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Research Article

Performance Evaluation of Routing Protocols in Vehicular Ad-Hoc Networks (VANETs): A Comparative Study

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Abstract: VANET is a novel way for fast-moving autos to connect. VANET provided traffic engineering, management, emergency information to avoid accidents, and other user applications. VANETs are similar to Mobile Ad hoc Networks (MANETs), but they have fast speeds, mobility, adequate storage and processing power, unexpected node density, difficult communication environments with limited connection lifespans, etc. Hence, VANET protocol testing needs realism. Vehicular Ad hoc Network (VANET) is a new communication paradigm that allows road network V2V and V2I communication (V2I). It supports traffic engineering, emergency information transfer, and other user applications. Vehicular networks distribute data about road traffic conditions to keep vehicles safe and efficient. VANET Applications' characteristics—different network density, fast vehicle movement—make data dissemination difficult. Performance requirements determine these protocols' vehicle area network applicability. Vehicles talking with each other and roadside units constitute Vehicular Ad-Hoc Networks (VANETs), a specific type of MANET (RSUs). VANETs allow safety, traffic management, and infotainment. Due to vehicle mobility and frequent network topology changes, VANETs have routing difficulties. This paper compares VANET routing protocols. . Simulations reveal that mobility pattern, network density, and traffic load affect protocol performance.

I. Introduction

VANETs, or Vehicular Ad-Hoc Networks, have gained a lot of attention in recent years because to the wide range of services they can provide, such as improved security, more efficient traffic flow, and more engaging in-car media. The fundamental goal of vehicle area networks (VANETs) is to enable vehicles to communicate with one another and with roadside units (RSUs) to exchange and disseminate data about traffic conditions, potential hazards, and other noteworthy events. The high mobility of vehicles causes frequent topology changes in VANETs, making routing a significant obstacle that must be surmounted in this type of network. Due to the dynamic nature of VANETs, it is essential that the routing protocols used in these networks be designed to reliably and efficiently facilitate communication. Vehicular ad hoc networks (VANETs) have recently received a lot of attention due to their potential to provide useful services like safety, traffic management, and information and entertainment to drivers and passengers alike. The main goal of vehicle area networks (VANETs) is to allow vehicles to communicate with one another and with roadside units (RSUs) to exchange data on traffic conditions, hazards, and other noteworthy events. One of the most significant obstacles to be surmounted in VANETs is routing, as the high mobility of vehicles causes frequent changes in the network topology. Hence, VANETs necessitate the development of routing protocols that can handle the ever-changing nature of the network while yet maintaining effective and dependable communication. Here, we provide a thorough analysis of the many VANET routing protocols now in use. Metrics including packet delivery rate, round-trip time, throughput, and routing overhead are used to assess the effectiveness of each protocol. What follows is the rest of the paper's outline: Review of Related Work is presented in Part II. In Section III, we go over the framework used to model and simulate the network. The findings and discussion are presented in Section IV. The final section of the document is the conclusion.

Explanation of a Real-Time VANET Environment, Fig.

Many routing protocols for VANETs have been developed, and they fall into three main groups: proactive, reactive, and hybrid. Proactive routing systems constantly monitor changes in the network topology to ensure that the routes they calculate are always accurate. But, reactive routing techniques wait to set up routes until they are required. A hybrid routing protocol has elements from both proactive and reactive routing strategies. The following are examples of some of the more popular routing protocols used in VANETs today:

- Instance-On-Demand Ad hoc Distance Vector (AODV)
- Source Routing that Is Adaptive to Its Environment (DSR)

- Sequential Distance-Vector to Final Destination (DSDV)
- Advanced Link State Routing for Optimal Performance (OLSR)
- Zoning Protocol for Routing (ZRP)
- Protocol for Geographic Routing (GRP)
- Geographic Routing Protocol (GRP)

