Performance Comparison of Topological Geographical and Clustering Routing Protocols in VANETS

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Abstract: Vehicular Ad hoc Networks (VANETs) represent a specialized form of Mobile Ad hoc Networks (MANETs), where communication takes place among mobile or stationary vehicles equipped with wireless transceivers. These networks support two primary communication modes: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I), enabling vehicles to exchange critical data either with each other or with fixed roadside units. In this study, we implement and evaluate several topological routing protocols—including AODV, DSR, DSDV, and OLSR—as well as geographical routing protocols such as GPSR, PA-GPSR, and MM-GPSR. The performance of these protocols is analyzed under varying network conditions and packet sizes. Additionally, clustering-based VANET protocols are also examined for comparative analysis. The paper presents a detailed comparison of topological and geographical protocols based on key performance metrics such as Packet Delivery Ratio (PDR), throughput, and end-to-end delay. Furthermore, a comparative evaluation is conducted among topological, geographical, and clustering protocols with respect to PDR, highlighting the relative effectiveness of each routing approach under different network scenarios.

Keywords: AODV*, *GPSR, E2ED*, *VANET*, *Throughput.

I. INTRODUCTION

Wireless networks rely on radio frequencies for data transmission and reception through the air, eliminating the need for physical cabling and significantly reducing both installation and maintenance costs. A Vehicular Ad hoc Network (VANET) is a specialized subclass of Mobile Ad hoc Networks (MANETs), designed specifically for vehicular environments. In VANETs, mobile or stationary vehicles are equipped with wireless transceivers that enable them to function as nodes capable of forwarding and receiving data. Communication within a VANET can occur either between vehicles (Vehicle-to-Vehicle, V2V) or between a vehicle and a fixed roadside unit (Vehicle-to-Infrastructure, V2I).

VANETs support a broad range of intelligent transportation applications such as collision avoidance, traffic safety, blind intersection alerts, dynamic route planning, and real-time traffic monitoring. According to Amena Bengag et al. [1], VANET routing protocols can be broadly categorized and compared based on performance metrics. Routing protocols for V2V communication are commonly grouped into four types: topology-based, position-based, multicast, and broadcast-based.The performance of routing protocols in VANETs is highly influenced by various factors including the vehicular mobility model, network density, and environmental conditions. As stated by Uma Nagraj et al. [2], minimizing delay is often prioritized over reducing packet loss due to the time-sensitive nature of VANET applications. Their study utilized the NS3 simulator along with Network Animator (NAM) and spreadsheet tools to analyze simulation results and generate performance graphs.David B. Johnson et al. [3] demonstrated that in source-routing protocols like DSR, the packet header grows in size with the route length, and route requests can potentially flood the network. Each sender constructs a complete route to the destination, embedded in the packet header. As the packet traverses the network, each intermediate node forwards it to the next hop specified in the route until it reaches the final destination.

N. Bhalaji et al. [4] examined a trust-based routing approach, showing that although the overhead in terms of packets and bytes is higher than standard DSR, it offers improved performance in other areas. Nodes maintain trust values for neighbors, which are updated based on successful packet exchanges or lack thereof. New neighbors are assigned initial trust values based on defined trust formation strategies.

In Charles E. Perkins et al. [5]'s study, it was observed that outdated source sequence numbers in protocols like AODV can lead to route inconsistencies. Nodes maintain awareness of their local topology using techniques such as "hello" messages. Local routing tables are dynamically updated to respond quickly to node mobility and route establishment requests. Guoyou [6] and Xin Yang et al. [7] analyzed the DSDV protocol, noting that while it requires periodic routing table updates—consuming power and bandwidth—it provides a reliable means of route maintenance. Optimization techniques such as shortening the update interval and reducing the settling time have been proposed to adapt DSDV for high-mobility environments like highways. In the domain of geographical routing, Brad Karp et al. [8] introduced Greedy Perimeter Stateless Routing (GPSR), which makes forwarding decisions based on the positions of neighboring nodes. Although efficient, GPSR can sometimes route packets into dead ends, leading to increased delays and hop counts. Further enhancements include MM-GPSR (Maxduration-Minangle GPSR) proposed by Xiaoping Yang et al. [9], which selects next-hop nodes based on the duration of stable communication, although it suffers from higher end-to-end delay compared to PA-GPSR. Andrey Silva et al. [10] proposed Path-Aware GPSR, which enhances GPSR's greedy and recovery modes using additional data structures such as the Deny Table (DT) and Recently Sent Table (RST) to improve packet forwarding decisions.

Finally, M.V. Pavan Kumar et al. [11] provided a practical comparison of GPSR with other routing protocols under real-world conditions. While GPSR supports multipath communication and handles moderate mobility well, other protocols may excel in different metrics but lack multipath capabilities or energy efficiency mechanisms.

II. CLASSIFICATION VANET OF ROUTING PROTOCOLS

Routing protocols can be categorized in various ways, with the most common classifications based on the routing strategy and the underlying network structure. From the perspective of routing strategy, protocols are generally divided into three main types: topology-based protocols (which include proactive and reactive approaches), geographical or position-based protocols, and clustering-based protocols.

A. Topological Protocols

1. Proactive routing Protocols

Proactive routing protocols, also known as table-driven protocols, maintain up-to-date routing information at every node by continuously exchanging routing tables. To stay aware of any changes in network topology, nodes periodically broadcast control messages to other nodes in the network. Optimized Link State Routing (OLSR) and Destination-Sequenced Distance Vector (DSDV) are common examples of proactive protocols. Reactive Protocols

2. Reactive routing protocols

Reactive routing protocols, also known as on-demand protocols, establish routes only when they are needed for data transmission. Instead of maintaining a complete routing table at all times, these protocols initiate a route discovery process to determine a path to the destination when communication is required. Examples of reactive protocols include Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector (AODV), and the Temporally Ordered Routing Algorithm (TORA).

