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Review of Routing Protocols in VANETs: Architecture, Technology, Challenges, Protocols and Application

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ABSTRACT

In recent years, a lot of research has been done on wireless technology. In wireless communications, VANET is the fastest growing region. Vehicle_Ad_Hoc_Network(VANet) is sub from Mobile_Ad_Hoc_Network (MANet) which used for improve safety in road as well as the passenger experience, thus providing a differentiated approach to Intelligent Transportation System. Intelligent transportation system (ITS) is expected to improve safety in road also driving efficiency by that innovation in wireless. VANET consists of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies that support IEEE 802.11p wireless access technologies, provide (safety \ non- safety) applications with share information to avoid an accident and provide travelers with reliable information. VANET promises new opportunities to improve driving comfort, safety in road and traffic efficiency. To make VANET more powerful, several issues need to be addressed. The VANET infrastructure network use mobile vehicles like sensors for collect data in real-time of the traffic conditions to share traffic information. This paper presents and discusses problems, routing protocols, and applications in a comparative environment.

Keywords: *Vehicle_Ad_Hoc_Network* (MANet), *Mobile_Ad_Hoc_Network (*VANet), *Vehicle-to-infrastructure (*V2V), V*ehicle-to-vehicle (*V2I).

1. INTRODUCTION

The World Health Organization (WHO) recorded in the world every year that many people die on road accidents and about 50 million people are injured in car accidents [1]. The intelligent transport system (ITS) has recently become an indispensable and a reality part of smart cities thanks to the advent of information and communication technologies (ICT) and integrated wireless sensors. There are some similarities between MANet and VANet [2]; VANet has well-defined characteristics. VANet stands for Mobile Vehicle Networks, and it is a subset of MANet. In VANet, each vehicle acts as a node or router to send and receive data for other mobile network nodes [3, 4]. Information and entertainment are employed to enhance traffic safety, efficiency, and information distribution [5, 6]. The characteristics of the VANet network due to challenging in routing because of high node mobility, dynamic topology change and a highly segmented network [7]. Depends on internal and external factors the performance of routing protocols works such as node mobility and signal blocking obstacles [8]. In VANets, vehicles share information to try reducing as possible dangerous accident by using safety \ non-safety applications [9]. Safety applications include information such as weather conditions, road conditions, traffic jams and crosswalk information. Non-safety includes passenger's amenities that include information such as hotel, restaurant, and gas station via navigation system in vehicles which route the source information to destination [10, 11, and 12]. Researchers have examined various routing protocols in VANet. The position-based routing protocols provide efficient delivery of data, throughput maximizing, and reducing rerouting times compared to over-the-top protocols topology-based routing [13, 14, 15, and 16].

2. Architecture of VANet

WAVE is a wireless communication system that connects vehicles and the vehicle and the roadside unit (RSU). This kind of communication allows safety apps to increase road safety and deliver a pleasant driving experience in addition to providing a wide range of information to drivers and passengers [17].

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The phrases "user" and "provider" refer to two distinct entities. During the user's use of the services, the provider provides them. Depending on where they are in the network, RSUs and OBUs can act as providers or users [18].As shown in Figure (1), the system is made up of three main components:

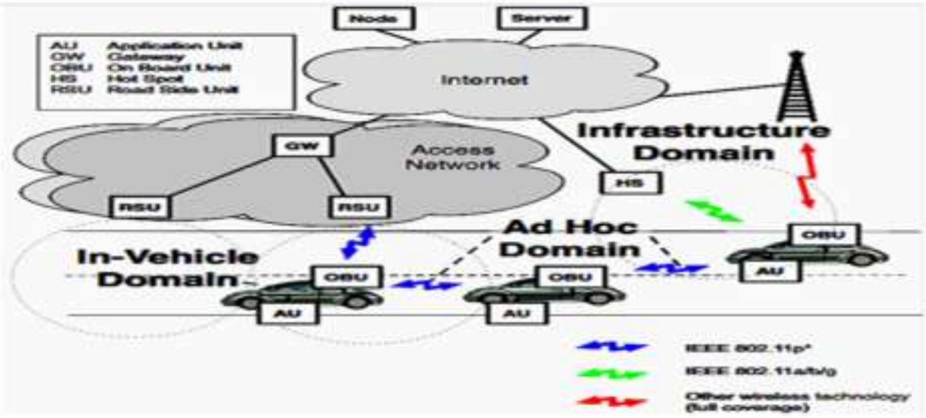

Figure (1) VANet Architecture

2.1 Application Unit (A.U.): The AU is an on-board device used in collaboration with the vendor's application to connect with the OBU. The UA can be used on the a typical device in addition to safety apps; Web services, for example, can be accessed via a personal digital assistant (PDA) [17].A wired or wireless uses the combination the OBU to the application units. It offers an Interactive connection to the OBU, allows information to be transmitted [18].