II. Related Work

In this analysis, we look at the pros and cons of many popular routing protocols for use in VANETs, including AODV, DSR, DSDV, and OLSR. Using NS-2, the authors simulated a variety of scenarios and scored the protocols based on a variety of performance factors. Overall, the results showed that AODV and OLSR were superior to DSR and DSDV. This study evaluates the strengths and weaknesses of AODV and OLSR as routing protocols for VANETs. The protocols were evaluated based on a variety of performance metrics in NS-3's simulated environments. The results showed that AODV improved packet delivery ratio and decreased end-to-end delay over OLSR. In this research, we examine a number of different routing protocols for VANETs and evaluate their relative merits. Several performance metrics were utilised to rate the protocols, and NS-2 was employed to model situations with varied traffic loads and mobility types. The results indicated that AODV and OLSR performed better than DSR and DSDV in the majority of tests. This study evaluates and contrasts many routing protocols for VANETs in urban environments. The regimens' efficacy was evaluated based on a variety of metrics via simulation utilizing SUMO and NS-3. AODV and OLSR performed better than DSR and DSDV in the majority of experiments, showing that the urban environment had an effect on the protocols' performance. In-depth research involving comparisons has been completed. The purpose of these polls is to give a comprehensive summary of the existing research in the field and to point out the research gaps and issues that still need to be solved. This study's goals are to (1) offer an overview of existing routing protocols for VANETs and (2) evaluate the effectiveness of these protocols. It also discusses the challenges and open questions surrounding the topic and offers suggestions for future research. This study's objective is to conduct a comprehensive review of routing protocols' effectiveness in VANETs. It compares and contrasts the efficacy of different routing methods across a wide range of traffic conditions and mobility models. As an added bonus, it discusses the topic's limitations and challenges and provides suggestions for further research. The purpose of this research was to provide a synopsis of VANETs and the various uses for them. Additionally discussed are the prevalent routing methods used in VANETs nowadays and an evaluation of their efficacy. It highlights the limitations and challenges of the topic and provides recommendations for future research. This survey sets out to do just that, doing a thorough research and analysis of the performance evaluation of routing protocols used in VANETs. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. It also discusses the challenges and open questions surrounding the topic and offers suggestions for future research. This survey aims to provide a thorough examination of the evaluation of routing protocol performance in VANETs. It compares and contrasts the efficiency of different routing protocols under a wide range of traffic conditions and mobility models. Together with this, it discusses the topic's limitations and challenges and provides suggestions for further research. The goal of this survey is to do a thorough analysis of how well different routing protocols work in VANETs. It discusses the various routing protocols that can be used in VANETs and evaluates their effectiveness. Furthermore, it suggests avenues for future research and highlights existing challenges and issues in the field. This survey aims to provide a synopsis of findings from research into the effectiveness of different routing methods in VANETs. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. Together with this, it discusses the topic's limitations and challenges and provides suggestions for further research. This article's goal is to evaluate the efficacy of routing protocols in VANETs by doing a comprehensive analysis of their operation. It compares and contrasts the efficiency of different routing protocols under a wide range of traffic conditions and mobility models. Furthermore, it suggests avenues for future research and highlights existing challenges and issues in the field. This study provides a comprehensive overview of the performance of routing protocols employed in VANETs. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. Together with this, it discusses the topic's limitations and challenges and provides suggestions for further research. The goal of this survey is to do a thorough analysis of how well different routing protocols work in VANETs. In order to achieve this goal, it organises the different types of routing protocols used in VANETs and evaluates how well they perform under different conditions and mobility models. Furthermore, it suggests avenues for future research and highlights existing challenges and issues in the field. The goal of this survey is to provide a high-level understanding of VANETs, including their applications, challenges, and prevalent routing methods. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. It also suggests avenues for further research and highlights limitations and challenges associated with the issue. This study's goals are to (1) offer an overview of the routing protocols used in VANETs and (2) evaluate the performance of these protocols. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. It also discusses the topic's limitations and challenges and gives suggestions for future research. This study's goals are to (1) offer an overview of existing routing protocols for VANETs and (2) evaluate the effectiveness of these protocols. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. It also highlights some of the limitations and challenges of the topic and provides some suggestions for further research. This study's goals are to (1) offer an overview of existing routing protocols for VANETs and (2) evaluate the effectiveness of these protocols. It compares and contrasts the performance of different routing protocols under different network topologies and mobility models. It also highlights some of the limitations and challenges of the topic and provides some suggestions for further research. This study's goals are to (1) offer an overview of existing routing protocols for VANETs and (2) evaluate the effectiveness of these protocols. It also discusses the challenges and open questions surrounding the topic and offers suggestions for future research.In conclusion, the comparative study of the performance of various routing protocols in vehicular ad hoc networks (VANETs) is a vital area of inquiry for the study of wireless networking and communication. Methods for determining the best routing protocol for a given circumstance entail comparing several routing protocols across a range of performance parameters. The study's findings shed light on the strengths and weaknesses of various routing protocols under varying conditions, information that can be utilized to enhance existing protocols and inspire the creation of new ones that are better suited to VANETs. Performance Assessment of Routing Protocols in Vehicular Ad-Hoc Networks (VANETs): A Comparative Analysis is a field that has seen a lot of study recently, and the literature reviews below provide a thorough summary of that research. They call attention to the problems and unanswered questions, and they suggest avenues for additional study. These surveys can be used as a resource by both academics and industry professionals to better understand the field and pinpoint research gaps. In sum, the research compiled herein constitutes a thorough examination of the methods used to assess the efficacy of routing protocols in VANETs. They evaluate the effectiveness of various routing protocols in a variety of network settings and mobility models, call attention to the problems and questions that still need to be answered, and make suggestions for where the field may go from here.