B. Geographical Routing Protocols

Geographic routing protocols, such as GPSR, PA-GPSR, and MM-GPSR, primarily depend on the location information of the destination node. This positional data is typically obtained through GPS or via periodic beacon messages exchanged between nodes. By leveraging knowledge of both their own coordinates and the destination's position, nodes can forward packets directly—without requiring complete knowledge of the network topology or performing traditional route discovery procedures.

C. Clustering Protocols

Clustering in ad hoc networks, such as VANETs, involves grouping nodes into manageable sets to enhance network performance, scalability, and resource efficiency. Each cluster typically has a cluster-head (CH) that manages communication with its member nodes, while gateway or border nodes connect multiple clusters. Clustering can be active, passive, or hybrid, depending on how clusters are formed and maintained. It can also vary in size, such as one-hop clusters where all nodes are directly linked to the CH. This approach improves manageability, conserves energy, optimizes channel use, and supports load balancing. Various protocols differ in how they elect CHs and handle routing within and between clusters.

III. SUMMARY OF ROUTING PROTOCOLS

A. AODV Working

This section explains the operation of AODV (Ad hoc On-Demand Distance Vector), a well-known reactive routing protocol. AODV establishes routes only when required by a source node and operates through two key mechanisms: Route Discovery and Route Maintenance.In the Route Discovery phase, if a valid path to the destination does not exist, the source node initiates the process by broadcasting a Route Request (RREQ) message to its immediate neighbors. This request continues to propagate until it reaches the destination or an intermediate node with a valid route. Upon receiving the RREQ, a Route Reply (RREP) is unicast back to the source node, which then begins transmitting data along the established path. If the source node later receives a better route (i.e., fewer hops), it updates its routing table accordingly.During Route Maintenance, if a link failure occurs along an active path, a Route Error (RERR) message is generated and sent back to the source node. Upon receiving this error notification, the source node may initiate a new route discovery process to re-establish connectivity with the destination.

B. DSR Working

Dynamic Source Routing (DSR) is a protocol specifically developed for multi-hop ad hoc networks composed of mobile nodes. In this protocol, the entire path from the source to the destination is determined by the source node and embedded within the packet header. While this approach increases header size and leads to some overhead, it effectively prevents routing loops.DSR operates using two primary components: Route Discovery and Route Maintenance. In the Route Discovery process, the source node first checks its route cache to see if a valid path to the destination already exists. If not, it initiates a Route Request (RREQ) by broadcasting a message that includes the source address, destination address, and a unique identifier. This request is forwarded across the network until it reaches the destination, which then responds with a Route Reply (RREP) sent directly back to the source node using unicast.The Route Maintenance mechanism is responsible for handling link failures. If a link break is detected while a route is in use, a Route Error (RERR) message is generated and sent to the source node, allowing it to remove the broken path from its cache and, if necessary, initiate a new route discovery

C. DSDV Working

Destination-Sequenced Distance Vector (DSDV) is a proactive (table-driven) routing protocol that is based on the Bellman-Ford algorithm [14]. In DSDV, each node maintains a routing table containing the list of reachable destinations along with the corresponding hop count and the sequence number for each route. The route with the most recent (highest) sequence number is preferred, which helps in preventing routing loops and reducing unnecessary routing overhead. To keep routing tables updated, DSDV uses two types of update messages: full dump and incremental updates. Full dump updates contain the complete routing table and are transmitted infrequently.Incremental updates carry only the changes since the last full dump, minimizing bandwidth usage when network changes are minor.

One of the main advantages of DSDV is that it ensures loop-free routing by using destination sequence numbers, and it allows for quicker route determination due to the constantly maintained routing tables. However, a notable limitation of the protocol is its lack of scalability, particularly in large or highly dynamic networks, where frequent updates can consume significant bandwidth and processing power.

D. OLSR working

The Optimized Link State Routing (OLSR) protocol is a proactive, table-driven routing protocol designed for mobile ad hoc networks. In OLSR, each node selects a set of neighboring nodes called Multipoint Relays (MPRs). These MPRs are responsible for forwarding broadcast messages during the routing process, significantly reducing the number of transmissions required across the network. MPR nodes also generate and broadcast link-state information, but only on behalf of their MPR selectors, rather than all neighbors. This selective dissemination of control messages helps maintain efficient routing and ensures the calculation of shortest paths to all destinations in the network. One key advantage of OLSR is that it functions without the need for a centralized control system, as it operates on a flat network topology. However, a major drawback is its relatively high processing overhead. The protocol demands more computational resources to discover alternative routes when compared to some other routing approaches [15].

E. GPSR Working

Greedy Perimeter Stateless Routing (GPSR) is a position-based routing protocol that makes forwarding decisions based on the destination's geographic coordinates and the positions of neighboring nodes. GPSR operates using two main forwarding strategies: **Greedy Forwarding** and Perimeter Forwarding. Nodes periodically exchange beacon messages with their one-hop neighbors to share their current coordinates. In Greedy Forwarding mode, a packet is forwarded to the neighbor that is geographically closest to the destination. However, if no such neighbor exists—known as encountering a local maximum—the protocol switches to Perimeter Forwarding. In Perimeter mode, the packet is routed around the "face" of a planar subgraph using the right-hand rule, which helps the packet navigate around voids in the network until greedy forwarding becomes possible again.