2.2 On Board Unit (O.B.U.): An on-board unit (OBU) is a piece of hardware in every vehicle. OBUs are WAVE devices that are mostly placed on vehicle to exchange data with RSUs or other OBUs. A transceiver, such as a router, is connected to an RF antenna and a CPU. It distributes data to other OBUs in addition to data transmission to other OBUs. The AU is provided with the opportunity by service programs [20]. As a means of interfacing with all external components, several wireless communication protocols may be supported [21].

2.3 Road Side Unit (R.S.U.): RSUs are usually placed along the roadside or in particular sites, such as near important junctions and parking lots [21, 22]. So because device is hooked up to the internet, it could be performed to prevent collisions and also provide safety information to the user. Only an authenticated user gets complete access to the data.

3. VANet's Technology

Dedicated Short-Range Communications (DSRC) is used by the VANET, a standard based on IEEE 802.11p used for short-range wireless communications that has been modified from the IEEE 802.11a standard. IEEE stands for Wireless Access in an Environment (WAVE), and the 1609 family of standards combines the entire communications suite. This DSRC is a non-profit institution. Its 75MHz licensed spectrum operates at a wireless signal frequency of 5.9GHz and supports data transmission rates of over 27Mbps. The bandwidth range is between 300 and 1000 meters, and can resist vehicle speeds of up to 200 km/h [9, 23]. Through new and growing technologies such as IEEE 802.11ac, that also delivers high data rates and reduces noise and energy usage by moving vehicles in high-traffic networks [24]. The media-independent transmission standard IEEE 802.21 lowers network latency and improves mobile node services and communications.

4. Challenges in VANet

Bandwidth limitations, interconnection difficulties, signal fading, security, privacy, and routing protocols are the significant challenges of VANet. Due to the general high mobility and dynamic changes in network topology, the network was frequently divided, making the learning process challenging [3, 9, 10, 25, 26, and 27].

4.1. Driver Behavior

Many academics are focusing on improving "driver behavior" in reaction to signals or information received in order to reduce the frequency of traffic collisions.

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4.2. Attenuation and Fading of Signals

fading of the signal is an important concern with VANet when obstacles between vehicles prevent the signal reaching its final destination. Other vehicles, large buildings, or radio waves towers which attenuate the broadcast signal are examples of obstacles.

4.3. Bandwidth Constraints

The time it takes to communicate the message is reduced when bandwidth is very well utilized. Due to the restricted bandwidth frequency, cars will experience increased delay if they must wait for a message to be delivered or if no congestion-free channel is available for data transmission. All we need is a central coordinator to control channel congestion and manage bandwidth.

4.4. Routing Protocol

At VANet, developing an efficient routing protocol is a main priority. By raising the amount of packets, network scalability, vehicle connectivity, and decreasing attenuation and interference from limitations such as buildings, progress increases.

4.5. Power Constraints

The OBU devices are constantly powered by strong and long-lasting car batteries. As a result of the usage of energy by numerous sensors in cars, this topic is attracting researchers who are creating energy efficiency solutions at VANet.

4.6. Dynamic Topology

The network's topology is determined by the duration of the wireless link between the cars. Rapid changes in topology in the network are caused by high-speed vehicle, their directions, and the most crucial behavior of the driver. When the range of a wireless connection is increased, the link's lifespan is extended. Since a result, Because many unnecessary routes are segregated, the connecting of linkers in compounds plays a crucial role in changing the network's topology.

4.7. Mobility

In mobile ad hoc networks, nodes move about at random, while mobility in VANet is predictable; they must conform to numerous limitations such as traffic signals, road topologies, road signs, route planning, and To provide and later obtain vital information, contact with other vehicles is necessary.

4.8. Scalability

In denser locations, such as city and highway scenarios, the network has to be scalable; it has to be unstable in rural and small locales, and the network must be vast in high-density urban areas where vehicle travel in vast numbers.

