIP movement needs to be communicated. Because RSU is directly under the jurisdiction of the TA (Trusted Authority), R2R is always treated as the trusted infrastructure rather than V2V/V2I. When there is a traffic jam within the reach of RSU1, the information is passed on to the subsequent RSU2, which broadcasts the information to the approaching vehicle nodes. The handoff procedure, in which a vehicle from one RSU range joins another RSU or a new RSU, is a significant action that takes place in RSU to RSU communication[10].

Figure.4.: RSU VANET Communication Model

V. VANET CHARACTERISTICS

VANET has its own unique characteristics when compared with other types of MANETs, the unique characteristics of VANET include:

i. **Conventional mobility:** Vehicles are regarded as nodes in a VANET, and these nodes are governed by the topology and design of the roads. Vehicles must abide by the laws governing traffic and communicate with other vehicles in the area regarding their mobility.

ii. Providing safety, comfort for drivers and increase the traffic effectiveness: In a VANET, two moving vehicles are directly connected, enabling wireless access and information sharing. The information includes new messages, traffic, alerts, or information on sudden breaks, so it prompts safety precautions for vehicles to take an alternate route.

iii. **Power resource availability** Vehicles in VANET are equipped with long-lasting batteries that can supply OBUs with steady power, therefore power shortages are not a problem like they are in MANET.

iv. **Inconsistent network solidity:** Depending on the traffic, the network density in a VANET varies. In comparison to metropolitan regions and highways, it is lower in rural areas.

v. **High computational facility:** Service providers now offer advanced computational capabilities in automobiles, including memory, efficient sensors, storage space, internet connection, advanced antenna technology, and GPRS.

vi. **Patterned Mobility:** Vehicles move in a specific pattern that depends on the underlying roadways, the traffic signals, the posted speed limit, the volume of traffic, and the driving habits of the drivers. Due to the unique mobility pattern, only traces obtained from the pattern make sense for the evaluation of VANET routing protocols.

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VI. CHALLENGES AND REQUIREMENTS IN VANET

When efforts are made to operate vehicle ad hoc networks in an effort to improve driver behaviour, with the goal of lowering the number of fatalities brought on by auto accidents, a number of problems develop. Numerous elements that are crucial to realising the VANET goal, represented by safety applications and nonsafety applications, must be taken into consideration in order to deploy the VANET idea. Therefore, it is crucial to identify the most significant obstacles facing VANET, and the primary issues from a technical standpoint are as follows:

i. **Signal loss:** In a wireless system, communicating between two moving vehicles can be difficult if there are any barriers in the way. Large structures or other vehicles in urban areas can be impediments. This causes signal fading and has an impact on the effectiveness of VANET transmission.

ii. **Bandwidth confines:** Since there is no central location or access point to keep track of everything and transfer it to the right place in a VANET environment, the node makes fair use of resources like bandwidth to improve speed.

iii. **Connectivity :**Another important problem is that when the topology of a network changes quickly, it causes frequent portioning, which increases response time and has an adverse effect on efficiency.

iv. **Security and privacy:** One of the biggest issues with VANET is striking a balance between security and privacy. Only an authenticator should send the information since the recipient must believe the message they have received from the source point.

v. **Routing protocol:** Designing an effective routing protocol is a difficult task in a VANET environment due to the fast changes in the network topology caused by joining or departing the network. The packet must be sent by the protocol in a predetermined amount of time.The few variables listed below must be taken into consideration while creating an effective routing protocol.

a) The system should be reliable
b) Reduce the signal fading in communication
c) It has to provide scalability

VII.VANET APPLICATIONS

The communications in the VANET environment enable the development of several apps and can give drivers and travellers access to a variety of information. High-tech components, including sensors, improved antenna, and efficient wireless access technologies, are used in the on board unit, which is located in the vehicles. With all of these, it will gather information from other vehicles and communicate with roadside equipment to relay it to other vehicles for safety measures and to comfort travellers. The few applications of VANET are listed below to provide the safety and the traveler feels comfort.

i. Console-Entertainment applications: The primary goal of the applications in this category, which are referred to as non-safety applications, is to provide comfort for the traveller. It offers information on the local eatery, gas stations, weather, and traffic.

ii. Safety applications: In this case, vehicle to vehicle or vehicle to infrastructure communication is used to provide safety and emergency information to other vehicles connected to the network.

iii. Accident avoidance in junction area : The likelihood of an accident is higher in intersectional areas, hence it is necessary to enhance intersection collision avoidance systems, which will prevent many traffic accidents. These systems rely on I2V or V2I communication. Through multihop communication, the vehicle communicates with other vehicles or with RSU. If an accident is likely, it will send warning messages to other vehicles in an effort to prevent the collision.

iv. Traffic efficiency and management application: It primarily focuses on maximising traffic flow by cutting down on traveller time and preventing gridlock.

VIII.VANET RESEARCH AREA'S

Researchers in a variety of sectors, such as electronics, networking, security, routing, cloud computing, automotive, transportation, and others, have given VANET research a lot of attention. Routing, Quality of Service (QoS), broadcasting, security intrusions and threats, capacity, collisions, and interference, the impact of transmission power on protocol performance and power control algorithms, congestion control, and service discovery are just a few recent results addressing VANET-related issues.

IX. CONCLUSION

It offers a thorough analysis of every problem affecting VANET, focusing on VANET architecture components, VANET communication

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domains, wireless access technologies, VANET features, problems, and requirements, as well as VANET applications. This examination enables academics to concentrate on the problems related to VANET and its applications, demonstrating a deep understanding of how to address every problem associated with VANET. Future intelligent transportation systems, intelligent vehicles, and intelligent infrastructure all depend on wireless vehicular networking as a crucial enabling technology. In actuality, mobile ad hoc networks' most significant manifestation is most likely to be VANETs.

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