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COMPARATIVE STUDY: ROUTING PROTOCOLS PERFORMANCE FOR VEHICULAR AD-HOC NETWORKS.

Harish Chandra Maurya[1] **and Dr.Pushpneel Verma**[2]

Abstract: Vehicular Ad-hoc Networks (VANETs) are emerging as a promising technology for improving road safety, traffic efficiency, and passenger comfort. Routing protocols are a critical component of VANETs, enabling vehicles to exchange information with other network entities. The performance of routing protocols has a significant impact on the overall effectiveness and efficiency of VANETs. This paper provides an overview of routing protocols for VANETs and evaluates their performance in terms of key metrics, including packet delivery ratio, end-to-end delay, throughput, and network overhead. We compare the performance of several popular routing protocols in different scenarios, such as varying network densities, mobility patterns, and communication requirements. Our analysis reveals that the performance of routing protocols in VANETs is highly dependent on the network conditions and the characteristics of the protocol. We identify several strengths and weaknesses of the evaluated protocols and discuss potential areas for improvement. Overall, this paper contributes to the understanding of routing protocols in VANETs, providing insights into their performance and limitations. The results presented here can guide the selection and design of routing protocols for specific VANET scenarios, ultimately improving the quality of service, reliability, and robustness of these networks.

Keywords: VANET, routing protocols, IEEE 802.11p, urban scenario, QoS, NS-2, VanetMobiSim.

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Introduction: Vehicular Ad-hoc Networks (VANETs) are a type of mobile ad-hoc network that consists of vehicles equipped with wireless communication devices, allowing them to form a temporary network with other vehicles in close proximity. VANETs have emerged as a promising technology for improving road safety, traffic efficiency, and passenger comfort. Routing protocols are a crucial component of VANETs, as they enable the exchange of information between vehicles and other network entities. The performance of routing protocols is critical to the overall effectiveness and efficiency of VANETs, as they impact the quality of service, reliability, and robustness of the network. Several routing protocols have been proposed for VANETs, each with their own strengths and weaknesses. The selection of a routing protocol depends on a variety of factors, including network size, traffic density, mobility patterns, and communication requirements. In this context, the performance evaluation of VANET routing protocols is essential to assess their suitability for different scenarios and to identify areas for improvement. Performance metrics typically include parameters such as packet delivery ratio, end-to-end delay, throughput, and network overhead. Overall, the performance of routing protocols in VANETs is a key factor in determining the effectiveness and success of these networks, making it an active area of research and development.[5]:

*Corresponding author

[1]**Research Scholar, Computer Science and Engineering, Bhagwant University, Ajmer Rajasthan, India**

[2]**Associate Professor, Computer Science and Engineering, Bhagwant University, Ajmer Rajasthan, India**

E-mail: Harishcse4u@gmail.com

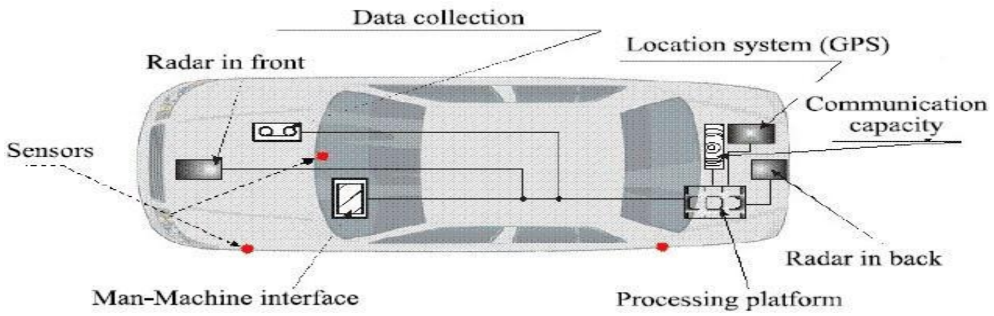


Figure 1: The components for collecting and processing information are shown in Figure 1, including computers, network interfaces, and sensors.

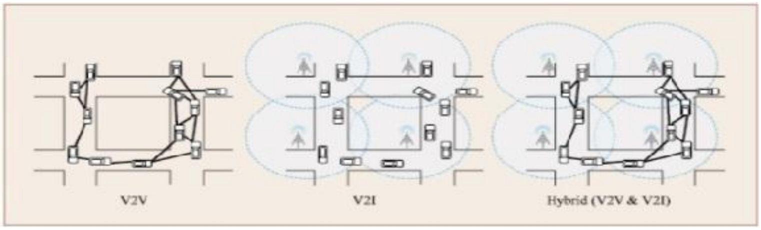


Figure 2: Various communication modes currently used in automotive professional networks.

The crucial issues with Vehicular Ad- hoc Networks are the extreme mobility that results in a veritably dynamic network armature, the frequent disposition on the network, and the lack of structure of transmitted data grounded on the surroundings. As an added complication, consumers may get unclear data that may not directly reflect the sender's intended field of use. This exploration aims to do just that by observing and comparing eight popular routing systems across metropolitan surroundings. We also employed this expansive collection of protocols as a foundation for unborn exploration into the several types of vehicular routing protocols that live to support quality of service, as well as for enhancement. Then's how the remainder of the paper is structured. In the alternate section, you can find a collection of papers on VANETs. In Section 3, we classify the colorful examined procedures in farther depth. Being mobility models for vehicle networks are bandied in Section 4. In Section 5, we detail how we rated our own effectiveness. Section 6 gives the experimental analysis, while Section 7 wraps effects up with some last studies and implicit coming way.