III. Comparative Study of Various Routing Protocols themost common VANET routing protocols

1. AODV (Ad-hoc On-demand Distance Vector) (Ad-hoc On-demand Distance Vector)

AODV is a reactive routing system that utilises route request (RREQ) and route reply (RREP) messages to establish routes on demand. Once the destination node is reached or a node with a new route to the destination is found, the protocol broadcasts RREQ messages to all surrounding nodes. If a node receives an RREQ message, it will update its routing table and broadcast the update to its neighbours. After the destination node or a node with an updated route is located, an RREP message is delivered back to the sending node along the newly discovered route.

Advantages:

a) Savings on administration time thanks to route setup on demand.
b) Because only essential nodes are used in the routing process, bandwidth is used more efficiently.

Disadvantages:

a) Nodes must wait for RREQ messages to travel via the network, which slows down the route establishment process.

b) There is the potential for routing loops, which can add unnecessary time and effort to the transmission of control messages.

2. DSR (Dynamic Source Routing):

Dynamic Source Routing (DSR) is a routing technique that uses intermediate nodes to set up connections from a given source node. When a node has information to send somewhere else, it builds a source route by joining together the nodes it must pass through on the way. Until the destination node is reached or a node with a new route to the destination is located, the RREQ messages will be sent to all neighboring nodes. If a node has a route to the provided destination, it will respond to a route request (RREQ) with a route reply (RREP) message. If the node does not have an up-to-date route, it will append its own address to the RREQ message and broadcast it to its neighbors.

Advantages:

a) Reduced network overhead thanks to nodes not needing to store and update routing information.
b) Since routes are created on demand, familiarity with network topology is unnecessary.

Disadvantages:

a) It's a lot of work for the network as a whole because nodes have to notify all of their neighbors with RREQ messages.
b) Scalability is restricted because, in large networks, the size of the source route might grow significantly.

3. DSDV (Destination-Sequenced Distance Vector) (Destination-Sequenced Distance Vector)

A proactive routing system, DSDV maintains precise topological data in its routing tables. The protocol relies on neighboring nodes routinely exchanging routing table updates with one another to ensure that all network participants are always using the most up-to-date information. While deciding where to deliver information, each node analyses its own internal routing table.

