# A Review of Multicast Routing Protocols for Vehicular Ad Hoc Networks (VANETs)

**Hamad Said[1], Hothefa Shaker[2], Zeyad Sharef[3], Seemaa Abbas[4]**

[1,2]Modern College of Business & Science, Muscat, Sultanate of Oman

[3,4]Ninevah University, College of Electronics Engineering, Ninevah, Iraq

**Abstract**

Vehicular Ad Hoc Networks (VANETs) are a specific type of mobile ad hoc networks (MANETs) that are specifically built for Intelligent Transportation Systems (ITS). Vehicular Ad Hoc Networks (VANETs) facilitate wireless connectivity between vehicles on roadways using communication technologies such as Wi-Fi and Bluetooth. An essential prerequisite for VANETs is their capacity to adjust to various situations and circumstances, regardless of the level of traffic and the positions of vehicles. These networks must operate efficiently in both urban and rural areas, regardless of the dynamic and frequently unpredictable nature of these environments. The dynamic nature and large population of users in VANETs pose continuous challenges, particularly with the efficiency of routing methods. Conventional routing protocols designed for Mobile Ad hoc Networks (MANETs) sometimes demonstrate path instability when used in Vehicular Ad hoc Network (VANET) settings. The instability results in a higher occurrence of packet loss, increased overhead owing to frequent route repairs or failure alerts, and as a result, lower delivery rates and longer transmission delays. This work presents a multi-factor system strategy to tackle these difficulties, intending to improve the routing efficiency in VANETs. In addition, this paper addresses the problems of path instability and enhances network performance in different vehicle contexts with our technique.

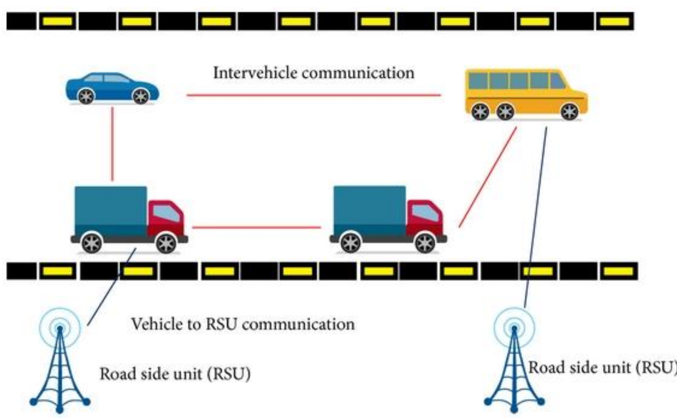
**Keywords:** VANET, MANET, ITS, Ad-Hoc

## 1. Introduction

The application of MANET has garnered significant attention and interest due to its potential in numerous industries. In contrast, the development of infrastructure is unfeasible and cannot progress without the implementation of MANET. MANET is a network design concept that is both scalable and self-configurable. In this concept, nodes are connected wirelessly and function as routers and data communication stations based on the needs of the network. VANET is a subset of MANET that encompasses all of its characteristics. Deploying a vast infrastructure across all roads and highways to enable vehicle-to-vehicle communication, as seen in Figure 1, is both prohibitively expensive and logistically challenging. One of the notable characteristics of VANET is the swift deployment of the assigned networks without the need for any management or central unit. [1]

VANET has implemented ITS technology to enhance driving by leveraging the newest communication technologies, ensuring efficiency, convenience, safety, and precision. ITS technology has advanced to provide a traffic system that is both more efficient and secure compared to traditional traffic management systems. The initial iteration of Intelligent Transportation Systems (ITS) was developed in 1991 in the United States, prompted by the significant loss of life resulting from traffic accidents. The aim of developing intelligent transport systems was to incorporate cutting-edge technology into the existing traffic system to minimise accidents and enhance road safety [26]. The initial iteration of the short-range communications system (DSRC) was created specifically for commercial vehicles operating at 915 MHz, boasting a data transfer rate of 0.5 Mbps. The DSRC technology was exclusively utilised by commercial vehicles for fee payments. In 1997, the Intelligent Transportation Systems (ITS) in the United States formally requested a bandwidth allocation of 75 MHz from the Federal Communications Commission (FCC) to facilitate the development of cutting-edge traffic system technologies. [1, 2]