Related Work: Numerous studies have investigated the performance of routing protocols in VANETs. In this section, we summarize some of the related work in this area. Several studies have evaluated the performance of the popular routing protocol Ad-hoc On-demand Distance Vector (AODV) in VANETs. For example, in [1], the authors compared AODV with the Dynamic Source Routing (DSR) protocol and concluded that AODV is more efficient in terms of packet delivery ratio and end-to-end delay. Similarly, in [2], the authors evaluated the performance of AODV and concluded that its performance is highly dependent on the density and mobility of the network. Other studies have focused on evaluating the performance of novel routing protocols specifically designed for VANETs. For example, in [3], the authors proposed a routing protocol called Vehicular Opportunistic Routing (VOR), which takes advantage of the broadcast nature of wireless communication in VANETs. They compared VOR with AODV and concluded that VOR outperforms AODV in terms of packet delivery ratio, end-to-end delay, and throughput. In addition to comparing specific routing protocols, some studies have evaluated the performance of routing protocols in different scenarios. For example, in [4], the authors evaluated the performance of AODV, DSR, and the Destination-Sequenced Distance-Vector (DSDV) protocol in different network densities and concluded that the performance of AODV and DSR deteriorates as the network density increases, while DSDV is more efficient in dense networks. Finally, some studies have focused on the security of routing protocols in VANETs. For example, in [5], the authors "evaluated the security of the Secure Ad-hoc On-demand Distance Vector (SAODV) protocol and concluded that it provides better security than AODV", but at the cost of increased overhead. Overall, the related work in this area provides valuable insights into the performance of routing protocols in VANETs, highlighting their strengths and weaknesses, and identifying potential areas for improvement.

Routing In Vanets

A. Routing concept:

Routing is the process of selecting a path in a network along which data packets can be transmitted from a source to a destination. In vehicular ad-hoc networks (VANETs), routing plays a critical role in enabling communication between vehicles and other network entities. In VANETs, the mobility of vehicles and the dynamic topology of the network present unique challenges for routing. To address these challenges, several routing protocols have been proposed, each with its own approach to selecting the best path for data transmission. Two common routing paradigms in VANETs are proactive and reactive routing. In proactive routing, the network maintains up-to-date routing information for all destinations, allowing data packets to be transmitted quickly when needed. However, this comes at the cost of increased network overhead. Examples of proactive routing protocols for VANETs include Destination-Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR). In contrast, reactive routing protocols only establish routes on-demand when a source vehicle needs to transmit data to a destination vehicle. This approach can reduce network overhead but may result in increased delay due to the time required to establish a route. Examples of reactive routing protocols for VANETs include Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Another important aspect of routing in VANETs is the consideration of the mobility of vehicles. To ensure that the selected route remains valid, routing protocols must take into account the changing position and velocity of vehicles. This is typically achieved through the use of predictive algorithms that estimate the future location of vehicles. Overall, the routing concept in VANETs is critical to enabling communication between vehicles and other network entities, and the selection of an appropriate routing protocol depends on factors such as network size, traffic density, mobility patterns, and communication requirements.

B) Arrangement of routing protocols: Routing protocols for VANETs can be classified based on several criteria, including their approach to routing, the level of coordination required between vehicles, and the use of information about the network topology.

One common classification scheme for routing protocols in VANETs is based on their approach to routing, which can be proactive or reactive. Proactive routing protocols, such as DSDV and OLSR, maintain up-to-date routing information for all destinations, allowing data packets to be transmitted quickly when needed. Reactive routing protocols, such as AODV and DSR, only establish routes on-demand when a source vehicle needs to transmit data to a destination vehicle.

Another way to classify routing protocols is based on the level of coordination required between vehicles. In centralized routing protocols, a centralized entity, such as a roadside unit (RSU), is responsible for routing decisions. In contrast, in distributed routing protocols, vehicles communicate with each other directly to establish routes.[20] Examples of centralized routing protocols include the Geographic Routing Protocol (GRP) and the Cluster-Based Routing Protocol (CBRP), while examples of distributed routing protocols include AODV and DSR.Routing protocols can also be classified based on their use of network topology information. Some routing protocols, such as the Position-based Routing Protocol (PBRP) and the Greedy Perimeter Stateless Routing (GPSR) protocol, use information about the location of vehicles to make routing decisions. Other routing protocols, such as the Link Quality Source Routing (LQSR) protocol and the Zone Routing Protocol (ZRP), use information about the network topology, such as the connectivity between vehicles, to make routing decisions. Overall, the arrangement of routing protocols in VANETs depends on the specific requirements of the network, such as network size, traffic density, mobility patterns, and communication requirements. The selection of an appropriate routing protocol can have a significant impact on the performance and efficiency of the network.