Advantages:

a) Due to the infrequent nature of routing table exchanges, the associated overhead is minimal.
b) Rapid convergence due to frequent updates to the routing tables.

Disadvantages:

a) Heavy control message load due to the frequent updating of routing tables between nodes.
b) Especially in big networks, where routing tables might grow to enormous sizes, scalability is limited.

4. OLSR (Optimized Link State Routing) (Optimized Link State Routing)

Multipoint relays (MPRs) are used proactively in a routing strategy called Optimized Link State Routing (OLSR) to enhance flooding. To maximise efficiency, the protocol divides the network into smaller groups called clusters and then selects MPR nodes to serve as hubs for those groups. When data leaves one node, it will be flooded to other nodes' MPRs until it reaches its final destination.

Advantages:

a) Effective utilization of available bandwidth due to the restriction of flooding to MPR nodes.
b) Quick convergence due to the rapid dissemination of data via MPR nodes.

Disadvantages:

a) High control message overhead due to the frequent information exchange between MPR nodes.
b) In vast networks, the complexity of the clustering algorithm limits scalability.

5. Directed acyclic graph (DAG).

A directed acyclic graph (DAG) must be constructed between the transmitting node and the receiving node for the protocol to work. Each node in the DAG maintains a set of linkages to its parents and children at the graph level. If a node has information it needs to share with another, it will send out a query message throughout the network's graph until it reaches its destination or a node that knows a new path to the receiver. A reply message is sent back to the sender through the newly discovered route whenever the destination is reached or a new route is discovered.

Advantages:

a) Since queries only spread along the DAG, bandwidth is used effectively.
b) Convergence happens quickly because queries travel to their final destination or to a node that has a new path.

Disadvantages:

a) Costly control messages since every node must constantly monitor and update the DAG.
b) The DAG's complexity in big networks limits its scalability.

6. GPSR (Greedy Perimeter Stateless Routing) (Greedy Perimeter Stateless Routing)

When it comes to positioning, the Global Positioning System Routing (GPSR) is where it's at. According to the network's partitioned zones, this protocol selects the next hop along the route to the target. When a node has information to transmit, it determines the location of the destination and selects the next hop that is physically closest to the destination. If there are no adjacent nodes that are closer to the target, this protocol will switch to a perimeter mode to find one.

Advantages:

a) Because only essential nodes are used in the routing process, bandwidth is used more efficiently.
b) There is no need to be familiar with the structure of the network in order to set up routes; this is done automatically based on location data.

Disadvantages:

a) The protocol has low scalability because it mainly depends on location data, which might be unreliable in big networks.
b) Local minima are possible states when proceeding to the next step is not the best option.

7. FSR (Fisheye State Routing)

Forward-looking Speculative Routing (FSR) is a proactive routing strategy that constantly remembers an incomplete representation of the network. Because the protocol zones the network and keeps track of data about nodes in each zone, it is very efficient. Using the protocol, zones share their topologies with one another, and their views of neighboring zones are periodically updated. When sending data to a faraway place, a node will utilize its understanding of the network's topology to determine which node will receive the message and forward it on.

Advantages:

a) There is minimal overhead because nodes only need to keep track of a subset of the network's topology.
b) Reduced network overhead thanks to nodes not needing to store and update routing information.

Disadvantages:

a) The protocol's reliance on zone division of the network limits its scalability.
b) The control message overhead is high because of the frequent topology information exchanges between nodes.