4.9 Security and privacy:

Finding an appropriate balance between security and privacy is one of VANet's main issues. As a result, the data should only be transferred by a verified individual, and the receiver must have faith in the information.

5. Routing Protocols in VANet

One of VANet's key architectural challenges is implementing a dynamic routing system for vehicle-to-vehicle data transfer. [28] Traditional MANet routing differs from VANet routing because of the very dynamic topologies.

5.1. Routing protocols in VANet

As shown in figure (2), VANET routing could be divided into the following main classifications:

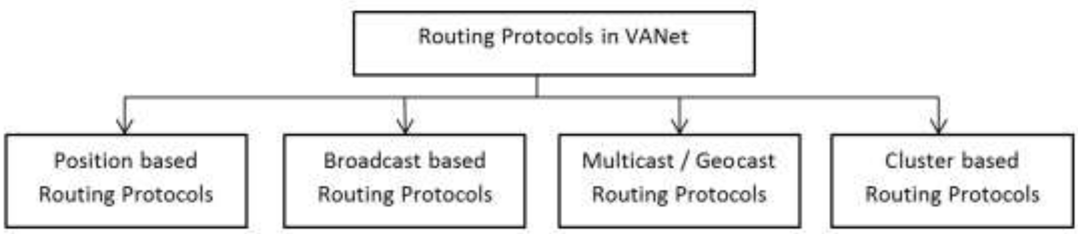

Figure (2) Routing Protocols in VANet

5.1.1. Position based Routing Protocols

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Routing options in position-based protocols are dependent on the geographic location of vehicles [29,30]. It does not need the creation or maintenance of routes, but it does need any use of location services to locate the destination. Simple location services (SLS), GPS, reactive location services (RLS), DREAM location services (DLS) are some of the most often used location services [31].

PROS: • Good performance in a road setting.
• Increased environmental stability with increased mobility.
• No requirement for an internet.

CONS: • Requires the use of a Global Positioning System (GPS).
• In the tunnel, the GPS gadget has ceased working.
• At some time, the web server will become stuck in a stalemate condition.

5.1.2. Broadcast_based_routing protocols

It is the most often utilized routing protocol in VANets, notably for safety-related applications [29]. In broadcast mode, a packet is sent to all nodes in the network, and each node broadcasts the message to additional nodes. Flooding is a frequent strategy used in broadcast routing systems [32]. Flooding which happens randomly, on the other hand, causes a broadcast storm problem. A storm of broadcast can cause congestion and lower communication dependability by overloading the channel's limited capacity [7]. Broadcast routing is commonly used in VANet to distribute traffic, weather, crises, and road conditions to cars, as well as to transmit messages and advertisements [33].VTRADE, BROADCOMM, DVCAST, and UMB are the various broadcast routing protocols.

PROS: • Due to the fact that packets are sent over numerous nodes, they are reliable;
• Due to the presence of broadcast storms, overhead expenditures were reduced.

CONS: • It necessitates a lot of bandwidth on the network.

5.1.3. Multicast/Geocast routing protocols

Messages can be disseminated from a single source to all beginning locations of interest via multicast routing [29, 34]. Geocast routing is a sort of location-based multicast routing that sends messages from a source node to all other nodes in a ZOR region. Instead of flooding packets throughout the network, a zone of forwarding (ZOF) is formed, in which packets are routed. To minimize needless quick reaction, vehicles with geocast directions are not informed outside of the ZOR [33, 34]. Geocast is a multicast service that is only available in a certain geographic location. It usually designates a staging region where packet flooding is directed in order to lessen message load and network congestion caused by packet flooding everywhere [31].

PROS: • Reduce network congestion and overhead.
• Packet delivery is reliable in a highly dynamic topology.

CONS: • Packet transmission is delayed because to network disconnection.

5.1.4. Cluster based routing protocol

Clustering is the virtual partition of dynamic nodes into various clusters in a VANet [30, 31, and 35]. A cluster is a group of nodes that have agreed to work together. The cluster's head private node is in charge of routing, relaying inter-cluster traffic, scheduling intra-cluster traffic, and assigning the channel to cluster members [34]. Because the cluster header will broadcast the packet to the cluster, the cluster and the node are mapped. When establishing clusters in a highly mobile VANet, good scalability may be achieved, although network latency and overhead can arise. To enable scalability in cluster routing, the virtual network topology must be constructed by cluster nodes [31].