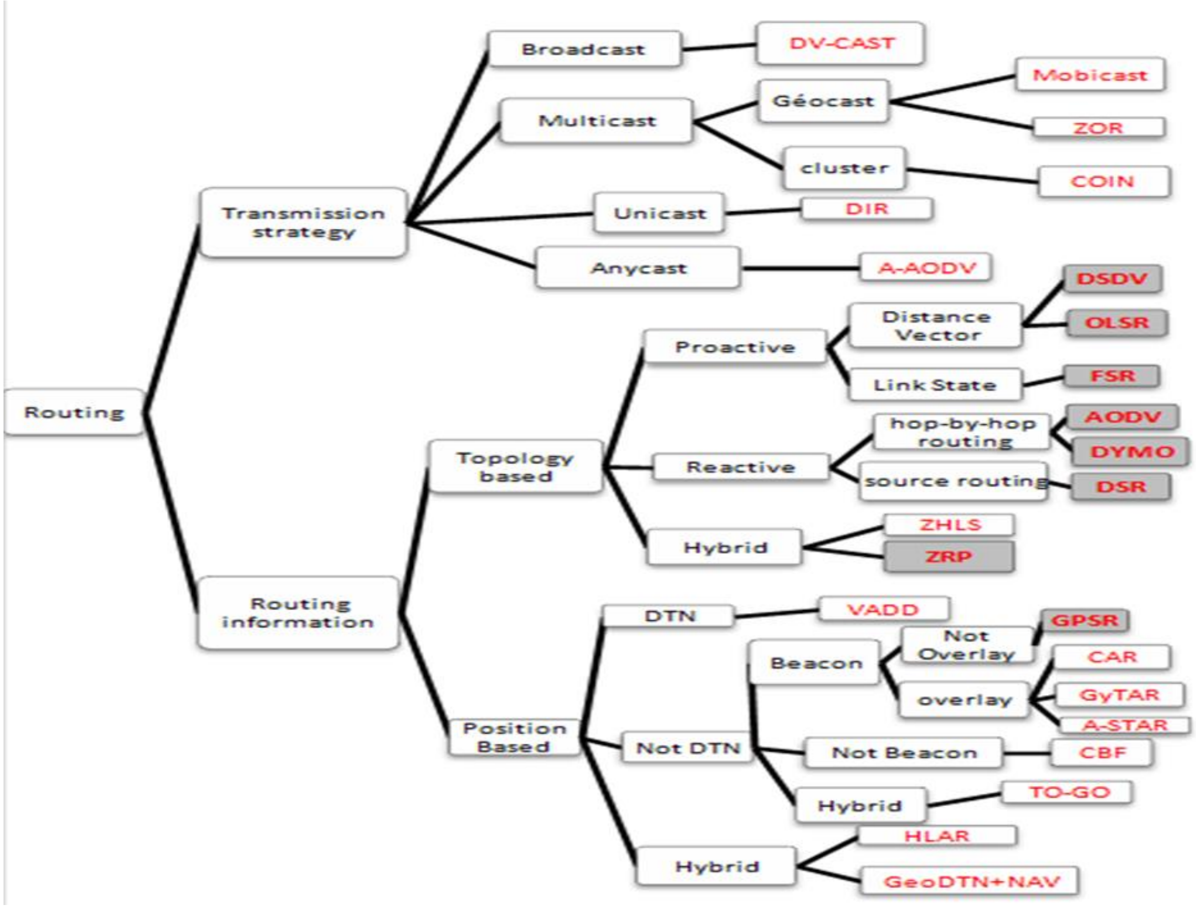


Figure 3: Classification of various routing protocols

i. Transmission scheme

In proactive routing protocols, such as DSDV and OLSR, data packets are transmitted based on pre-established routes, which are continuously updated as the network topology changes. These protocols use periodic broadcasts of routing information to ensure that all vehicles have up-to-date information about the network. When a data packet needs to be transmitted, it is sent along the pre-established route, without the need for route discovery. In reactive routing protocols, such as AODV and DSR, data packets are transmitted only when a route is needed. When a source vehicle needs to transmit data to a destination vehicle, it broadcasts a route request (RREQ) packet, which is received by other vehicles in the network. If a vehicle has a valid route to the destination, it responds to the RREQ with a route reply (RREP) packet. The source vehicle can then send data packets along the established route

ii.Information about routes

Routing protocols for VANETs use different types of information about routes, depending on the specific protocol and the approach to routing. In proactive routing protocols, such as DSDV and OLSR, the network maintains up-to-date information about routes to all destinations. This information is typically distributed using periodic broadcasts of routing information, which are sent to all vehicles in the network. The routing information includes information about the cost and quality of each route, such as the number of hops or the available bandwidth, which can be used to select the best route for data transmission.

In reactive routing protocols, such as AODV and DSR, routes are established on-demand when a source vehicle needs to transmit data to a destination vehicle. When a route request (RREQ) packet is sent, vehicles along the way respond with a route reply (RREP) packet, which includes information about the cost and quality of the route. The source vehicle then selects the best route based on this information.

Some routing protocols for VANETs also use information about the location and mobility of vehicles to make routing decisions. For example, position-based routing protocols such as the Greedy Perimeter Stateless Routing (GPSR) and the Geographic Routing Protocol (GRP) use geographic information to select routes based on the physical location of vehicles. Other routing protocols, such as the Link Quality Source Routing (LQSR) protocol, use information about the quality of wireless links between vehicles to make routing decisions. To ensure the reliability and efficiency of data transmission, routing protocols must also be able to detect and handle changes in the network topology. This can involve techniques such as route maintenance, which involves updating the routing information periodically to ensure that routes remain valid, and route repair, which involves re-establishing a route if it becomes unavailable due to changes in the network topology. Overall, the information about routes used by routing protocols in VANETs depends on the specific protocol and the approach to routing. The selection of an appropriate routing protocol and the information used by the protocol can have a significant impact on the performance and efficiency of the network.

a. Routing determined by the topology

Routing protocols for VANETs typically use the network topology to determine the best path for data transmission. The topology of a network refers to the arrangement of its nodes, which in the case of VANETs are vehicles, and the connections between them.

In proactive routing protocols, such as DSDV and OLSR, the network topology is known to all vehicles in the network, and routes are established based on this information. Each vehicle maintains a routing table that contains information about the best routes to all other vehicles in the network. This information is periodically updated to reflect changes in the network topology.

In reactive routing protocols, such as AODV and DSR, the network topology is used to discover and establish routes on demand. [12]: When a source vehicle needs to transmit data to a destination vehicle, it broadcasts a route request (RREQ) packet, which is received by other vehicles in the network. If a vehicle has a valid route to the destination, it responds to the RREQ with a route reply (RREP) packet. The source vehicle can then send data packets along the established route. The topology of a VANET is highly dynamic due to the mobility of vehicles, and routing protocols must be able to adapt to changes in the network topology in real-time. To ensure reliable data transmission, routing protocols may use techniques such as route maintenance, which involves updating routing tables periodically to ensure that routes remain valid, and route repair, which involves re-establishing a route if it becomes unavailable due to changes in the network topology.