**Figure 1. Strategies of VANET Application [1]**



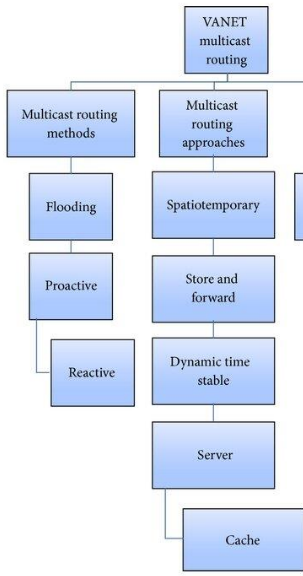

In 1999, the Federal Communications Commission (FCC) designated the 5.9 GHz band (specifically, the region from 5.85 GHz to 5.925 GHz) for use in the second generation of dedicated short-range communications (DSRC). This allocation provided a bandwidth of 75 MHz. The project aimed to establish dependable vehicle-to-vehicle communication to receive accurate information regarding weather conditions, accidents, traffic congestion, and other related data. Furthermore, there is no fee for accessing the DSRC 5.9 GHz band, resulting in a decrease in overall installation expenses. The primary objective of the target allocation range is to mitigate road accidents through the utilisation of VANET technology. Table 1 displays the comparison of wireless network technology. [1, 2]

**Table 1. Comparison between wireless technologies. [1]**

| Attributes | DSRC | Cellular | Satellite |
|---|---|---|---|
| Communication range | 100 to 1000 meters | 35 + Kms | 1000 +kms |
| Communication latency | 200 µs | 1.5 to 3.4 sec | 10 to 60 sec |
| Infrastructure Cost | None | Costly | Very costly |

There are two types of DSRCs (RSU and OBU), and they are used in VANET. These units are installed in vehicles with directional antennas for access to the wireless channel. Road Side Unit (RSU) are devices fixed and installed along roads and highways with on-board unit (OBU) )---like functions. While the general road structure consists of RSUs of antenna and processor to facilitate communication between vehicles. [1,28]

**Figure 2. VANET multicast routing classification. [1]**




The purpose of this paper is to review and categorize all VANET multicast routing protocols. It is difficult to classify the performance of all the protocols reviewed at this stage due to their development in different environments and scenarios. Therefore, all protocols are arranged under the geocast class and the category based on the approaches and techniques used in these protocols. All the protocols are based on different and different schemes to achieve the desired results as shown in Figure 2. These schemes have been developed for VANET environments that have been identified according to the required requirements. This paper was compared to understand the reader and the ease of knowing each system in a different environment. This understanding will facilitate the way for further research and development in the different communications of VANET multicast routing protocols. Another new aspect of this paper will be to include and illustrate new technical trends introduced in the VANET multicast routing, such as spatiotemporal scheme, geographical multicasting at highways, and store and forward scheme, as shown in Figure 2. [1, 2, 3]

## 2. VANET Multicast Routing

Multicast routing protocols are the most active research in the region because of their viability and mobility within the environment such as VANET. The multiplication of the transmitter, which reduces energy consumption, less overhead, and control of public expenditure is by sending messages to various vehicles at the same time. In the case of VANET Multicast routing protocols, messages are transmitted to a specific set of destination vehicles. Multiple routing methods are categorized as follows: flooding, proactive, and reactive approaches as shown in Figure 2. [1, 2, 3]

