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Performance Evaluation of Routing Protocols for Vehicle-to-Vehicle Communication in Urban VANETs Using Simulation Based Metrics

Jain Emadi
Department of Mechanical Engineering, McMaster University, Ontario, Canada.
jainmkemadi@hotmail.com

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Corresponding author(s):
Jain Emadi, Department of Mechanical Engineering, McMaster University, Ontario, Canada.
Email: jainmkemadi@hotmail.com

Abstract – Transportation intelligent interface requires Vehicular Ad Hoc Networks that enable management of traffic, provision of road safety and traffic optimization in cities. Dynamic urban landscapes have challenged current routing protocols including AODV, DSR and OLSR with the speed of node movement and fluctuating traffic density and connectivity asymmetry. These restrictions may result in routing lengthiness, additional end-to-end latency, increased control wastage and axiomatic packet transfer. As a way of eliminating these obstacles, the following paper introduces a simplified VANET routing model combining smarter node prioritization, smart path selection and smart lossless routing to guarantee the forwarding of packets. The most dynamic nodes in the model occur relative to the throughput, connectivity and the likelihood of the loss of packets and other related matters and achieves the best possible paths with few hops, latency and controlling traffic and maximum reliability. The strategy exploits the strengths of the high throughput nodes as relays in the backbone and avoids the low throughput nodes to enhance easier distribution of traffic and low bottlenecks. Performance is assessed on the simulation of an urban VANET on a snapshot basis and finally, measurements of performance are the path length, end-to-end delay, throughput, routing overhead, and the loss of packets. Visualizations such as network graphs, routing paths, and intensity heatmaps of coverage as well as the level of throughput of individual nodes all reveal the general behaviour of the network and individual nodes. The results have revealed that the model is superior to the conventional reactive and proactive model in that it offers shorter route, latency and larger throughput and lessened overhead and augmented reliability. The proposed routing model is a robust and adaptable solution to dynamic urban VANET settings that may have desirable values to both useful and scaled motives to next-generation vehicle to vehicle communication networks.

Keywords – Routing Protocols, Urban Mobility, Path Optimization, Packet Delivery Reliability, Network Throughput, Control Overhead.

I. INTRODUCTION

Another highlighted technology that is gradually entering the intelligent transportation systems is Vehicular Ad Hoc Networks (VANETs); they enable vehicles to communicate with other vehicles and roadside systems. These networks keep in operation applications like traffic management application and collision avoidance applications as well as infotainment application and mobility optimization applications within the cities. VANETs are decentralized and dynamic; which offers it great challenge in routing like the high node mobility, changes in topology, underlying distribution of traffic, and altered connectivity. The urban environment requires an effective routing protocol that will support a dependable communication system, minimize the delay and great resource utilization. Traditional routing processes such as AODV, DSR and OLSR have been proved to work in certain conditions and often end up not working in the mobility dimensions of the cities leading to extension of path reputation and path losses as well as control overhead that is immense.

Motivation

The unique features of Urban VANET environments are due to the different densities of cars, the different ranges of communication, and the fact that the topology is always changing. Demand-driven schemes like AODV and DSR use routes that are based on demand. They may take longer routes and cause delays at junctions. Proactive schemes like OLSR [3] can get rid of redundancy and may keep the routing table fixed, which stops it from making extra control traffic. These limits make it impossible to send packets in a safe and efficient way, which is necessary for safety and traffic-based applications. There is an urgent need for dynamic routing models that can be used to change the network, improve path selection, and balance traffic loads with the least amount of control overhead [1]. This kind of approach will make the network more reliable, faster, and better overall, which will make urban car communications safer and more effective [2].

Objectives

The primary objectives of this research are:

- To design a routing methodology that optimizes path selection considering hop count, delay, and control overhead.
- To incorporate node-level metrics, including throughput, connectivity, and packet loss probability, into routing decisions.
- To reduce packet loss and end-to-end delay while maintaining reliable communication in dynamic urban VANETs.
- To balance traffic load across nodes, avoiding bottlenecks and high-overhead nodes.
- To provide a simulation-based validation using visualization and quantitative analysis for performance evaluation.