An important advantage of GPSR is its ability to scale efficiently in large and dense networks, due to its reliance on localized information rather than full network topology. A notable disadvantage, however, is that it may occasionally select next-hop nodes that fall outside the actual communication range, or create redundant paths, which can affect routing efficiency [16].

F. MM GPSR

Maxduration-Minangle GPSR (MM-GPSR) is an enhanced version of GPSR that also employs two forwarding strategies: Greedy Forwarding and Perimeter Forwarding.

In the Greedy Forwarding phase, MM-GPSR selects the next-hop node based on the maximum cumulative communication duration with its neighbors. This approach favors more stable connections, improving reliability in highly dynamic environments. If greedy forwarding is not possible—such as when the packet encounters a local maximum—the protocol switches to Perimeter Forwarding. In this mode, it calculates the angle formed between the neighboring nodes and the destination. The neighbor with the smallest angle relative to the destination is chosen as the next hop, helping the packet progress efficiently toward its target [17].

G. PAGPSR

PAGPSR is a Vehicle-to-Vehicle (V2V) communication protocol specifically developed for urban environments. This protocol enhances the greedy and recovery forwarding methods used in GPSR by incorporating two key mechanisms: the Deny Table (DT) and the Recently Sent Table (RST), which help in preventing routing loops. Additionally, it improves the traditional right-hand rule by integrating both right-hand and left-hand forwarding strategies [18].

H. Multihop-Cluster-Based Ieee 802.11p And Lte Hybrid Architecture For Vanet Safety Message Dissemination - Vmasc–Lte

This protocol selects cluster heads (CHs) by analyzing the relative mobility patterns of vehicles, specifically focusing on their average relative speeds, while also aiming to minimize [19]

I. Weight Based Clustering Algorithm For Military Vehicles Communication In Vanet

They utilized both average speed data and inter-vehicle distance to facilitate the clustering process and make informed decisions for cluster head (CH) selection.[20]

J. Enhanced Load Balanced Clustering Technique For Vanet Using Location Aware Genetic Algorithm - Location Aware Genetic Algorithm

A load-balanced clustering-based VANET protocol was developed using a Genetic Algorithm (GA) to optimize the clustering process and ensure balanced network load distribution among nodes.[21]

K. Clustering-Based Routing Protocol For Vehicular Ad-Hoc Network Using Two Metaheuristic Algorithms-Metaheuristic Algorithms

They employed heuristic models, specifically the Harris Hawks Optimization (HHO) algorithm and the Artificial Bee Colony (ABC) algorithm, to optimize clustering and determine the most efficient routing paths in VANET environments.[22]

IV. RESULT AND DISCUSSION

The topological and geographical protocols were simulated using the NS3 simulation tool. In the simulation, nodes were randomly placed within a 500m by 500m area.

A. *Performance and comparision Analysis of Topological Protocols*

The performance of Topological protocols are analysed and compared with respect to varying packet size (200 to 2048) across a varying range of nodes or vehicles in the network (20 to 200).

1.Packet Delivery Ratio v/s Number of Nodes

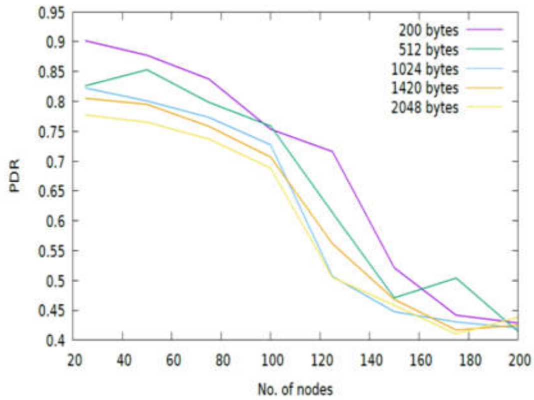

Fig 1. PDR vs. No. of Nodes for AODV

The analysis of the graphs indicates that as the packet size increases, the Packet Delivery Ratio (PDR) tends to decrease. Specifically, in the case of the AODV protocol, the highest PDR value of 0.9 is achieved when transmitting packets of 200 bytes. In contrast, the lowest PDR, around 0.77, is observed with packet sizes of 2048 bytes, as illustrated in figure 1. Across all five packet sizes, the PDR consistently declines as the number of nodes increases, following an exponential trend. Experimental findings highlight that varying packet sizes significantly influence network performance. Each communication medium defines a Maximum Transmission Unit (MTU), and packets exceeding this limit are typically dropped. Larger packet sizes require more time to transmit and are more prone to transmission errors, which negatively impacts the overall performance of VANETs.