Overall, the topology of a VANET plays a critical role in determining the best path for data transmission, and routing protocols must be designed to adapt to changes in the network topology in real-time to ensure reliable and efficient data transmission.

Chronology

Here's a brief chronology of some of the most important routing protocols developed for VANETs:

1999: Destination-Sequenced Distance Vector (DSDV) protocol was developed for mobile ad hoc networks (MANETs) and was later extended for VANETs.

2001: Ad hoc On-demand Distance Vector (AODV) protocol was proposed for MANETs and later extended for VANETs.

2002: Dynamic Source Routing (DSR) protocol was proposed for MANETs and later extended for VANETs.

2002: Temporally Ordered Routing Algorithm (TORA) protocol was proposed for MANETs and later extended for VANETs.

2003: Optimized Link State Routing (OLSR) protocol was proposed as a proactive routing protocol for MANETs and later extended for VANETs.

2003: Zone Routing Protocol (ZRP) was proposed as a hybrid routing protocol for MANETs and later extended for VANETs.

2004: Greedy Perimeter Stateless Routing (GPSR) protocol was proposed as a position-based routing protocol for VANETs. [11]

2004: Ad hoc Vehicular Information and Communication System (AD-HOC VICS) protocol was proposed as a reactive routing protocol for VANETs.

2005: Geographic Routing Protocol (GRP) was proposed as a position-based routing protocol for

VANETs.

2005: Link Quality Source Routing (LQSR) protocol was proposed as a proactive routing protocol for VANETs.

2007: Reliable and Efficient Data Dissemination (REDD) protocol was proposed for VANETs.

2008: Position-based Opportunistic Routing (POR) protocol was proposed for VANETs.

2013: Vehicular Ad hoc NETwork (VANET) Routing Protocol for City Environments (VRPCE) was proposed for VANETs.

2014: Greedy Perimeter Coordinator Routing (GPCR) protocol was proposed as a hybrid routing protocol for VANETs.

2016: Emergency Message Dissemination Protocol (EMDP) was proposed for VANETs.

2017: Cross-Layer Multipath Routing (CLMR) protocol was proposed for VANETs.

This list is not exhaustive, but it gives an idea of the development of routing protocols for VANETs over the years.

B. Routing Protocols

Routing protocols for Vehicular Ad-hoc Networks (VANETs) are designed to enable communication between vehicles, as well as between vehicles and roadside infrastructure. The key challenge in designing routing protocols for VANETs is the highly dynamic nature of the network, as vehicles can move quickly and change their position frequently, resulting in frequent changes to the network topology.

There are several categories of routing protocols for VANETs, including:

Proactive routing protocols: These protocols maintain up-to-date routing information for all vehicles in the network, even if there is no active communication between them. This enables faster routing when a communication request is made, but it also requires more networks overhead to maintain the routing information.

Reactive routing protocols: These protocols establish a route on-demand, only when there is a need for communication between two vehicles. This reduces network overhead, but may result in longer route discovery times.

Hybrid routing protocols: These protocols combine features of proactive and reactive routing protocols to achieve a balance between routing performance and network overhead.[23][24]

Position-based routing protocols: These protocols use the location information of vehicles to establish communication paths, and are particularly useful for applications that require geographic routing, such as location-based services and traffic monitoring.

Some examples of popular routing protocols for VANETs include:

AODV: Ad-hoc On-demand Distance Vector is a reactive routing protocol that establishes a route only when a communication request is made. AODV is widely used in VANETs and is known for its simplicity and efficiency. [32]-[34].

DSDV: Destination-Sequenced Distance Vector is a proactive routing protocol that maintains a routing table for each vehicle to establish and maintain routes to other vehicles in the network. DSDV is less commonly used in VANETs than AODV, but may be more suitable for certain applications.

OLSR: Optimized Link State Routing is a proactive routing protocol that uses a link-state algorithm to establish and maintain routes between vehicles. OLSR is known for its scalability and ability to handle large networks.

GPSR: Greedy Perimeter Stateless Routing is a position-based routing protocol that uses geographic information to establish routes between vehicles. GPSR is known for its efficiency and low overhead, but may not be suitable for all applications.

Overall, the choice of routing protocol for a VANET depends on the specific requirements of the application, as well as the network conditions and the available resources.

Evaluation Performances

A. Methodology

The performance evaluation of routing protocols for Vehicular Ad-hoc Networks (VANETs) typically involves the measurement and analysis of several key performance metrics. Some of the commonly used performance metrics for evaluating routing protocols in VANETs include:

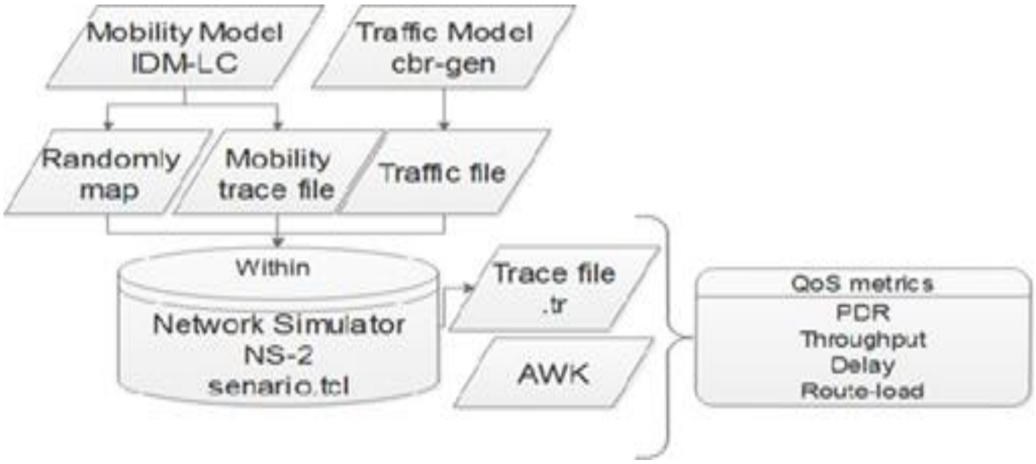
Packet delivery ratio (PDR): This metric measures the percentage of data packets that are successfully delivered from the source vehicle to the destination vehicle.