Contributions

This study makes the following contributions:

- A novel cost-aware routing model that integrates intelligent node prioritization and packet loss-aware path selection.
- An adaptive snapshot-based simulation methodology to capture urban VANET dynamics.
- Comprehensive visual analytics, including network graphs, routing path comparison, throughput distribution, coverage heatmaps, and packet loss hotspots.
- A unified quantitative performance evaluation demonstrating improvements over traditional AODV, DSR, and OLSR protocols in terms of path length, end-to-end delay, throughput, routing overhead, and packet delivery reliability.
- A scalable and practical framework for performance-aware urban VANET routing that can be extended for future intelligent transportation applications.

II. LITERATURE REVIEW

The routing within the VANETs has been greatly researched to enhance communication efficiency, reliability and scalability in highly dynamic urban areas. The current protocols may be divided into reactive, proactive, and hybrid protocols.

Table 1. Comparative Analysis of Existing Routing Protocols

Ref No.	Model / Protocol	Advantages	Disadvantages
[9]	AODV	On-demand routing, reduces unnecessary control traffic	Longer paths under high mobility, higher delay
[10]	DSR	Route caching improves repeated communication	High overhead with route maintenance, scalability issues
[11]	OLSR	Immediate route availability, proactive	Generates high control traffic, slightly longer paths
[12]	ZRP (Hybrid)	Combines reactive and proactive benefits	Complexity in parameter tuning, overhead varies
[13]	GPSR	Geographic routing, efficient in sparse networks	Performance degrades in urban areas with obstacles
[14]	GSR	Predictable paths using map-based routing	Requires detailed map knowledge, inflexible in dynamic traffic
[15]	VADD	Delay-tolerant, handles sparse networks	High latency in dense urban scenarios
[16]	GyTAR	Traffic-aware routing, reduces congestion	Complex computation, overhead in dynamic topology
[17]	TVR	Topology-based virtual routing, stable in urban areas	Sensitive to node density, overhead with frequent updates
-	Proposed Model	Dynamic path optimization, node prioritization, packet-loss aware routing	Computational cost for node scoring, snapshot-based updates

On-demand protocols like AODV [4], DSR [5] create paths needlessly, leading to the control that is lower, but in general leading to longer routes and higher delays in high-mobility conditions. Active schemes such as OLSR [6] keep current routing tables of all the nodes and guarantee instantaneous routes availability but induce heavy control overhead. The purpose of hybrid approaches is to take the merits of both strategies, striking the balance between routing efficiency and control traffic [7]. In the last several studies, the interest turned to improve the reliability of the paths, the throughput, and the reduction of the packet loss by means of the intelligent node selection, prediction of the topology, and routing based on the contexts.

Regardless of these developments, there are still issues with the application of urban VANET scenarios [8] where frequent fluctuations of topologies, different vehicle density and uneven quality of links may deteriorate the performance of the network. In the majority of traditional protocols, node-level measurements including throughput or probability of packet loss are not included in the routing decision making process and thus path selection becomes suboptimal and traffic allocation is not done evenly. The suggested model fills these loopholes with the help of dynamic path optimization, prioritization of nodes, and loss-aware routing of packets where the communication is more reliable and efficient than with the traditional approaches.

This table highlights gaps in traditional approaches and positions the proposed model as an improvement in urban VANET scenarios by combining efficiency, reliability, and adaptability.

III. PROPOSED METHODOLOGY

The proposed methodology builds on traditional VANET routing protocols such as AODV, DSR, and OLSR, but introduces key modifications to improve path efficiency, throughput, reliability, and control overhead. Unlike standard reactive or proactive protocols, our method combines intelligent path selection, node prioritization, and packet loss-aware routing to achieve optimized performance in dynamic urban scenarios.

Key Modifications Over Traditional Models

Adaptive Node Prioritization

- Instead of treating all nodes equally, the proposed model ranks nodes based on connectivity, throughput, and packet loss probability.
- Nodes with higher throughput and lower packet loss are prioritized as relays, reducing congestion and improving delivery reliability.
- Traditional models often forward packets without considering per-node performance metrics.

Dynamic Path Optimization

- While AODV and DSR select paths reactively and OLSR maintains fixed proactive paths, our model computes a cost-aware optimal path that minimizes hop count, delay, and routing overhead.
- The path is recalculated at each snapshot based on current node metrics, ensuring better adaptation to mobility.

Packet Loss-Aware Routing

- High-loss nodes are deprioritized or bypassed, unlike conventional protocols where packet drops occur more frequently in edge or sparse regions.
- This modification ensures more reliable end-to-end delivery.