In flooding, the messages are broadcast over the network, such as the chain of interaction. Each node sends to all its neighbours except the sender. Broadcast messages can be limited and limited in a geographical and desirable area. Therefore, the nodes can only resend the message when it falls within the specified geographical area. The flooding algorithm is simple to the appliance which delivers messages constantly. Flooding consumes a lot of bandwidth and power supply, due to traffic congestion and slow network returns to frequent messages. This frequency is a network collision resulting in loss of data and packets. [1, 3, 4, 5]
In Proactive, Routing information is stored and stored in routing tables by processes with routing paths. It is periodically updated to distribute this information over the network. In this case, the shortest distance of the routing path is adopted without resorting to road detection. In terms of modernization, roads are maintained at regular intervals without considering their use. Therefore, there is only partial information required for ways to reduce bandwidth consumption and response time. In real time it is suitable for applications due to low response time [27]. Aware of the other side, maintenance of unused routing paths increases the bandwidth supply. The continuity of the complexity of maintaining the routing tables at a high altitude and in the end does not respond to any type of link failure within the network. [1, 3, 4, 5]
In Reactive, It is the path to calculate on demand and based on any mechanism designed to respond. Where the connections between the sender and the desired receiver only. In this approach, it is not necessary to update the paths continuously at intervals, because such approaches are also needed for airflow in general. And that will result in a decrease in bandwidth consumption because the actual box is engaged. This approach responds to the probability that the phallus type will arrive at the subsystem within the network. It has high potential because the routers will be discovered on demand. [1, 3, 4, 5]
In multicast routing protocols, MANET is not capable of performing well in VANET, because the topology updates and changes continue when the vehicles are not stable by moving a different way. Also, it is difficult to change the range of bandwidth to reduce it and consume the power to high mobility in VANET. All those issues and challenges related to the VANET multicast routing protocol. The aim of developing multicast in VANET is to lower the overhead of route transmission, keep updated and maintain the adaptable topology, avoid loop information, and reduce the load of processing.[6]

## 3. VANET Multicast Routing Protocol Classification

VANET multicast routing protocols use different schemes in routing messages and depend on the plans and requirements of VANET design. These schemes are shown in Figure 2 and their basic roles will be discussed in this section. The next section will explain the advantages and disadvantages of routing protocols. [1, 7, 8, 9]
In the spatiotemporal scheme, the allotted time specified by the sender, the messages will be transmitted to other vehicles. In this approach, all the transmissions depend on restriction by the time. It is possible to combine the time factors with types of events. If the spatiotemporal scheme combines with geo-cast, then the transmission will be sent at a specific time into a desired geographical area to the vehicle requested, as this area is “a zone of relevance at the time” (ZOR).[1,7,8,9]
Another way to store the messages in RSUs is to deliver them to the vehicle at a specific time required. Also, the server approach is used to deliver messages to vehicles within a specific time and ZOR. The time factor will keep the receiving messages for a specified period at the destination, then send it to vehicles. Many

scenarios are required for message transmission in the time factor like the position-based advertisement and location-based announcements. Another application is available to distribute and send traffic guidance, warning signs and weather updates to vehicles at a specific time in a desired geographical area. These protocols are called mobicast and geocast routing protocols. [1, 7, 8, 9]

## 4. VANETS Multicast Routing Protocols

All VANET multicast routing protocols based on two types are geocast and cluster-based. All these protocols will be explained in this section with a comparison between advantages and disadvantages. [1]

***4.1 IVG*** "VANET Intervechicles Geocast Protocols", It is a protocol used to send and distribute safety messages to multiple vehicles when an accident or any serious obstacle happens on the highways. These messages can be transmitted to a set of vehicles at the same time called a multicast group. Additionally, the protocol is developed to achieve secure, reliable communication, and efficiency especially for the intelligent transmission system. The protocol aims to understand and inform the vehicles about the risk if available in the emergency area. The multicast group of messages is selected related to the risk factor available in the emergency area. The risk factor is determined by driving directions and the place of multiple vehicle contention. The vehicle damaged by accident will transmit the message to a multicast group. Then all vehicles that went to that same location will receive that message and the same scenario will repeat to inform other vehicles who are incoming in the risk region. [1, 2, 27]

*Advantages*, The IVG protocol minimises the number of hops by efficiently distributing messages through the use of multicast groups. Moreover, this protocol mitigates network fragmentation through regular broadcasts. Additionally, determine the time for rebroadcasting based on the velocity of vehicles to optimise and enhance the protocol. Upon conducting tests in various contexts, the simulation for this protocol will yield scalable and dependable results.. [1, 2]