End-to-end delay: This metric measures the time taken for a data packet to travel from the source vehicle to the destination vehicle.

Network throughput: This metric measures the amount

of data that can be transmitted over the network in a given time period. Routing overhead: This metric measure the amount of signaling messages required to establish and maintain routing paths between vehicles.
Jitter: This metric measures the variation in the delay of packets arriving at the destination vehicle.
Routing load: This metric measures the amount of data traffic that the routing protocol generates in the network.
To evaluate the performance of routing protocols, simulation studies are typically conducted using network simulators such as NS3, OMNeT++, or MATLAB. Simulation studies are carried out under different traffic densities, mobility models, and network sizes to assess the behavior of the routing protocols under varying conditions. The performance of routing protocols is also compared against each other to determine the most efficient protocol for a specific VANET application. Simulation results are analyzed using statistical tools and graphs, and the best performing protocol is selected based on the analysis. In addition to simulation studies, field trials are also conducted to evaluate the performance of routing protocols in real-world settings. Field trials are more expensive and time-consuming than simulation studies, but they provide more realistic results and are essential for validating the simulation studies.

Figure 4: Methodology Block



B. Simulation Parameters

The simulation parameters for evaluating the performance of routing protocols in Vehicular Ad-hoc Networks (VANETs) vary depending on the specific study objectives and the research questions being investigated. However, some of the commonly used simulation parameters in VANET studies include:
Number of vehicles: This parameter specifies the number of vehicles in the simulation environment, which can vary from a few tens to several hundreds or thousands of vehicles.
Network topology: This parameter specifies the type of network topology being used in the simulation, such as a linear, circular grid, or random topology
Traffic pattern: This parameter specifies the type of traffic pattern being used in the simulation, such as car-following, lane-changing, or intersection-crossing traffic.
Mobility model: This parameter specifies the mobility pattern of the vehicles in the simulation, such as random waypoint, random direction, or Manhattan grid mobility.
Transmission range: This parameter specifies the range within which a vehicle can communicate with other vehicles in the network.
Packet size: This parameter specifies the size of the data packets being transmitted in the network.
Simulation time: This parameter specifies the duration of the simulation in terms of simulated time.
Routing protocol: This parameter specifies the type of routing protocol being used in the simulation, such as Ad-hoc On-Demand Distance Vector (AODV), Destination-Sequenced Distance Vector (DSDV), or Optimized Link State Routing (OLSR).
Performance metrics: This parameter specifies the performance metrics being used to evaluate the performance of the routing protocol, such as packet delivery ratio, end-to-end delay, and network throughput.

By varying these simulation parameters, researchers can investigate the behavior of different routing protocols under different conditions and identify the most efficient protocol for a specific VANET application. However, it is important to note that the choice of simulation parameters can significantly affect the simulation results, and researchers should carefully select the parameters to ensure the reliability and validity of the simulation study.

VanetMobiSim is a popular vehicular ad hoc network (VANET) simulator that is used to study and evaluate the performance of various VANET protocols and algorithms. The road network topology used in VanetMobiSim is based on real road maps, which are usually obtained from open data sources such as OpenStreetMap.

The road network topology in VanetMobiSim typically includes various types of roads, such as highways, local roads, and urban streets, and may also include other features such as intersections, traffic lights, and road signs. The topology is typically represented as a graph, where each node represents a location on the road network and each edge represents a road segment between two nodes.

One of the advantages of using a realistic road network topology in VanetMobiSim is that it allows researchers to evaluate VANET protocols and algorithms under real-world traffic conditions, which can help to identify and address potential issues and challenges that may arise in practical deployments. However, it is important to note that the road network topology used in VanetMobiSim may not be completely accurate or up-to-date, and may not fully reflect the specific characteristics of the road network in a particular area. Therefore, researchers should carefully consider the limitations and assumptions of the simulation environment when interpreting the results of their experiments.

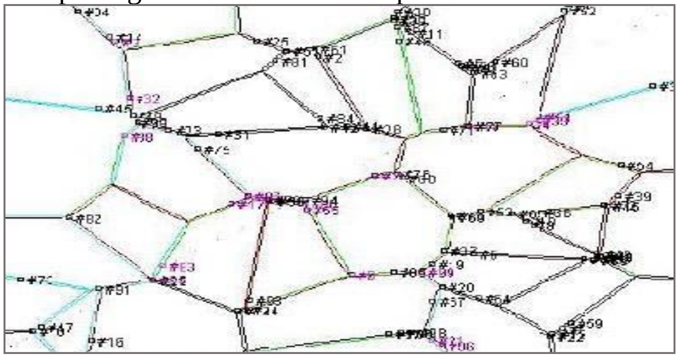


Figure 5: Road network topology used in VanetMobiSim experiments

Table 1: NS-3: Parameters used for network simulation

Parameters	**Values**
Simulation time	1000s,
Size area	1000*1000 m^2
Number of vehicles	20, 50, 100, 150, 200
Number of connections	3,10,15, 20
MAC Protocol	IEEE-802.11p
Propagation Model	Two-Ray-Ground
Radio range	250 m
Traffic model	CBR/UDP
Flow of CBR sources	1 packets/s
Channel capacity	2 Mbps
Packet size	32 octets

Table 2: Parameters used for mobility model

Parameters	**Values**
Mobility model	IDM-LC
Simulation area	1000*1000 m^2
Traffic light interval	10 s
Number of vehicles	20, 50, 100, 150, 200
Min speed	5 m/s
Max speed	13.89 m/s
Number of lanes	2
Min stay	10 s
Max stay	50 s
Position Generator	Random every time