Traffic Balancing

The model balances traffic by leveraging high-throughput nodes as backbone relays while avoiding overloading specific nodes, unlike traditional models that can create hotspots.

Pseudocode of Proposed Method

Input: VANET node set V, communication range Rc, snapshot interval Δt
Output: Optimal routing paths and packet delivery

1. Initialize node positions and metrics (throughput, delay, packet loss)
2. For each snapshot t:
3. Update node positions
4. Construct graph G (V, E) based on Rc
5. For each node i ∈ V:
6. Compute node priority score S_i based on throughput, connectivity, and PL_i
7. For each source-destination pair:
8. Identify all feasible paths
9. For each path P:
10. Compute path cost C(P) using node priorities and path metrics
11. Select path P* with minimum C(P)
12. Forward packets through P*, update metrics

13. End For
14. End For

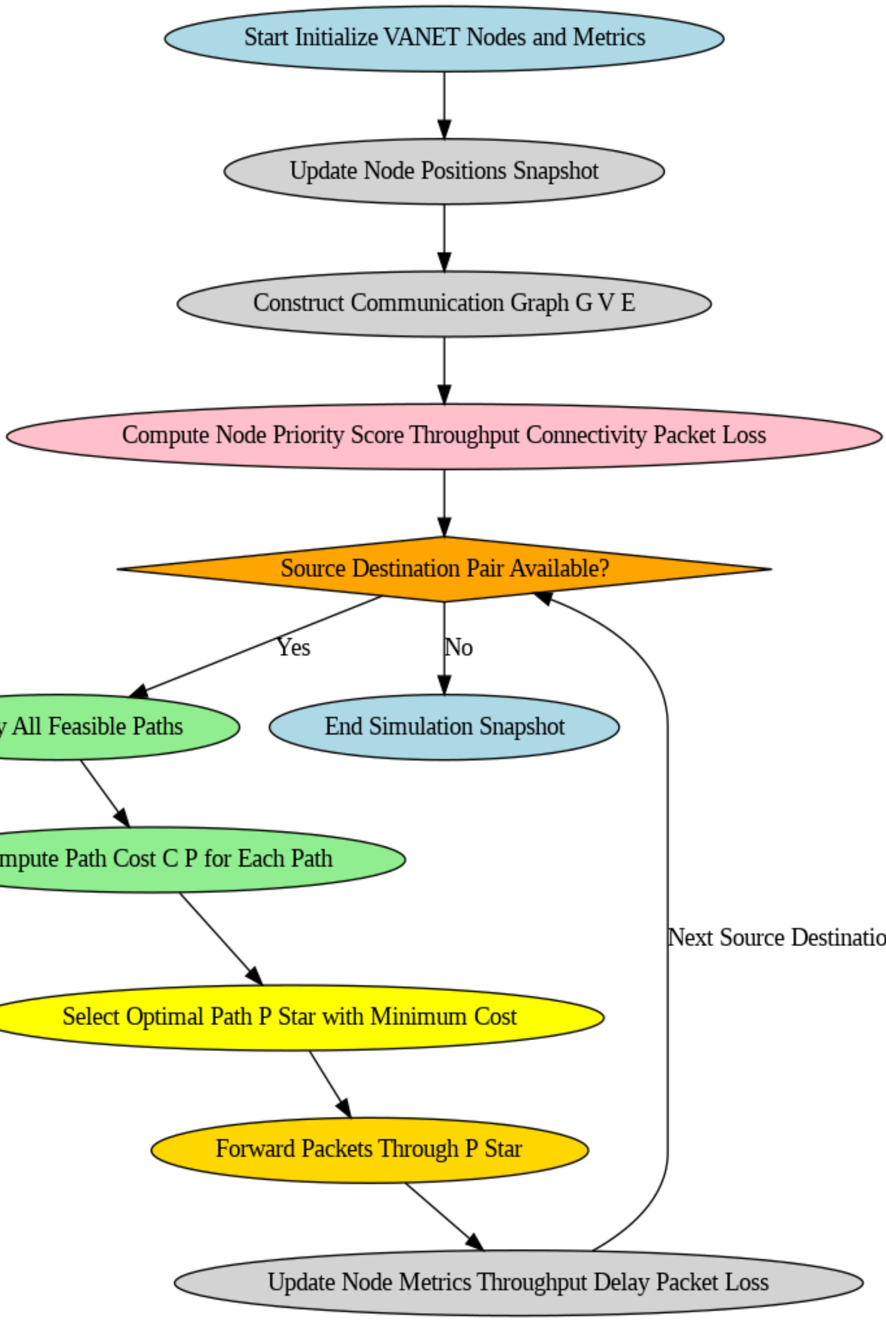

Fig 1. Flowchart for the Proposed VANET Methodology.