*Disadvantages*, more transmission is a delay, when vehicles are informed to other vehicles by the rotary transmission of beacons, the result of transmission load is increased, then increasing the number of transmission groups within the congested traffic area. [1, 2]

***4.2. Cached Geocast***, this protocol means to forward geocast messages. The cache is added in the routing layer to store the geocast messages. It means if not found the neighbour suitable, then the geocast messages are saved into the cache. The cache contains two parts of messages such as unforwardable and unroutable messages. When the messages are forwarded to find the near nodes required. Sometimes, the destination node is not registered in the table of routes. So, the messages are saved in the cache and forwarded to the registration of the node required. This protocol is used for the application that depends on virtual warning signs on the highway. Hence, the messages are delivered to all vehicles in the desired geographical area rather than communicating along with the vehicles. [11, 12, 13]

*Advantages*, reduce the forwarding messages stored in the cache because disconnection of the network causes stopping the network partitioning. Sometimes, the stored messages are delivered and found a suitable neighbour. But the messages are kept in the cache. So, that neighbour is improved and efficient to reduce the load of the network and delay for transmission. [11, 12, 13]

*Disadvantages*, The increase in the overhead of transmission relates to records of nodes neighboring that request to be maintained in the table. The cache is updated automatically if any transaction happens for a neighbouring node like a new joining, leaving, or changing the location. Similarly, it requires adding the timing for storing, maintaining, and retrieving the messages in the cache. [11, 12, 13]

***4.3. Abiding Geocast***, is a time-stable protocol which delivers messages to a desired geographical location at a specific time. This protocol contains three approaches to message delivery. In the first approach, the servers stored the messages locally until delivered upon finding the destination node, and the storage of the server can be infrastructure-based. In the second approach, the node is selected from a desired geographical area to deliver the messages to all the neighbouring nodes in the area. In the last approach of abiding by geo cast protocol, the node which is a destination node is elected by the server to store the messages and delivering to all vehicles in the region within a specific time. The process to select the node The last approach of abiding by geocast protocol, the node as a destination node is elected by the server to store the messages and delivering to all vehicles into the region within a specific time. The process of selecting the node or electing for the server to deliver the messages depends on the criteria in the algorithm abiding geocast protocol. Also, the handover process of the server to the electing node is based on this protocol. All the messages are stored in the server for a limited period. So, the bandwidth is saved by avoiding it because the messages are delivered at a specific time within a desired geographical location. This protocol is developing an application to advertise information distribution about any risk factor on the highway. Also, inform the vehicles about the state of the current road like traffic congestion, slippery conditions, and snow falling level. [10]

*Advantages*, reduce the overall network load because of the results of all the messages stored in the server before transmission on a limited lifetime. Also, this protocol does not require the beaconing system, because the messages are broadcasted continuously. [10]

*Disadvantages*, the latency is high and the transmission of the packet is a loss in this protocol as compared to other protocols because saving and retrieving the messages from the server takes a long extra time. This protocol is reliable because the messages are delivered by selecting the server to the destination nodes on complex procedures. There are other issues relating to assigning a limited lifetime when storing the messages on the server within an assigned limited time if the messages are assigned a short lifetime, then new nodes cannot receive it. [10]

***4.4. GVGrid***, is a reactive routing technology that is designed to prioritise quality of services (QoS). This protocol intends to establish and maintain reliable and high-quality communication links between vehicles and wayside communication systems. It partitions the map into a grid composed of squares of equal size. It utilises this method to determine the adjacent nodes and the nodes navigate to locate the subsequent step inside a grid. Next, choose those vehicles that are moving at the same velocity and in the same direction. Furthermore, this protocol is unsuitable for highways with high vehicle speeds as it is specifically developed for managing traffic congestion. [14, 15]

*Advantages*, it does not create new routes if the link is broken. It dismisses the broken link and replaces the missed node with another node. Therefore, it quickly directs and recovers the route efficiently rather than searching for a new route in the network. It finds alternative nodes and develops into missed nodes successfully. Therefore, route lifetime will become longer rather than improve the packet delivery. [14, 15]

*Disadvantages*, need to improve efficiency and develop in practice and intensity because of the increasing complexity process in developing alternate routes. Therefore, increases the delay of communication between various routes of the network. [14, 15]