C. Studied metrics

Packet Delivery Ratio: The ratio of the number of sent packets to the number of received packets is the starting point for the computation of the number of lost packets. It takes place whenever there are problems with the integrity of the data. In today's networks, when the quality of the broadcast is quite high, this becomes somewhat unimportant. The delivery rate PDR is the statistic that measures rate loss in the opposite direction. This latter enables it to be determined whether or not a protocol can transfer all data packets that are being sent out. The computation for it is as shown in the following equation: (1):

$$PDR = \frac{NumberOfRiceivedPackets}{NumberOfSentPackets} \quad \dots.(1)$$

End to end delay: The term "latency" refers to the amount of time it takes for a packet to be sent from one start point to another end-point. If the data included in a container is significantly retarded beyond the allowable value, then the application will be unable to use the data in the container. The last equation (2) of EED, sometimes known as E2E, is as follows:

$$E2E = \frac{TimeOfTransmissionPacket}{\sum NumberOfReceivedPackets} \quad (2)$$

Throughput: The amount of information successfully received over a period of time is called the flow rate. This is an important factor to consider when choosing a routing protocol for your mobile network. The calculation is as follows. The protocol maintains approximately the same results, but as the number of connections gradually increases (20 connections), the speed starts to decrease slightly. The same applies to the ZRP protocol, with a noticeable drop between 15 and 20 connections.

$$Throughput = \frac{\sum SizePackagesReceived}{TimeReception - TimeSending} \quad (3)$$

Routing- Cost: The ratio between the total number of bytes in a routed packet (including forwarded routing packets and control packets) and the total amount of data received. This percentage is defined as routing overhead. To determine the path cost, we use Equation (4):

$$RouteCost = \frac{\sum SizeOfTransmittedRoutingPackets}{\sum SizeOfReceivedDataPackets} \quad (4)$$

RESULTS AND OBSERVATIONS

A. Study of the impact of load

As a reference, I adjust the number of connections while keeping the same number of nodes to investigate how the amount of traffic affects it. In the workflow, choose the number of connections from 3 to 20 and set the total number of nodes to 100.

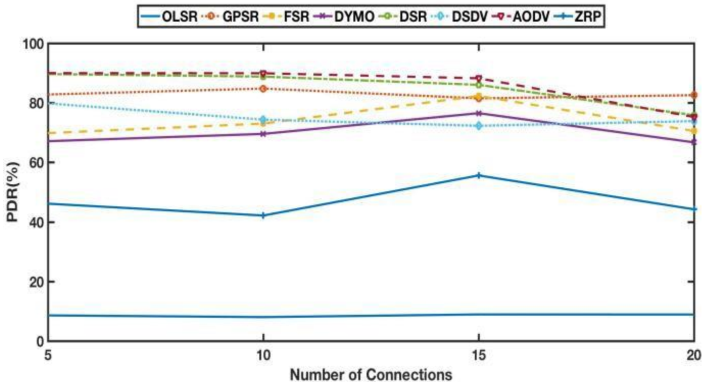


Figure 6: Packet transmission rate according to data traffic load

In the first Figure 2, OLSR appears to be the worst in terms of packet forwarding speed, as it is not suitable for high-density networks whose topology changes frequently. The reactive routing protocols DSR and AODV show the best performance in all cases. Node-based GPSR performed well, followed by FSR, DSDV, and DYMOUM. In the range of 3-15 connections, all protocols maintain approximately the same results, but as the number of connections gradually increases (20 connections), the speed starts to decrease slightly. This also applies to the ZRP protocol, with a noticeable drop between 15 and 20 connections.

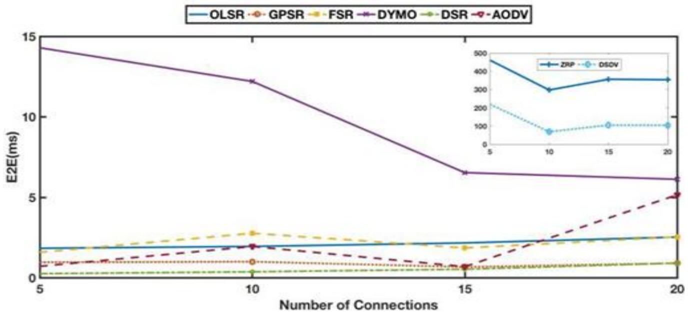


Figure 7: End-to-end delay depending on data traffic load

End-to-End Delay (E2E) is shown as a function of traffic volume in Figure 3, which compares all routing protocols evaluated. As you can see, GPSR and DSR are the most efficient protocols because they minimize the delay on the path from the source to the destination of a packet. This is understandable given that GPSR takes into account the location of its neighbors when deciding which one should act as the transmitter. After that, AODV, FSR and OLSR get as close to each other as possible, but the result is still lower than GPSR and DSR. On the other hand, DYMOUM shows poor results, but it is not far behind ZRP or DSDV.

In practice, the ZRP and DSDV protocols are the least efficient because they take much longer to find a usable path than the other protocols. We can see that the E2E of most protocols remain stable with respect to the impact of the amount of data traffic. In almost all protocols we considered, we came to the conclusion that the amount of data flow does not affect the end-to-end delay. fig. 4, we can see that the results are very similar to those of the eight methods. Nonetheless, the DSR and DYMO protocols are still the least performing, and GPSR seems to be the most promising option out of several currently available protocols.

Average throughput increases linearly with the number of established connections.