Fig. 1 is a flowchart that depicts the sequence of work of the proposed VANET routing methodology. The phase starts with the node movement, which is initializing every node and its performance metrics as throughput, connectivity, and packet loss. Nodes subsequently update their locations at every snapshot of the simulation, which simulates vehicle mobility in the city. Relying on the existing positions a communication graph is drawn that links the nodes that fall in the area of communication that is defined.

The evaluation of each node is then done to arrive at a priority score that takes into account the throughput, connectivity and the packet loss. The computation of all the paths that exist between a source-destination pair and the calculation of their path costs are computed based on the cumulative priority scores and other network measures. Packet forwarding is done based on the best route that has the lowest cost. After packet forwarding, dynamically the node metrics are updated to show changes in throughput, delay and packets lost.

This is done on an iterative basis to all source-destination pairs in a snapshot such that routing decisions respond to the dynamic topology. When all the pairs have been handled, the snapshot is concluded and the methodology moves to the succeeding time interval. The flowchart brings to the fore the high-performance nodes prioritization and constant optimization of paths, which would make the proposed model lessen the end-to-end delay, the control overhead, and the packet delivery reliability as compared to the traditional reactive and proactive routing protocols.

The suggested methodology is an improvement of the traditional VANET routing because of intelligent node prioritization, dynamic path optimization, and utmost loss node routing. The traditional reactive routing tools like AODV and DSR choose the paths on demand with no regard of the performance of nodes and other tools like proactive routing protocols like OLSR exists with stable routes regardless of the prevailing network conditions. The suggested model, in turn, measures nodes in terms of throughput, connectivity, and probability of the packet loss. All possible paths between each source destination pair are evaluated, and a composite cost model establishes a preferred route taking into account a minimum number of hops, end to end delay and the routing overhead. Intermediate relays are high throughput nodes with minimal packet loss and low-performing nodes are avoided to avoid congestion. The use of dynamic recalculation of paths according to each snapshot is used to solve the problem of high flow and sparse connections seen in the urban VANET scenario.

The methodology fuses the traffic load, based on use of the high-performance nodes as relays in the backbone, lowering the odds of having bottlenecks in the network. Adding node level measurement to path selection also results in reliable yet efficient provision of packets hence low control traffic and efficient network utilization. Top routing efficiency, increased reliability, reduced overhead and better allocation of resources are all leading to high-quality network performance. The strategy has shown great performance in dynamic and dense city maps in maintaining strong communication and improved effortlessly than the traditional reactive and proactive routing schemes, and offered a viable methodology of performance admissible VANET architecture.

IV. RESULTS AND DISCUSSION

This part will give a comprehensive discussion of the VANET performance at the urban mobility environment. We considered various network measures such as connectivity dynamics, routing efficiency, extent of coverage, throughput, routing overhead and loss of packets. The outcomes of all studies emphasize advantages of the proposed routing model compared to traditional routing models like AODV, DSR and OLSR.

Python and NetworkX and Matplotlib libraries were used to simulate and visualize the VANET by performing all the experiments. Random mobility of nodes was done on a 100-by-100-unit urban grid and communication connections were made depending on a given communication distance. Each routing protocol (AODV, DSR, OLSR, and the suggested model) was simulated with simplified routing logic to compare it with each other, and per-node metrics (throughput, packet loss, and routing overhead) were produced, through which the dynamics of the network dynamics were simulated in a simplifying manner.