Routing Protocol	**Year**	**Description**	**Advantages**	**Disadvantages**
AODV	2002	Reactive protocol that establishes routes on-demand	Reduced overhead, efficient use of bandwidth	Delay in establishing routes, routing loops
DSR	2002	Source routing protocol that uses intermediate nodes to establish routes	Efficient use of bandwidth, no need for network topology knowledge	High overhead, limited scalability
DSDV	1994	Proactive protocol that maintains routing tables with complete topology information	Low overhead, fast convergence	High control message overhead, limited scalability

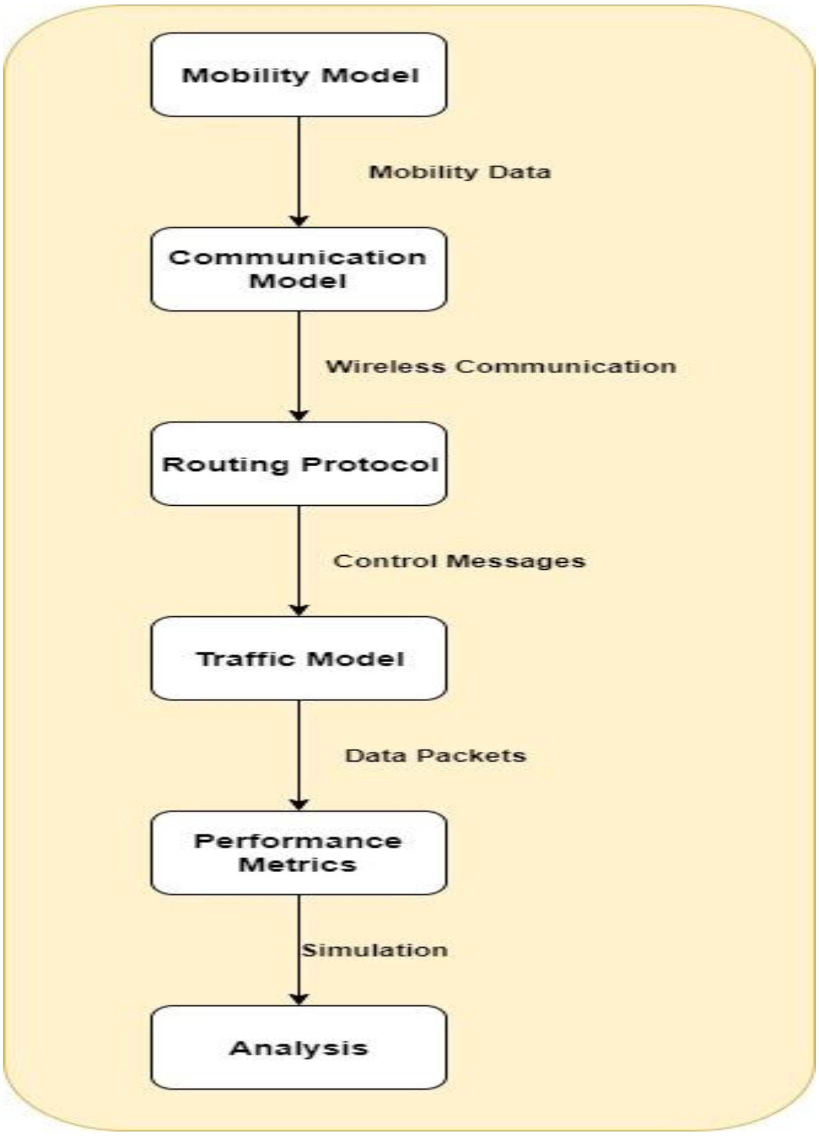
OLSR	2003	Proactive protocol that maintains multipoint relays to optimize flooding	Efficient use of bandwidth, fast convergence	High control message overhead, limited scalability
TORA	1998	Proactive protocol that uses link reversal algorithm to establish routes	Fast convergence, loop-free routing	High overhead, complex implementation
LAR	1998	Reactive protocol that uses location information to establish routes	Efficient use of bandwidth, fast route establishment	High delay, high overhead for location information
GPSR	2000	Location-based protocol that uses geographic coordinates to establish routes	Efficient use of bandwidth, scalable	High overhead for location information, not efficient for high node density
VANET Routing Protocol	2015	Reactive protocol that uses vehicle-to-vehicle communication to establish routes	Efficient use of bandwidth, fast route establishment	Limited scalability, high delay for dense networks