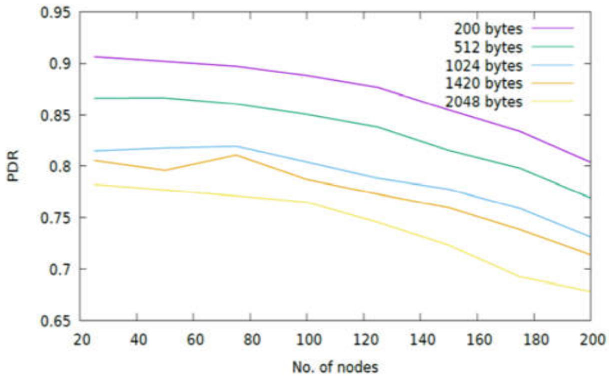

Fig 2. PDR vs. No. of Nodes for DSDV

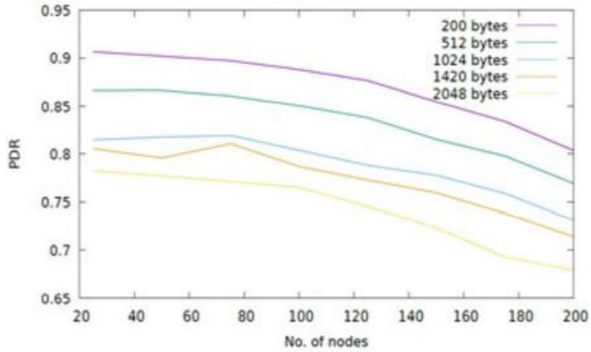

Fig 3. PDR vs. No. of Nodes for DSR

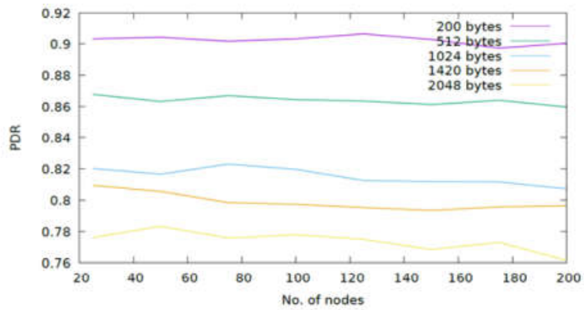

Fig 4. PDR vs. No. of Nodes for OLSR

The same results pertain throughout the complete network. Similar to the aforesaid results, a better performance of lower sized packets than the higher sized ones is observed for the protocols DSDV and DSR. These two protocols also undergo a decrease in performance in terms of PDR, but in a gradual manner as shown in figure 2 and figure 3, unlike AODV. For OLSR protocol, it can be observed in figure 4 that the PDR value remains the same, irrespective of the network density. Thus, for a stable requirement, OLSR is preferred. Also, the pattern of lower sized packets outperforming the higher sized packets persists.

2.Overhead v/s Number of Nodes

The performance of AODV protocol can be observed in figure 5, where the packet size of 200 bytes exhibits the highest overhead whereas, the packet size of 2048 bytes has the lowest overhead.

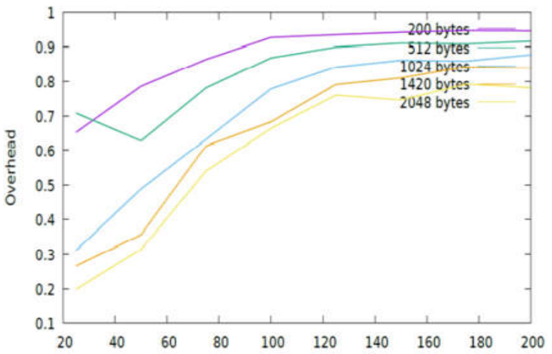

Fig 5. Overhead vs. No. of Nodes for AODV

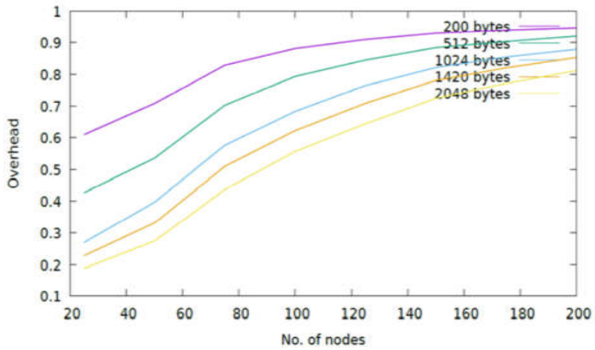

Fig 6. Overhead vs. No. of Nodes for DSDV

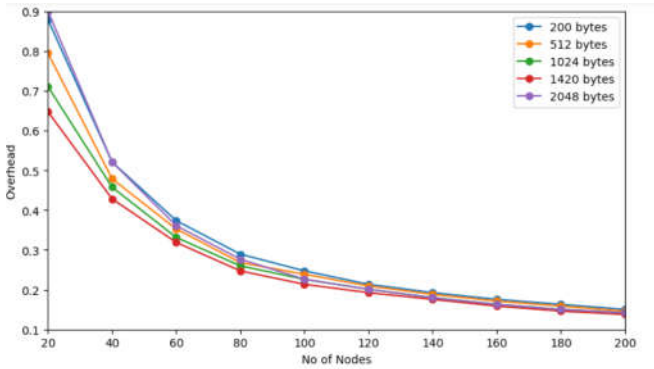

Fig 7. Overhead vs. No. of Nodes for DSR

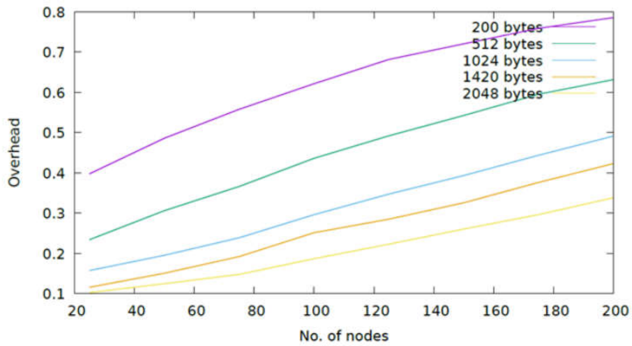

Fig 8. Overhead vs. No. of Nodes for OLSR

For DSDV protocol, as observed in figure 6, the graph depicts an increase in the overhead with an increase in the network density. The highest overhead value achieved is approximately 0.95, which is a highly undesirable value. We can also observe that the packet size of 200 bytes has the highest overhead achieved, whereas, a packet size of 2048 bytes has the lowest overhead, of approximately 0.2. A similar pattern of output can also be found in the graph of DSR and OLSR protocol (figure 7,8). Except that the highest overhead value achieved is nearly 0.99 and the lowest is nearly 0 as shown in