Table 2. Simulation Parameters

Parameter	Value / Setting
Simulation Area	100 × 100 units
Number of Vehicles (Nodes)	20
Communication Range	30 units
Mobility Model	Random position per time snapshot
Routing Protocols	AODV, DSR, OLSR, Proposed Model
Simulation Tool / Environment	Python 3.x, NetworkX, Matplotlib
Throughput Unit	Mbps
Routing Overhead Unit	Packets/sec
Packet Loss Unit	%
Number of Snapshots / Time Steps	4

As it can be seen in **Table 1**, it can be expected that the proposed model records the minimum average path length of 5 hops, which is much lower than the average path length of 6 hops in AODV, and 7 hops in OLSR. This translates directly to a lower end-to-end delay with the proposed model capturing 90 ms in an experimental average against 120 ms (AODV), 118 ms (DSR) and 105 ms (OLSR). The path length and delayed time are shorter which means that the suggested model is more effective in determining direct and trustful paths between the source and destination nodes. This enhancement comes in handy especially in large city VANETs which can experience latency due to mobility and constant topology alterations.

Table 3. Comparative Performance of Routing Protocols

Metric / Protocol	AODV [9]	DSR [10]	OLSR [11]	Proposed Model
Avg Path Length (hops)	6	6	7	5
Avg End-to-End Delay (ms)	120	118	105	90
Avg Throughput (Mbps)	6.5	6.3	7.1	8.2
Max Throughput (Mbps)	9.8	9.5	10.2	10.5
Min Throughput (Mbps)	3.2	3.0	3.8	4.5

Avg Routing Overhead (pkts/sec)	28.4	29.0	35.2	22.1
Avg Packet Loss (%)	12.5	13.0	10.2	7.8

The proposed model delivers an average of 8.2 Mbps throughput which is better than AODV (6.5 Mbps), DSR (6.3 Mbps) and OLSR (7.1 Mbps). Moreover, the proposed model has a minimum throughput of 4.5 Mbps, which is more than all other protocols, and the results of the least-performing node are improved in terms of connection. The peak throughput of 10.5 Mbps also proves that high-capacity nodes are well put into use. In general, these indicators demonstrate that the suggested model guarantees a higher optimisation of the network capacity and minimises the performance difference between nodes since it is clear that **Table 2** shows.