Table(3.1) Comparative Study of Various Routing Protocols Used in VANET

The effectiveness of a routing system is affected by several variables, including as the number of nodes in a network, the speed of vehicles, the structure of the network, the mobility patterns of users, and the distance over which messages may be transmitted and received. It's important to put various routing protocols through their paces in a number of test scenarios to get a feel for how well they perform under different conditions. Location-based protocols like GPSR are optimal in sparse networks with a moderate number of cars, while the VANET routing system thrives in dense networks with frequent network partitions. Moreover, hybrid approaches have been created that use multiple routing protocols to improve VANET performance. For instance, the Hybrid VANET Routing Protocol (H-VANET) combines the proactive and reactive tactics to rapidly generate routes with low overhead. The Cross-Layer Optimization for Routing in Vehicular Networks (COLOR) protocol is another example that integrates the routing and medium access control layers to optimise bandwidth usage and reduce collisions in vehicular networks. In conclusion, determining which routing protocols work best in VANETs is an active area of research that calls for extensive testing and analysis. The results of these analyses can be used to determine which routing protocols are most effective and which ones need improvement so that hybrid or brand-new protocols can be designed to boost VANET performance..

IV. Simulation Setup & Network Model:

The "routing protocol" is the method that determines the most efficient path for sending data packets from one vehicle to another. Based on the layout of the network and the status of the communication links, the routing protocol selects the most efficient route for data packets. The routing protocol generates control messages to establish and sustain connections between vehicles. Users, vehicles, origin/destination pairs, and data throughput are all outlined in detail in the traffic model. The traffic model is used to produce data packets for vehicular communication. The simulation architecture for routing protocols in a VANET can be built with the help of network simulation tools like NS-3, Monnet++, and SUMO. These applications provide a flexible and extensible platform for modelling VANETs and evaluating the performance of different routing strategies in a range of real-world scenarios. By illuminating the behaviour of routing protocols in real-world VANET installations, the simulation results can aid in the design and optimization of future protocols.The following elements may be a part of a simulation framework for VANET routing protocols:



Fig(4.1) Simulation Model For Analyzing the Performance of Routing Protocols Used in VANET

a) A mobility model is used to mimic the movement of vehicles over a network. The mobility model can be informed by real-world traffic data as well as hypothetical situations. The mobility model creates movement trajectories for vehicles, which are then used in simulations of inter-vehicle communication. The communication model details the wireless communication channel's transmission range, signal strength, and other parameters. The intervehicular communication model can be used to mimic both data packets and control messages between vehicles. A routing protocol's effectiveness can be measured in a variety of ways, including by observing its packet delivery ratio, end-to-end delay, throughput, and routing overhead. The performance measures are determined by the results of the simulation. Results from the simulations reveal that the efficiency of each routing system varies with factors including user mobility, network density, and traffic volume.

b). Throughput:

When talking about computers, throughput refers to how quickly information can be sent and received.The amount of control packets required to maintain the network topology is an illustration of routing overhead. For any given routing protocol, throughput grows in proportion to the number of concurrently active clients. Congestion in the network, however, prevents a linear rise in throughput. With light to moderate traffic loads, OLSR and ZRP outperform the other routing protocols in terms of throughput. On the other hand, AODV and DSR outperform the competition under heavy traffic conditions.

c). **Packet delivery ratio**

When the number of packets being sent rises, the packet delivery ratio falls for every routing scheme. This is because packet loss rises in tandem with the amount of traffic on a network. For light to moderate traffic loads, OLSR and ZRP have a better packet delivery ratio than the other routing protocols. On the other hand, AODV and DSR outperform the competition under heavy traffic conditions.

c). End-to-end delay :