3.Throughput v/s Number of Nodes

As seen in Fig 9, the AODV protocol has exhibited a very unstable performance irrespective of the packet sizes. Nevertheless, the performance of packet sizes 200 and 512 bytes can be considered optimum for this protocol. Yet again for the DSDV protocol, the performance has been varying throughout the network, irrespective of the packet size and density of the network, as observed in figure 10. After keen observation and a few considerations, the packet size of 200 bytes has performed better on an average. Although it is observed to face a dip in it's performance at node 100, where

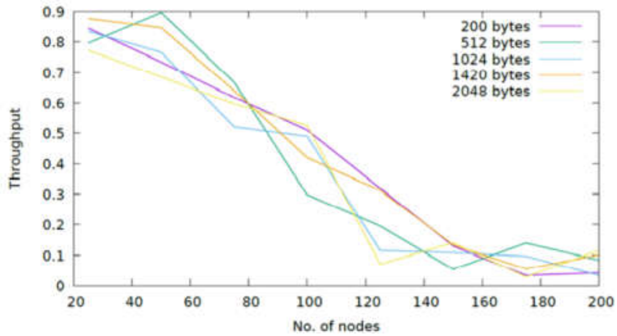

Fig 9. Throughput vs. No. of Nodes for AODV

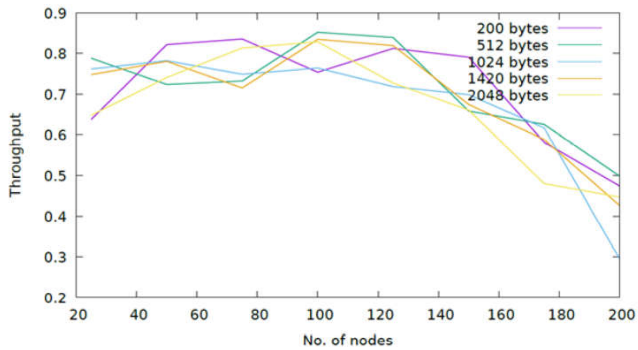

Fig 10. Throughput vs. No. of Nodes for DSDV

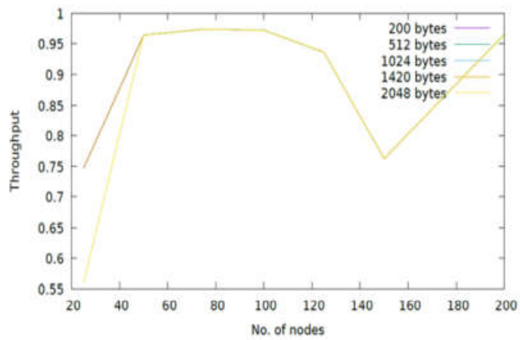

Fig 11. Throughput vs. No. of Nodes for DSR

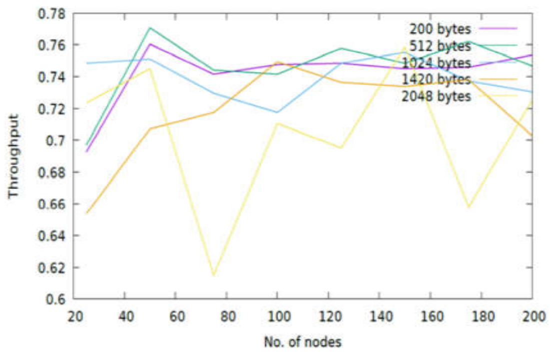

Fig 12. Throughput vs. No. of Nodes for OLSR

the packet size of 512 has performed well and whose output matches the previous values of 200 bytes. It is also observed that, after the node 120, the performance of all five packet sizes have deteriorated. figure 11 displays the performance of DSR protocols. It is observed that upto node 50, the packet size of 2048 is observed to have a lower throughput than the rest. The rest of the network has observed a uniform throughput irrespective of the packet sizes. However, a dip at node 150 is found and neglected. figure 12 displays the throughput analysis for OLSR protocol, where it is observed that a packet size of 512 bytes performs better than the rest throughout the network. Whereas, the performance of 2048 bytes is the least.

B. *Comparison analysis of Topological protocols*

This comparison consists of analysis of various topological protocols across various performance metrics namely, PDR, throughput and overhead, for a packet size 200 bytes. The graph is plotted across a varying network density i.e., varying the number of nodes (20 to 200)

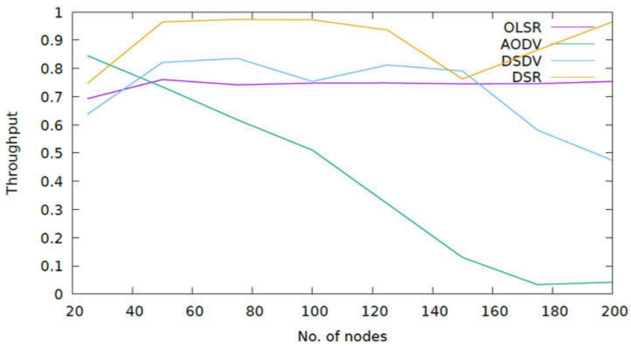

Fig 13. Throughput vs no. of nodes

Figure 13. shows the analysis of throughput across varying network density. It can be observed from the graph that the DSR protocol outperforms the rest of the three protocols with a throughput value reaching almost 0.99. For closer observations, the results observed for a network containing less than 30 nodes, AODV performs better than the rest. Whereas, for the rest of the network, DSR has performed better and for AODV, the throughput has decreased with an increase in the number of nodes.