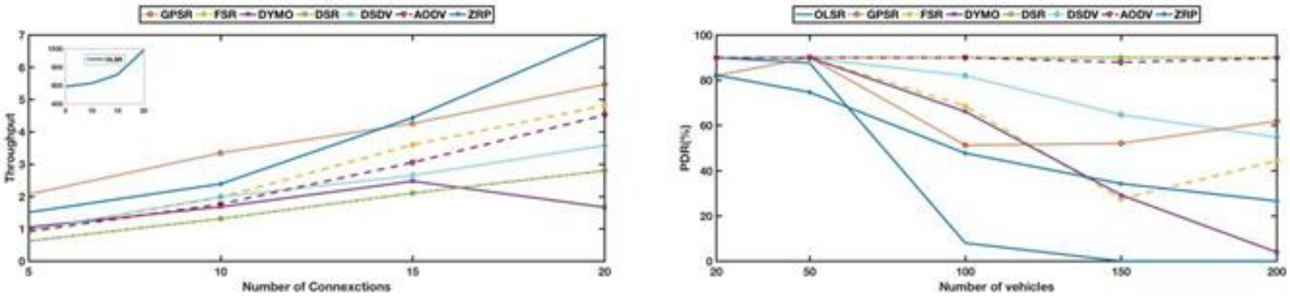


Figure 8: Bandwidth versus data traffic load

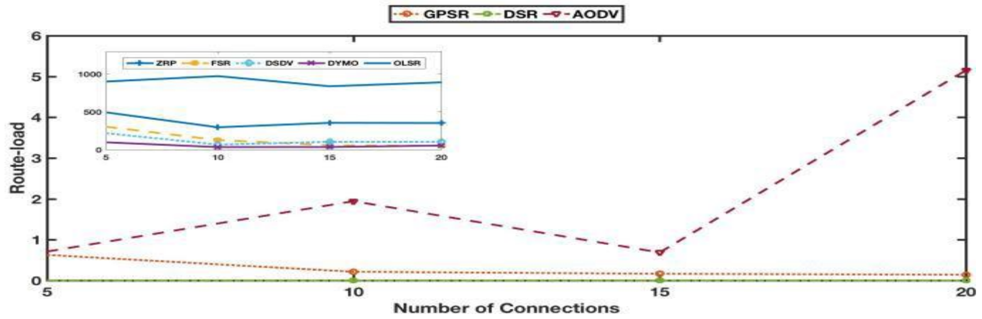


Figure 9: Routing cost according to data traffic load

Displays the average routing cost for all different routing protocols evaluated. Again, DSR and GPSR are the most efficient because of their low routing overhead. This is to be expected in that GPSR manages topology changes with fewer messages.

As far as DSR is concerned, the result can be explained by pointing out that it uses a cache to discover paths. First of all, a cache is a data structure that contains information about the different paths that can be taken to reach a particular location. Used frequently by DSR to find routes to avoid network congestion due to Route Request packet transmission. The amount required to use the AODV route increases proportionally with the number of connections. OLSR and ZRP are the two least performing routing protocols and should obviously be avoided in VANETs in metropolitan areas.

This is most likely due to the high density of the network, frequent topology changes that disrupt routes, and frequent restarts of route discovery processes that add to routing costs.

B. Study of the impact of density

Vary the number of nodes while holding the number of connections fixed to see the effect of density. In a given city topology in our work, the number of vehicles varies from 50 (low density) to 200 (critical density) and the amount of CBR data traffic remains at level 3.

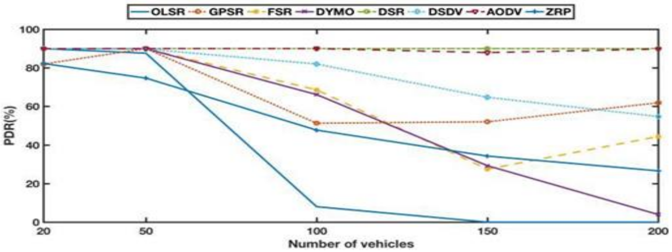


Figure 10: Packet Transmission Rate by Density

Error! Link source not found. Display of the achieved Packet Delivery Ratio (PDR) for each routing protocol as a function of the number of vehicles in an urban environment. There is no doubt that the PDRs of AODV and DSR are much higher than the others (approximately 90%). This is because of the method they use to find new routes and update existing ones.DSR provides internal optimizations that prevent the use of invalid incoming routes and in the event of a route violation, intermediate nodes restore the road without notifying the nodes responsible for generating the traffic.

Protocols like DSDV, FSR, DYMO and GPSR have good PDR in low density scenarios. This is because the probability of communication channel failure between nodes is low. As a result, there are fewer invalid entries in the routing table, which increases the rate at which packets are issued. On the other hand, the performance of almost all methods degrades with increasing density.

As network density increases, the effectiveness of the ZRP protocol gradually decreases. This predicament is understandable given the fact that ZRP works based on area radius. In practice, ZRP behaves like a pure proactive protocol when the area radius is larger. As a result, delivery rates have decreased due to its proactive nature. For OLSR, it exhibits interesting rates in low-density networks, but falls short as density increases. In fact, the age of vehicles from 50 to 100 is rapidly declining, and when the total number of vehicles reaches 100, the PDR OLSR becomes meaningless

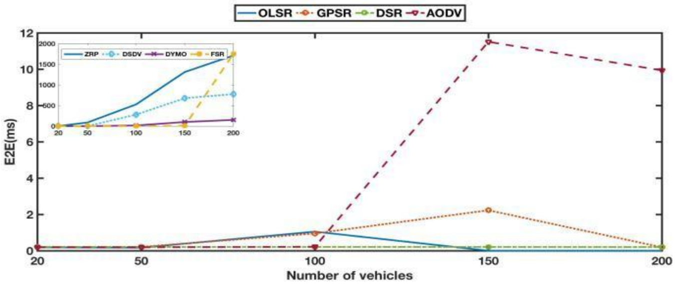


Figure 11: End-to-end delay as a function of density

Meanwhile, in the picture. Figure 5 shows the (average) end-to-end delay versus vehicle density achieved for each tested routing protocol. As you can see E2E increases for 8 protocols This is to be expected, as network congestion can increase traffic and cause significant end-to-end latency. As with the data traffic load study, DSR and GPSR work best. AODV also has minimal latency, but only in low-density scenarios. When density is important, E2E increases and then AODV performance decreases. Following ZRP, the worst protocols like DSDV, DYMO, and FSR take a very long time to deliver packets to their final destination compared to other protocols. Because OLSR does not support dense networks, it can be classified as unrestricted. Finally, GPSR is the best choice for keeping end-to-end latency to a minimum, especially if RDP is available.