***4.5. DRG*** (Distributed Robust Geocast), is developed depending on a distance-based back-off algorithm in dynamic environments. This protocol is adaptable to changing topology and reduces the number of hops in dynamic various environments. Additionally, it is based on the approach to complete transmission in which the messages are kept active in the destination to confirm the reliable delivery of messages. Also, the new nodes of routes into the same region can receive the messages. This protocol will reduce the number of redundant because the nodes do not rebroadcast the messages until their distance exceeds the specific value from the sender. The transmission is divided into two regions to receive the messages from the sender are called ZOR and ZOF. ZOR is the sender area in which the vehicles receive the messages from the sender in that area, but ZOF is the area in which the nodes can forward the messages to other nodes. This protocol is developing an application to deliver reliable emergency messages in a specific geographical region. [16, 17]

*Advantages*, this protocol has network fragmentation and is avoided by using the ZOF approach. When reducing network load, the protocol does not exchange beacons periodically. High packet delivery rates in good networks, hence increasing the density ratio by using ZOF. [16, 17]

*Disadvantages*, overhead the network and increase the packet delivery ratio by increasing the delay of the packet because of more geocast messages available and kept alive with a long duration at ZOR. [16, 17]

***4.6. ROVER*** (VANET Robust Vehicular Routing), It is classified as a multicast geographical protocol. It is developed to provide reliable routing for communication between vehicles. ROVER has two phases of the messages communicated. In the first phase, only control traffic packets are allowed to broadcast within ZOR, and flooding by using a reactive approach. In the Second phase, the data packets are unicasted. Additionally, the ROVER protocol uses location information, map information, and identification numbers for routing protocols. [18]

*Advantages*, ROVER is reliable and efficient within the geographical multicast protocol, because it is only flooding control traffic packets, where the data packets are unicast. [18]

*Disadvantages*, increased overhead for transmission of control packets. Also, increase the delay for retransmissions and redundant messages. The delay can be reduced by using the two zones provided in Bronzed and Kristiansen. It can use hop count when the packet is forwarded and discarded on arrival to zero. [18]

***4.7. DG-CastoR***, is developed for infotainment applications in VANET. It develops a virtual community by predicting the future location of mobile nodes with a group called a rendezvous which is meeting in the future. So, this protocol is based on spatiotemporal routing approaches because it uses the time factor in the routing. The query is broadcast only between the nodes belonging to the rendezvous group at an assigned specific time. In this protocol, it is also possible to estimate the path of those neighbours who have a similar path to the transmitter in the period required. This protocol avoids congestion by transmitting packets to the rendezvous group only instead of a complete network, thereby reducing unnecessary transmissions. [19, 20]

*Advantages*, this protocol has to maintain a large network for nodes in VANET by using robustness. Also, network congestion is reduced by estimating nodes' position in the future. [19, 20]

*Disadvantages*, in this protocol, the quality of the neighbourhood trajectory is maintained by estimating future nodes of the contract thereby increasing the overhead network. The route table needs to be constantly updated when you perform a simple operation as a change by sending hello Messages. [19, 20]

***4.8. Mobicast***, It is a geographically consistent spatiotemporally multicast routing protocol. Therefore, by combining the geographical and spatiotemporally, the messages are transferred at a specific time within a specific geographical region called a ZOR. These messages are transmitted within multiple vehicles within ZOR. The location of vehicles is found by using GPS. So, this protocol was developed for various applications used in emergency scenarios, like online video advertisements and games. [21]

*Advantages*, the message delivery rate was successfully improved and the overhead load ratio with ZOF was reduced (a group of receiving which forward multicast messages). Also, the problem of the fragmentation of the network is avoided by using ZOF. Similarly, reduce the delay of the packet delivery by using ZOR and ZOF. [21]

*Disadvantages*, The presence of link failure between ZOR vehicles in case of sudden change in the speed of vehicles on highways, whether the vehicle speed is suddenly high or slow. It also relies on GPS to obtain location information, information on network density, and global density information to know which may not be available at that time. Therefore, they may be affected in their performance in large networks and highly dynamic environments. [21]