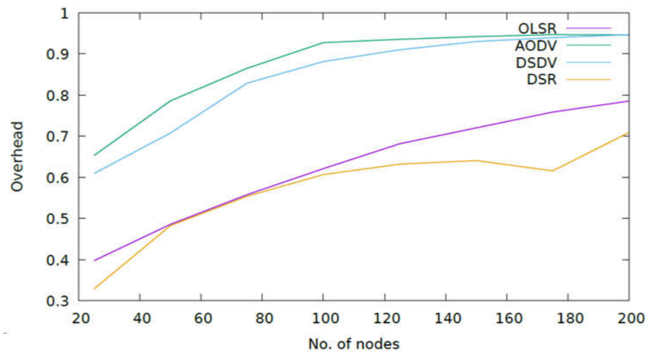

Fig 14. Overhead vs no. of nodes

DSR protocol possesses the lowest overhead throughout the network, as shown in figure 14. AODV has the highest overhead, followed by the DSDV protocol. The OLSR protocol has the overhead values similar to that of the OLSR protocol. But, the DSR protocol has a huge dip of around 5-10% after node 160. Thus, DSR has the lowest overhead throughout the network. Although, it can be observed that the overhead of all the four protocols increase with an increase in the network density

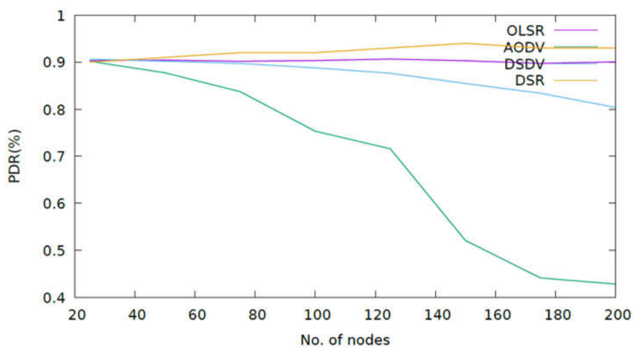

Fig 15.PDR vs no. of nodes

Figure 15. represents the performance of all four protocols in terms of PDR. The PDR of DSR protocol is observed to be the highest throughout the network, with an average value of 0.9 across the network. OLSR and DSDV display a moderate performance. Whereas, the performance of AODV protocol has decreased with an increase in the number of nodes. At node 200, the PDR of AODV protocol has nearly reached a value of 0.4 which depicts a poor performance of the protocol

C. *Performance Analysis of geographical Protocols*

The performance of Geographical protocols are analysed and compared with respect to varying packet size (512 and 1024) across a varying range of nodes or vehicles in the network (25 to 200).

1. PDR vs. No. of Nodes for 512 bytes

Figure 16 depicts a plot of PDR across the three position based protocols, GPSR, PA-GPSR and MM-GPSR. From the graph it can be observed that for a network consisting less than 75 nodes, PA-GPSR protocol has a higher PDR%. Whereas, for a network denser than that, MM-GPSR is found to have a higher PDR% of 90%.

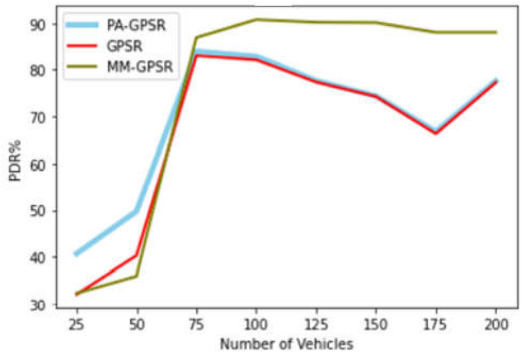

Fig 16. PDR vs. No. of Nodes

2. Packet loss Rate vs. No. of Nodes for 512 bytes

figure 17. displays the packet loss rate of the position-based protocols. Similar to PDR it can be observed that the packet loss rate for a network density less than 75 nodes is the lowest for PA-GPSR protocol, whereas for a network with a density higher than this the packet loss rate is observed to be the lowest for MM-GPSR

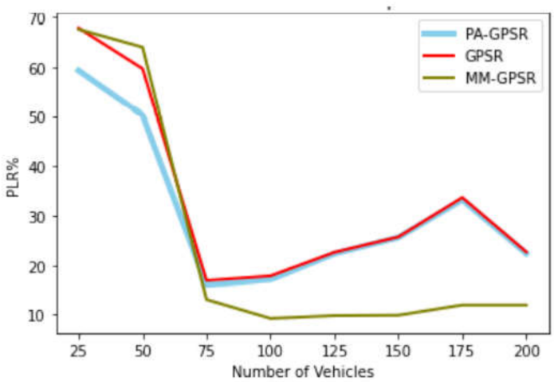

Fig 17. Packet Loss Rate vs. No. of Nodes

3. Average End-to-End Delay vs. No. of Nodes for 512 bytes

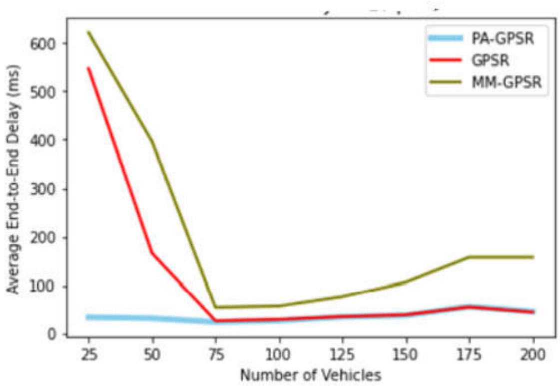

Fig 18. Average End-to-End Delay vs. No. of Nodes

The average end - to-end delay of PA-GPSR protocol is found to be the least with a value nearing to zero, irrespective of the network density. Whereas, the end-to-end delay of MM-GPSR is found to be the highest for lesser dense network and decreasing with an increase in the density of the network as shown in figure 18. These results are obtained for packet size of 512 bytes.