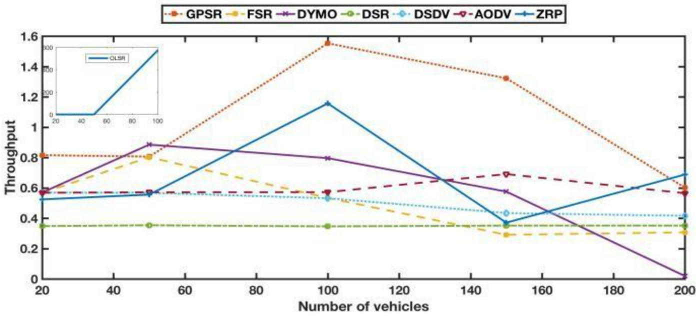


Figure 12: Performance as a function of density

The relationship between throughput and vehicle density is shown in Figure 6. This shows that the GPSR protocol has higher throughput than the others. The throughput of AODV and DSDV remains approximately the same regardless of data density, whereas the throughput of ZRP, DYMOUM and FSR fluctuates in unpredictable ways. Also, compared to other protocols, DSR has low throughput in areas where it handles the most missing values.

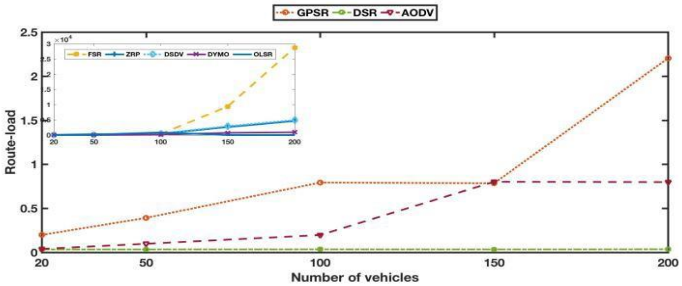


Figure 13: Routing Cost as a function of density

Figure 7 shows the cost of a route as a function of the number of vehicles traveled. First of all, it should be noted that the cost increases with the increase of mobile nodes, especially for FSR, ZRP, DSDV, DYMO and OLSR. Additionally, the GPSR, DSR, and AODV protocols reduce routing costs compared to the other five protocols by varying the number of nodes. This reduction in routing costs can be explained by the fact that these protocols reduce the number of TC packets and do not increase the size of the HELLO message header. Therefore, no additional signaling overhead is incurred.

Conclusion & Perspectives: This article describes a simulation model based on the topology of the number of nodes in the network and the amount of data traffic it experiences. It is important to evaluate the ability to provide quality of service (QoS) and scalability of the above eight protocols for automotive peer-to-peer networks by applying real-world situations. We use a large urban environment with realistic vehicle mobility and network traffic generated by VanetMobiSim in a benchmarking study of the performance of eight popular VANET routing protocols. These are AODV, DSDV, DSR, FSR, OLSR, GPSR and DYMO protocols. This study compares the performance of these routing protocols. The packet delivery ratio, the throughput, the end-to-end latency, and the routing cost are the four qualities of service measures that have been selected. This study contributes to the discussion in three different areas. The first one is an illustration of the literature surveying, in which we offer a worldwide overview of VANET, including the various routing protocols and how they are classified. The second topic is the effect that metropolitan settings have on routing methods, and in the end, we propose using this extensive collection of routing protocols for vehicle ad hoc networks.

Our objective is to not only offer a better knowledge of these protocols and their behavior but also to provide a reference that is helpful and valuable for future research on various classes of vehicular routing protocols that enable QoS. According to the analysis of the results, it can be said that geographic routing protocols perform better in automotive P2P networks compared to other routing protocols. This is because geographic routing protocols use location information appropriate for these networks. In the course of this study, we considered a variety of routing protocols, each with its own characteristics and consequences. This comparison is necessary to improve existing protocols and develop new protocols for VANETs. In the near future, the focus of our research will shift to this topic.

Acknowledgement: Routing protocols are an essential component of Vehicular Ad-hoc Networks (VANETs) as they enable the communication between vehicles and infrastructure. The performance of routing protocols in VANETs is crucial for the safety and efficiency of communication between vehicles. Several routing protocols have been proposed for VANETs, such as Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Destination-Sequenced Distance-Vector (DSDV), and Geographic Routing. However, the performance of these protocols varies depending on the network topology, mobility patterns, and the density of vehicles in the network. To evaluate the performance of routing protocols in VANETs, several metrics are used, including packet delivery ratio, end-to-end delay, routing overhead, and throughput. Packet delivery ratio measures the percentage of packets that are successfully delivered to their destination, while end-to-end delay measures the time taken for a packet to travel from the source to the destination. Routing overhead measures the number of control messages required for routing, and throughput measures the amount of data that can be transmitted in a unit of time. Acknowledging the performance of routing protocols in VANETs is crucial for researchers, designers, and network operators to choose the most appropriate protocol for their network. Moreover, the development of new routing protocols can be guided by the shortcomings and limitations of existing protocols.

In conclusion, the performance of routing protocols is an important aspect of VANETs that must be carefully evaluated and acknowledged to ensure the safety and efficiency of communication between vehicles.

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