***4.9. DTSG*** (Dynamic Time Stable Geocast Routing), the protocol ensures temporal stability by allowing the preservation of messages within a defined geographical area for a specific duration. The Protocol has created an application that features an emergency warning system for highways and other commercial activities. This system is capable of saving and delivering messages to all cars within a specific geographical area. Furthermore, this protocol is highly dependable as it ensures the timely delivery of messages to cars in the designated geographical spot. DTSG operates in two distinct stages known as the prestable stage and the stable stage. During the prestable stage, messages are transmitted within a designated area. The subsequent step, known as stable, involves intermediate nodes transmitting the messages to cars within a specified timeframe using a mechanism called storing and forwarding. This strategy involves the storage of communications by vehicles and their subsequent forwarding to other vehicles based on the specified time. [22]

*Advantages*, Performance of vehicle speed in highways and traffic density are not affected by the use of forwarding and storage techniques. The protocol can also operate in a separate environment because it specifies the appropriate period of work (prestable/stable) depending on vehicle speed and traffic density. This is a stable dynamic protocol of time in any message Delivery time can vary according to need which makes its performance robust. [22]

*Disadvantages*, This protocol is encountered in the network to increase the number of messages and not set the message delivery time and switch between stages of stability. [22]

***4.10. Constrained Geocast***, this protocol aims to develop Cooperative Adaptive Cruise Control (CACC) control automatic traffic. So, the vehicles can control and manage the speed automatically by the CACC system. In this protocol, the vehicle is considered to apply this system to be reliable and efficient in the future. Also, the delivery of the route packets with reliability selected even with the high load of the network and density environments may depend on the vehicle positions. [17, 23]

*Advantages*, this protocol has a distinct performance where it relies on dense networks because node locations are already known in the same area. The vehicles adjust their speed according to traffic and can combine with other vehicles in different passages by communication between vehicles. [17, 23]

*Disadvantages*, The reasons for the high overhead of the network through the development of the assessment of parking in complex and dense networks. As a result, network fragmentation occurs for high mobility of nodes. [17, 23]

***4.11. Geocache,*** is designed to develop the traffic system and manage the safety of the road by reducing traffic congestion. The information is shared between vehicles to avoid a load of traffic on all routes. In this protocol, the cache mechanism is introduced. Where information is saved and retrieved from the cache rather than from other nodes in the region. Therefore, the amount of information exchanged decreases significantly, and therefore the network load is reduced as well. Information accuracy and traffic efficiency are also maintained despite cache management. [1, 2]

*Advantages*, This protocol effectively reduces traffic load and efficiently exchanges through information storage and traffic congestion. This buffer provides a way to reduce transmission in terms of time and frequency according to the result of the ZOR technology mentioned in the geocast protocol. [1, 2]

*Disadvantages*, as the congestion factor increases, the response time increases. However, to avoid it by maintaining the level of distance between vehicles. [1, 2]

***4.12. CBDRP*** (Cluster-Based Directional Routing Protocol), this protocol has been developed effectively and fundamentally for high-speed vehicles that travel on highways where minimum delays are required. The vehicles form a kind of block to follow the same direction as other vehicles. The source node moves the packet to its cluster head first, and then the message is redirected to the top of the block where the destination node is located. Finally, the message is sent to the destination node, the results show through this process it is characterized by low response time, high stability and high delivery rate of packets. [24, 25]

*Advantages*, achieve the stability of the connector by specifying a new routing head when one of the transmission lines falls on the highway scenario. As a result of the analysis, the transmission becomes fast and reliable, reducing the data traffic rate because only the required packet is sent to the cluster headers. [24, 25]

*Disadvantages*, high traffic delays due to the increase in the number of clusters and their unidirectional correlation. [24, 25]

***4.13. COIN*** (Clustering for Intervehicle Communication Network), protocol has been developed to be essential for communication between vehicles in an intelligent transport system due to lack of infrastructure. In addition, the communication efficiency between cluster headers and assembly nodes is maintained by reducing node speed. Clusters are formed to navigate and maintain the position and the efficiency of their behaviour in different environments. Cluster headers reschedule node access to wireless media, which helps reduce network load and collision while moving. [1, 2]