4. PDR vs. No. of Nodes for 1024 bytes

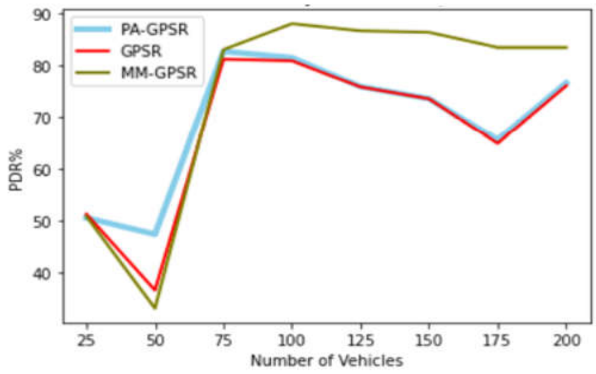

Fig 19. PDR vs. No. of Nodes

5. Packet loss Rate vs. No. of Nodes for 1024 bytes

The similar results are obtained for packet size of 1024 bytes. figure 19 shows the PDR to be highest for MM-GPSR. figure 20.Shows the Packet Loss Rate to be the least for MM-GPSR. figure 21. shows the end-to-end delay to be the minimum for PA-GPSR. Thus, the variation in packet size has not affected the performance of the geographical based protocols.

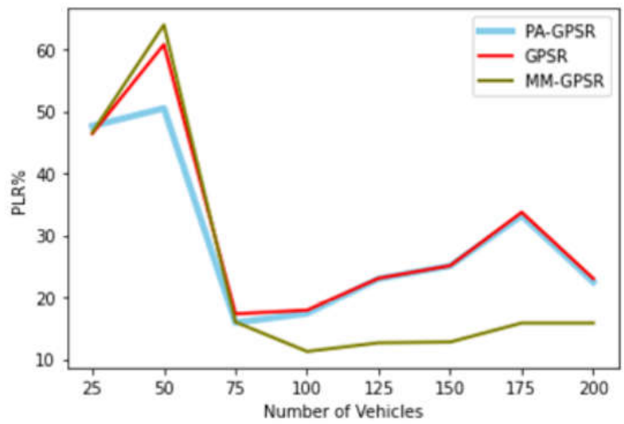

Fig 20. Packet loss Rate vs. No. of Nodes

6. Average End-to-End Delay vs. No. of Nodes for 1024 bytes

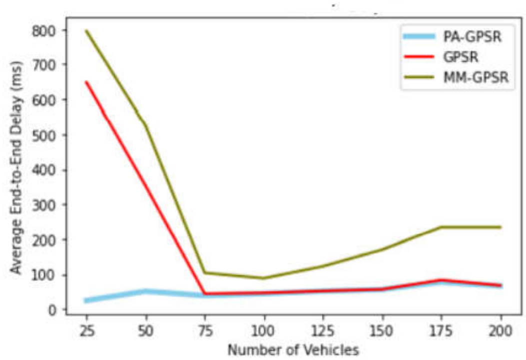

Fig 21. Average End-to-End Delay vs. No. of Nodes

D. ***Comparison of Topological vs geographical protocols***

1. PDR vs. No. of Nodes for all protocol

A complete analysis of all seven protocols in terms of PDR and Packet Loss Rate is performed. figure 22.

shows the plot of PDR of both topological and position-based protocols. For a network consisting of less than 75 nodes, the position-based protocols are found to have the lowest PDR and the topological protocols display a comparatively higher PDR. When the network density starts increasing, the performance of position-based protocols starts to increase, whereas, the performance of topological protocols start to deteriorate. The PDR of AODV decreases exponentially with an increase in network density