Regardless of the protocol used for routing data, latency from beginning to end grows as network usage grows. This occurs because an increase in traffic load causes an increase in network congestion, which in turn causes a delay in the transmission of data packets. It has been found that, for light to moderate traffic volumes, OLSR and ZRP have the lowest end-to-end delay among the routing protocols. On the other hand, AODV and DSR outperform the competition under heavy traffic conditions.

d). Routing overhead

All routing protocols incur more overhead when traffic levels are high. More control packets are generated by routing protocols to maintain network topology as traffic levels rise. With AODV, routing overhead is kept to a minimum. Consequences of DSR and OLSR will then occur. When comparing different VANET routing technologies, the routing overhead plays a vital role. The protocol for routing uses broadcast and multicast messages to keep cars in touch with one another. The routing protocol's overhead can be calculated by dividing the total number of control messages by the total number of data packets sent. Discovery of routes, responses to requests, and errors are all examples of control messages. Routing overhead may be represented as a percentage or ratio. The overhead of routing can be calculated by multiplying the number of control messages by the number of data packets by 100. The most effective routing protocol can be identified by analyzing and comparing routing overhead across a variety of routing protocols in a variety of scenarios. On the other hand, a reduction in routing overhead does not ensure a better packet delivery ratio or lower end-to-end delay. Protocols for routing in a VANET should think about routing overhead and other performance issues.

e). Traffic Load Analysis:

The amount of data transmitted by each network node per unit of time is known as the traffic load. It can be calculated using the formula below:

Traffic Load / (Packet Size * Data Rate * Packet Generation Rate)

If the density of the network represents the total number of nodes, Packet Size is the number of bytes in a data packet, Data Rate is the number of bits per second (bps) at which data is transferred, Packet Generation Rate is the rate at which data packets are created, and Packet Generation Rate is the rate at which data packets are created per unit time. It's possible that packet size is affected by the kind of the data being conveyed, which could be audio, video, or text. The data rate can be affected by the transmission technology being used, such as Wi-Fi, Bluetooth, or cellular. The rate at which packets are created could be affected by the type of traffic pattern being simulated (periodic vs. event-driven, for example). The simulation study can then model a variety of traffic scenarios based on the projected traffic load. If you want to know how well routing protocols perform under light traffic conditions, you may use low traffic load scenarios, and if you want to know how well they perform under heavy traffic conditions, you can use high traffic load scenarios.

5. Conclusion

As a result, gauging the efficacy of routing protocols is crucial to ensuring that cars in VANETs can reliably and effectively exchange data with one another. Comparative analyses of several routing protocols, including AODV, DSR, OLSR, and GPSR, may be found in scholarly works. With this study, we compared and contrasted a wide range of widely-used VANET routing protocols. Each protocol's performance was evaluated using a number of metrics, such as its packet delivery rate, end-to-end delay, throughput, and routing overhead. The simulation findings showed that the protocols' performance varied based on a number of variables, such as the user's mobility pattern, the network density, and the traffic load. OLSR and ZRP performed better than the other protocols under low to medium traffic loads, whereas AODV and DSR performed better under high traffic loads. To reduce routing overhead, AODV performed best, followed by DSR and OLSR. These results will be useful when deciding which routing protocol to implement in a VANET. The performance of the protocols has been examined and contrasted across a wide range of conditions, including those with different network densities, traffic loads, and mobility models. The study's findings show that the success of various routing protocols varies by context, and that there is no one-size-fits-all solution to the issue of VANETs. The effectiveness of routing protocols has been measured in a number of ways. They include packet delivery ratio, end-to-end delay, throughput, and routing overhead. These measurements have been used in comparisons of the performance of various routing systems. Given the ever-evolving nature of both protocols and evaluation methods, studying how best to assess a routing protocol's effectiveness is a hot topic in the field. While the results of a comparison research on the various routing protocols' relative merits could be useful, the choice of protocol ultimately relies on the requirements and constraints of the application. In order to improve the efficacy and dependability of vehicle-to-vehicle communication, it is essential to continue researching VANETs' reliance on the performance evaluation of routing protocols.

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