*Advantages*, COIN allocates time related to each transmission group, which helps reduce the size of the network load control. This Protocol Improves mass stability and stability for adoption by choosing anodes that have the same efficiency in motion ratio and low movement. [1, 2]

*Disadvantages*, Keep the low for maintaining mobility between the nodes and the radio connection with other nodes. Increase the overhead of cluster stability, because nodes speed limits the scalability and productivity decline. [1, 2]

## 5. Conclusion

This study provides a review of VANET multicast routing protocols, examining various routing approaches and ideas. The protocols discussed in this study were adversely impacted in VANET due to the dynamic movement of the nodes and the resulting instability, leading to network dispersion, transmission latency, and reduced productivity. Hence, multicasting is employed to enhance the efficiency of VANET routing protocols and minimise power usage, transmission, fragmentation, and control traffic overhead by transmitting numerous messages from the source node to several designated vehicles. The evaluation of multicast routing protocols for VANET focuses on the distinct attributes of routing, including location-based, spatiotemporal, and real-time aspects. The VANET routing protocol is designed based on the specific application area and the surrounding environment. Therefore, it is impracticable to devise a solitary protocol that applies to all VANET setups. Finally, I have provided a comprehensive explanation of the operation of all VANET multicast routing protocols, as well as their respective advantages, limitations, and performance in various environments.

Several multicast routing protocols have been created for efficient and real-time communication in VANET. However, there are still numerous areas where these protocols need to be implemented. Implementing VANET multicast directive protocols can enhance productivity by lowering end-to-end delay and minimising network congestion. Furthermore, protocols can be adjusted to a highly dynamic environment and minimise the amount of data being transmitted in networks with a high density of nodes.

## References

1. Farooq, W., Khan, M. A., Rehman, S., & Saqib, N. A. (2015). A survey of multicast routing protocols for vehicular ad hoc networks. International Journal of Distributed Sensor Networks, 11(8), 923086.
2. Liu, J., Wan, J., Wang, Q., Deng, P., Zhou, K., & Qiao, Y. (2016). A survey on position-based routing for vehicular ad hoc networks. Telecommunication Systems, 62(1), 15-30.
3. Hassan, U., Awan, F. G., & Qureshi, S. A. (2016). A Direction-Based Make-Before-Break Routing Protocol for Vehicular Ad Hoc Networks. Mehran University Research Journal of Engineering and Technology, 35(4), 599-618.
4. Saleh, M. E., & Dong, L. (2017). Secure Location-Aided Routing Protocols With Wi-Fi Direct For Vehicular Ad Hoc Networks. arXiv preprint arXiv:1707.00654.
5. Bhoi, S. K., Khilar, P. M., Singh, M., Sahoo, R. R., & Swain, R. R. (2018). A routing protocol for urban vehicular ad hoc networks to support non-safety applications. Digital Communications and Networks, 4(3), 189-199.
6. Moniruzzaman, A. B. M., & Rahman, M. (2014). Analysis of topology-based routing protocols for the vehicular ad-hoc network (vanet). arXiv preprint arXiv:1411.7662.
7. Xia, H., Zhang, S. S., Li, B. X., Li, L., & Cheng, X. G. (2018). Towards a Novel Trust-Based Multicast Routing for VANETs. Security and Communication Networks, 2018.
8. Maratha, B. P., Sheltami, T. R., & Salah, K. (2017). Performance Study of MANET Routing Protocols in VANET. Arabian Journal for Science and Engineering, 42(8), 3115-3126.
9. Altayeb, M., & Mahgoub, I. (2013). A survey of vehicular ad hoc networks routing protocols. International Journal of Innovation and Applied Studies, 3(3), 829-846.