PROS: • Large-scale network scalability.
• In dynamic networks, delays are reduced.

CONS: •There will be an increase in network overhead.

5.2. Comparison between Various Routing Protocols

According to contemporary concerns and challenges, position-based routing methods function more efficiently and better than other routing protocols in VANets, as demonstrated in Table (1).

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Table (1) Routing Protocols Comparison.

Parameters	Position based routing protocols	Broadcast based Routing Protocols	Multicast / Geo cast Routing Protocols	Cluster based Routing Protocols
Network scalability	Scalable	Not scalable	Not scalable	Not scalable
Network topology	Dynamic	Fixed	Fixed	Fixed
Bandwidth utilization	High	Low	Low	Low
Mobility	Predictable	Random	Random	Random
Performance	High	Low	Low	Low
Power constraint	Low	High	High	High
Resource utilization	High	Low	Low	Low
Message overhead	Low	High	High	High
Suitable for and stable in	High-mobile environments	Small networks	Small networks	Small networks
Prior forwarding method	Heuristic method	Wireless multi hop forwarding	Wireless multi hop forwarding	Wireless multi hop forwarding
Scenario	Urban	highway	highway	Urban

6. VANet Applications

Drivers and passengers in a VANET system have access to a wide range of information and may construct a range of applications, as shown in Table 1. (2). Sensors, powerful antenna technology, and efficient wireless access are among the technologies used in the vehicle's units. The technology sends data from the road unit to other vehicle for maximum safety and to make passengers feel more at ease. It will communicate with other vehicles and collect data from them.

6.1 Safety-related VANet applications:

support to drivers, Pre-collision detection, cornering speed measurement, lane change, traffic signal violation, electronic emergency brake light, stop sign movement, and left turn assistance are among the eight possible safety-related applications listed by the vehicle safety communication consortium [36]. We need to deploy big road safety applications on our roadways in order to prevent road accidents and fatalities [37]. These applications help drivers avoid a crash with other cars on the road by providing them with relevant traffic information.

6.2 Non-safety-related VANet applications:

VANETs can also be utilized to deliver useful or commercial services. Traffic efficiency, passenger comfort, advertising efficiency, and computerized toll collecting all benefit from this sort of application (ETC). These firms' applications include the capacity to identify weather, traffic, hotels, and petrol stations, as well as different places of interest (POIs) such parking lots, hotels, shopping malls, fast food restaurants, gas stations, and so on. VANet for business and convenience purposes is seen to be adverse to traffic safety and efficiency. It's also annoying and interferes with safety-related technology.

6.3 Efficiency applications:

A vehicle is detected from its present position in the city streets, and its movements are improved, using this program. Vehicle-to-vehicle communication, as well as vehicle-to-RSU communication, takes place in essence. Road and level crossing management, as well as congestion reduction, are two main types of applications [2].

6.4 Comfort applications:

There are services that reveal information to drivers to make their journey more convenient and pleasurable. This sort of application [38] can include weather data, information on available parking spots, maps of gas stations, and catering spots.

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Table (2) Vehicular Application

Category	Sub Classification	Vehicular Application
Safety VANet applications	Driver assistance Alert information Warning alerts	Pre-crash detection, curve speed measurement, lane-change, traffic sign violation, emergency electronic brake light, stop sign movement and left turn assistance.
Non-safety VANet applications	Traffic efficiency Passenger comfort Advertisement effectiveness Electronic toll collection (ETC)	Identify weather information, traffic, hotels, gas stations as well as different points of interest (P.O.I) such as parking lots, gas stations, shopping malls, hotels, fast-food restaurants, etc.
Efficiency applications	Vehicle to vehicle communication Vehicle to RSU communication	Road and crossing management, and traffic jam reduction.
Comfort applications	Information	Climate information, information concerning vacant parking spaces, maps of gas stations, and restaurant areas.

7. CONCLUSION

This review presents an overview of various research publications on the architecture, attributes, applications, and security problems of VANet. A number of large subjects in the field of vehicle communication are now the focus of extensive research and discussion. VANet networks have the ability to develop from mobile networks. V2V and V2I connections will be utilized to assess a connection's performance.

The VANet routing protocol's performance is greatly influenced by node mobility, vehicle density, and a variety of external factors such as the driving environment. To address the individual QoS needs of each application, we must create a customized routing protocol and mobility model. Security and privacy in VANet apps must be addressed in the future, as they have recently become hot topics.

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