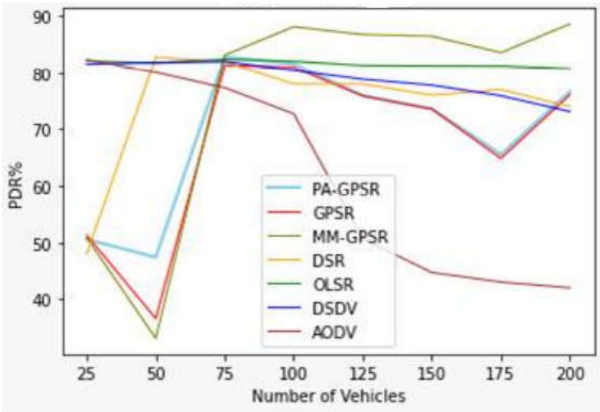

Fig 22. PDR vs. No. of Nodes for all protocol

2. Packet Loss Rate vs. No. of Nodes for all protocols

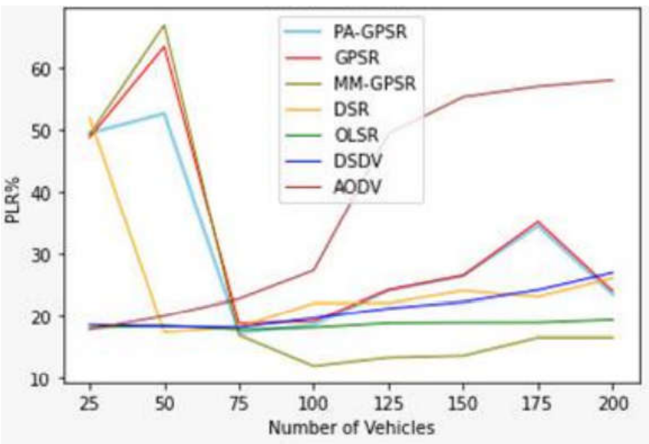

Fig.23 Packet Loss Rate vs. No. of Nodes

A similar trend can be observed in the graph of Packet Loss Rate, as shown in figure 23. The Packet Loss rate of topological protocols is observed to be minimum for less dense networks and keeps increasing with an increase in the network density. The contrary is observed for position-based protocols. This trend is observed since the topological protocols maintain a routing table. A routing table is maintained at each and every node. As the nodes are less, the maintenance of the routing tables are easy and thus, better performance. But when the number of nodes increases, the geographical based protocols perform better. This is because the topological protocols have to maintain a bigger routing table that might reduce the throughput due to higher overhead and memory requirement Since the real-time scenarios usually are a higher dense networks, MM-GPSR is an optimum choice in terms of both PDR and Packet Loss Rate.

E. *Comparison of Clustering Protocols*

Here comparison with respect to PDR is made with the clustering protocols (varying range of nodes or vehicles from 0-200 in the network) shown in figure 24. PDR of [21] is high which is 87% when compared to other protocols.

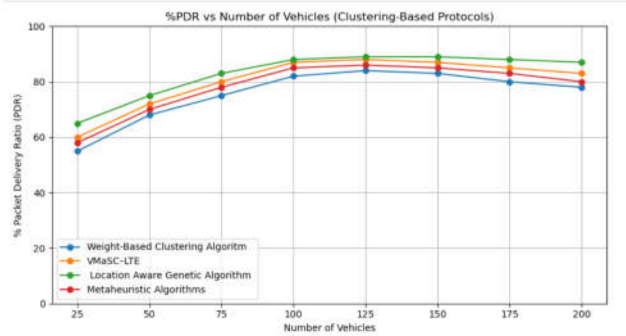

Fig 24. PDR vs. No. of Nodes for all clustering protocol

F. *Comparison of Topological vs geographical vs clustering protocols*

Figure 25 illustrates the Packet Delivery Ratio (PDR) for various routing protocol categories, including topological, position-based (geographical), and clustering protocols. From the figure, it is evident that the protocol referenced in [21] achieves the highest PDR among all evaluated protocols, indicating its superior performance in reliable data delivery.

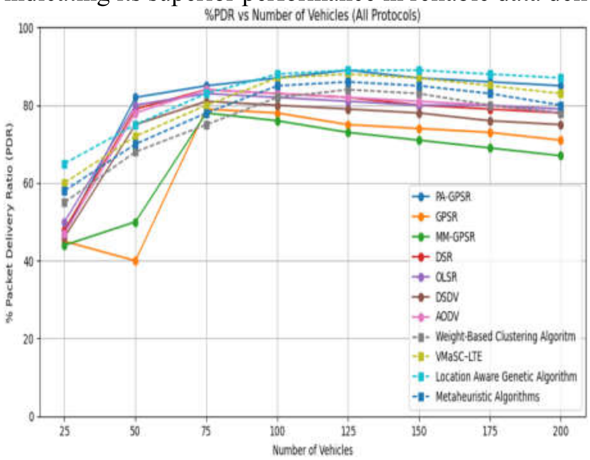

Fig 25. PDR vs. No. of Nodes for all protocol

V. CONCLUSION

For topological protocols, the optimum packet size that has to be used to obtain maximum performance across all performance metrics world be a packet size of 200 bytes. Although, the overhead of this packet size is higher compared to the rest, the PDR and throughput is observed to be the highest, concluding it to be an optimum choice. Considering the above packet size, analysis of various protocols are made, where the DSR protocol has outperformed the rest. It has the highest PDR and throughput with the lowest overhead, thus, making it appropriate for all applications. However, it can be observed that for a less dense network containing nodes less than 30, AODV has performed better.

For the geographical routing protocols, the routing protocols under simulation are GPSR, MM-GPSR and PA-GPSR. When the number of nodes under consideration is small, PA-GPSR performs better. But when the number of nodes increases over 100, which would be the scenario in the actual world, the MM-GPSR protocol tends to outperform the rest. When the overall comparison between the topology based and position based protocols are analyzed, an observable trend is that for a smaller node numbers, the topological protocols perform better. This is due to the routing table maintained at each and every node. As the nodes are less the maintenance of the routing tables are easy and thus, better performance. But when the number of nodes increases, the position based protocols perform better. This is because the topological protocols have to maintain a bigger routing table that might reduce the throughput due to higher overhead and memory requirement.

When comparing clustering protocols with topological and geographical routing protocols, it is observed that the Packet Delivery Ratio (PDR) is significantly higher for clustering-based approaches. This improvement in PDR can be attributed to the hierarchical structure of clustering protocols, which reduces routing overhead, minimizes collisions, and improves link stability within clusters. By localizing route maintenance and data forwarding within smaller, more manageable groups, clustering protocols effectively enhance the reliability and efficiency of packet transmission, especially in dynamic and large-scale network environments."

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