10. Zhang, X., Yan, L., & Li, W. (2016). Efficient and Reliable Abiding Geocast Based on Carrier Sets for Vehicular Ad Hoc Networks. IEEE Wireless Communications Letters, 5(6), 660-663.
11. Luhach, A. K., & Gao, X. Z. (2018, February). Analysis of Enhanced Hybrid Approach Using Greedy Perimeter Stateless Routing in VANET. In International Conference on Futuristic Trends in Network and Communication Technologies (pp. 464-471). Springer, Singapore.
12. Kaiwartya, O., & Kumar, S. (2015). Cache agent-based geocasting in VANETs. International Journal of Information and Communication Technology, 7(6), 562-584.
13. Kaiwartya, O., & Kumar, S. (2015). Guaranteed geocast routing protocol for vehicular adhoc networks in highway traffic environment. Wireless Personal Communications, 83(4), 2657-2682.
14. Khan, I., Khan, H., Awais, M., Sohail, A., & Ikram, M. (2018). Routing Protocols in Vehicular Ad Hoc Networks: Survey and Future Perspectives.
15. Singh, A. K., Rao, R. S., & Baghel, A. S. (2016). Position based routing protocols for vehicular ad hoc network: a review. International Journal of Computer Science and Mobile Computing (IJCSMC), 5, 206-212.
16. Senouci, O., Aliouat, Z., & Harous, S. (2019). A review of routing protocols in internet of vehicles and their challenges. Sensor Review, 39(1), 58-70.
17. Bousbaa, F. Z., Zhou, F., Lagraa, N., & Yagoubi, M. B. (2016). Robust geocast routing protocols for safety and comfort applications in VANETs. Wireless Communications and Mobile Computing, 16(10), 1317-1333.
18. Rungta, J., Satghar, M., Prabhu, A., Sanu, V., & Agrawal, S. (2015). A Proposal on Wireless Ad Hoc Network Controlled Rovers. International Journal of Computer Applications, 117(22).
19. Verma, R., Rauthan, M. M. S., & Vaisla, K. S. (2017, November). A comparative analysis of multicast routing protocols in VANET for smart city scenario. In 2017 International Conference on Inventive Computing and Informatics (ICICI) (pp. 810-814). IEEE.
20. Singh, S., & Aujla, G. S. (2015). A closer look through routing protocols in vehicular ad hoc networks (VANETs). IOSR Journal of Computer Engineering, 4(6), 58-64.
21. Jain, N., & Jangir, H. (2017). Survey On Underwater Acoustic Wireless Sensor Networks Of Routing Protocols.
22. Dora, D. P., Kumar, S., Kaiwartya, O., & Prakash, S. (2016). Secured time stable geocast (S-TSG) routing for VANETs. In Proceedings of 3rd International Conference on Advanced Computing, Networking and Informatics (pp. 161-167). Springer, New Delhi.
23. Wang, H., Zhu, T., Lei, S., Yang, W., & Wang, Y. (2015). CMTG: A content-based mobile tendency geocast routing protocol in urban vehicular networks. International Journal of Distributed Sensor Networks, 11(3), 163157.
24. Farooq, W., Khan, M. A., Rehman, S., Saqib, N. A., & Abbas, M. (2017, December). AAGV: A Cluster Based Multicast Routing Protocol for Autonomous Aerial and Ground Vehicles Communication in VANET. In 2017 International Conference on Frontiers of Information Technology (FIT) (pp. 315-320). IEEE.
25. Abuashour, A., & Kadoch, M. (2018). Control overhead reduction in cluster-based VANET routing protocol. In Ad Hoc Networks (pp. 106-115). Springer, Cham.

26. Mahesh, R. K., & Jawaligi, S. S. (2023, July). A Brief Review on Optimal Routing in Vehicular Ad-hoc Network. In 2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT) (pp. 1-8). IEEE.
27. Ahmad, T., Ismail, N. S. N. B., Rahman, M. A., Waseem, Q., & Safri, A. M. (2023, August). Hop Restricted-AODV (HR-AODV) Routing and Its Applicability on Different Wireless Channels for Vehicular Network. In 2023 IEEE 8th International Conference On Software Engineering and Computer Systems (ICSECS) (pp. 1-6). IEEE.
28. Stefanovic, K., Malnar, M., & Jevtic, N. (2023, November). Survey of Multicast Routing Protocols in VANET. In 2023 31st Telecommunications Forum (TELFOR) (pp. 1-4). IEEE.