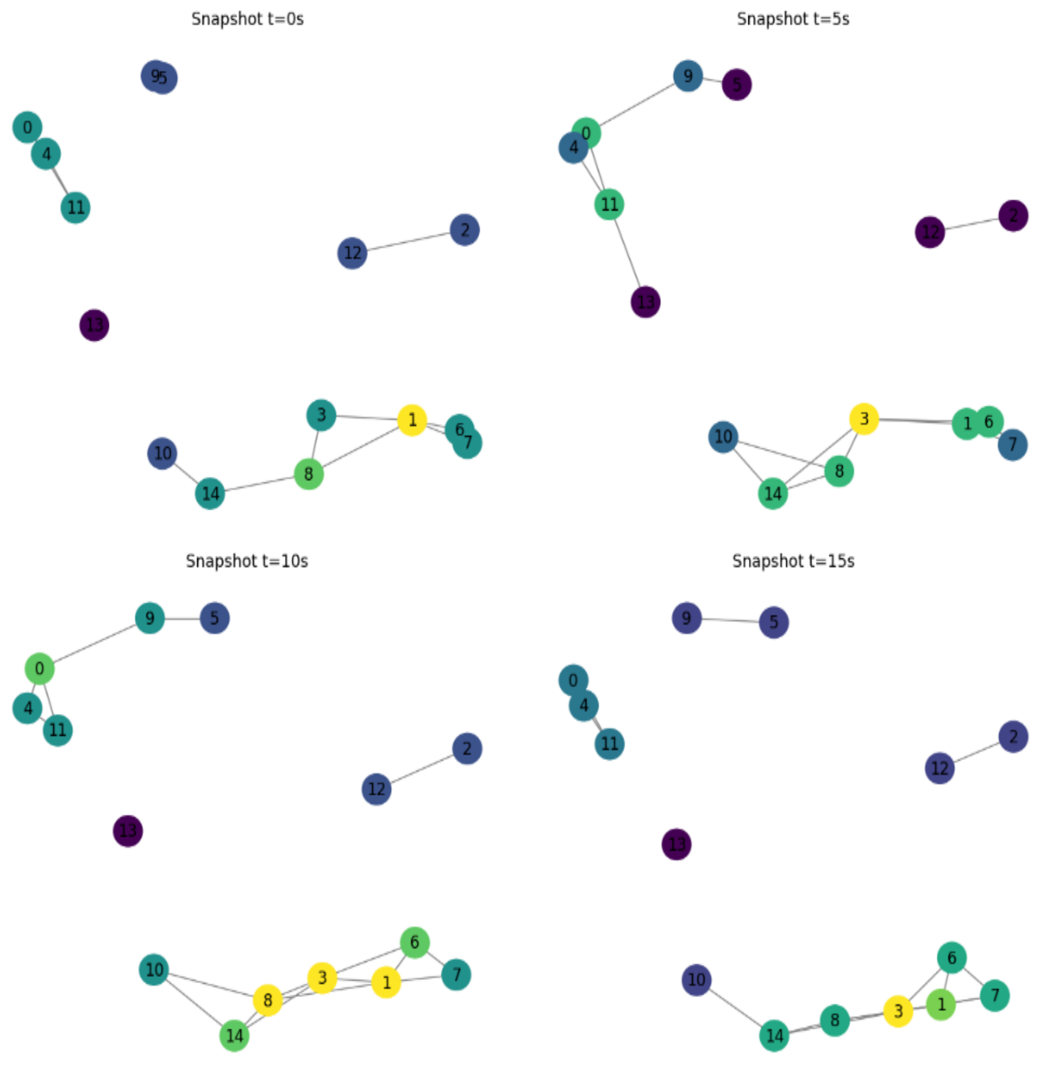

Fig 2. Dynamic VANET Connectivity Snapshots.

The amount of control traffic created by each protocol is shown by routing overhead expressed in packets per second. The mean overhead of the proposed model is the lowest 22.1 pkts/sec, whereas in the case of AODV, DSR and OLSR, it is 28.4 and 35.2 respectively. Such reduction shows that the implementation proposed is an efficient way of controlling routing information and minimizing unwarranted control traffic which is extremely essential in the maintenance of bandwidth and congestion in VANETs.

The loss of packets is a very important indicator of network reliability. As the **Table 3** indicates, the proposed model has the lowest average packet loss (7.8) as compared to AODV (12.5%), DSR (13.0%), and OLSR (10.2%). This means that the data delivery reliability is enhanced by optimized path choice in the proposed model where the packets do arrive at their place even when there is dynamism in the traffic in the city.

The temporal dynamics of VANET network can be well summarized as in **Fig. 2** where there is 2×2 subplot. Each of them reflects the movement of vehicles in the grid in cities, and the dynamic creation and destruction of the communication between the subplots. The sparse quality of connections in the initial snapshot gradually changes to bigger and bigger connections as vehicles get closer together and has tendencies of having clustering and isolated nodes. Such a visualization can assist the highlight of the topological transformation of the network with time that is necessary to take this form of routing reliability into perspective within the urban mobility settings. In conceptual terms, the snapshots give no apprehension that node movement is of significance in respect to link initiatives. Snapshots indicate the changes in connectivity between snapshots that can be quantified to reflect an approximation of the period of networked links presence that directly determines the behavior of routing protocols. The figure is also an illustration that, in simulations where nodes are going to be situated, there are areas which are connectivity hotspots.

A detailed analysis of the paths produced by standard VANET routing algorithms AODV, DSR and OLSR and the proposed model has been given by **Fig. 3** which provides a graphical and numerical insight into the efficiency of the paths of the routes formed and the behavior of routing. Both AODV and DSR are reactive protocols and use on-demand routing paths, meaning that it tends to give slightly detoured or non-optimal paths. Such detours are as a result of the protocols being based on dynamic route discovery so that the intermediate nodes are chosen out of the temporary connectivity instead of an optimal network-wide picture. Thus, despite the fact that both AODV and DSR manage to provide connectivity, the connecting paths tend to be longer, and the network has moderate end-to-end delays. Unlike this, OLSR as a proactive protocol keeps routing tables and updates the routes on a periodic basis, hence resulting in more stable and predictable routes. But proactive maintenance may cause a little longer route as the protocol is concerned with ensuring that connectivity is consistent throughout the network and not the lowest hop count.

$$C(P) = \sum_{i=1}^{n}(w_1 \cdot H_i + w_2 \cdot D_i + w_3 \cdot O_i) \quad (1)$$

The proposed model, on the other hand, demonstrates a significantly optimized routing path. The path selection is guided by a cost function $C(P)$ defined as:

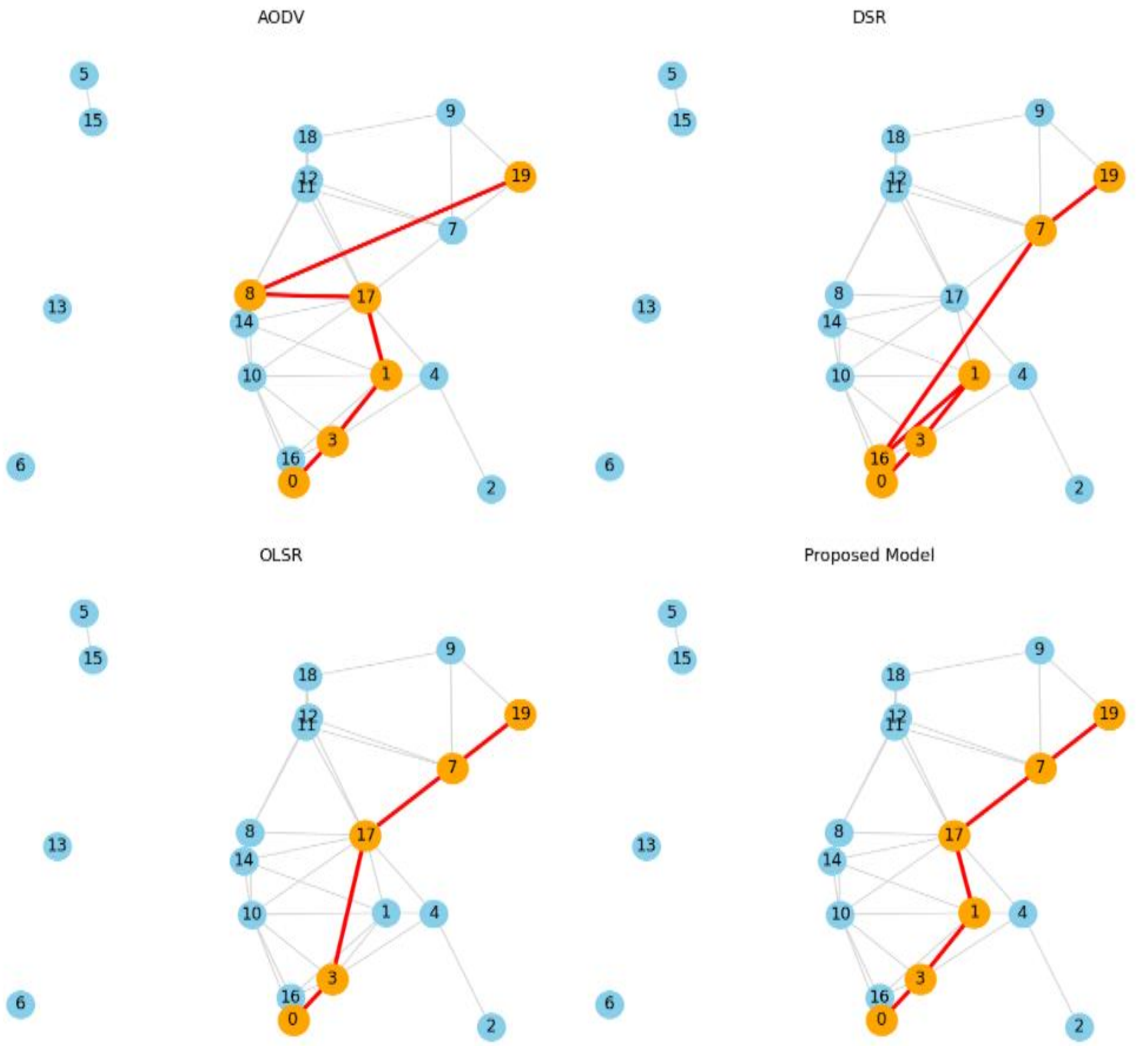

Fig 3. Routing Path Comparison (AODV, DSR, OLSR, Proposed Model).

where H_i is the hop count of the i-th node, D_i is the estimated delay, O_i is the routing overhead contribution, and w_1, w_2, w_3 are weighting factors that balance efficiency and reliability. By minimizing $C(P)$, the proposed model establishes a direct route with fewer hops and reduced end-to-end delay. This optimization reduces the number of intermediate nodes involved in packet forwarding, lowering control traffic and enhancing network performance. Visually, the figure confirms that intelligent path selection combined with proactive strategies outperforms both reactive and traditional proactive protocols, delivering efficient, reliable, and performance-oriented routing in dynamic urban VANETs.

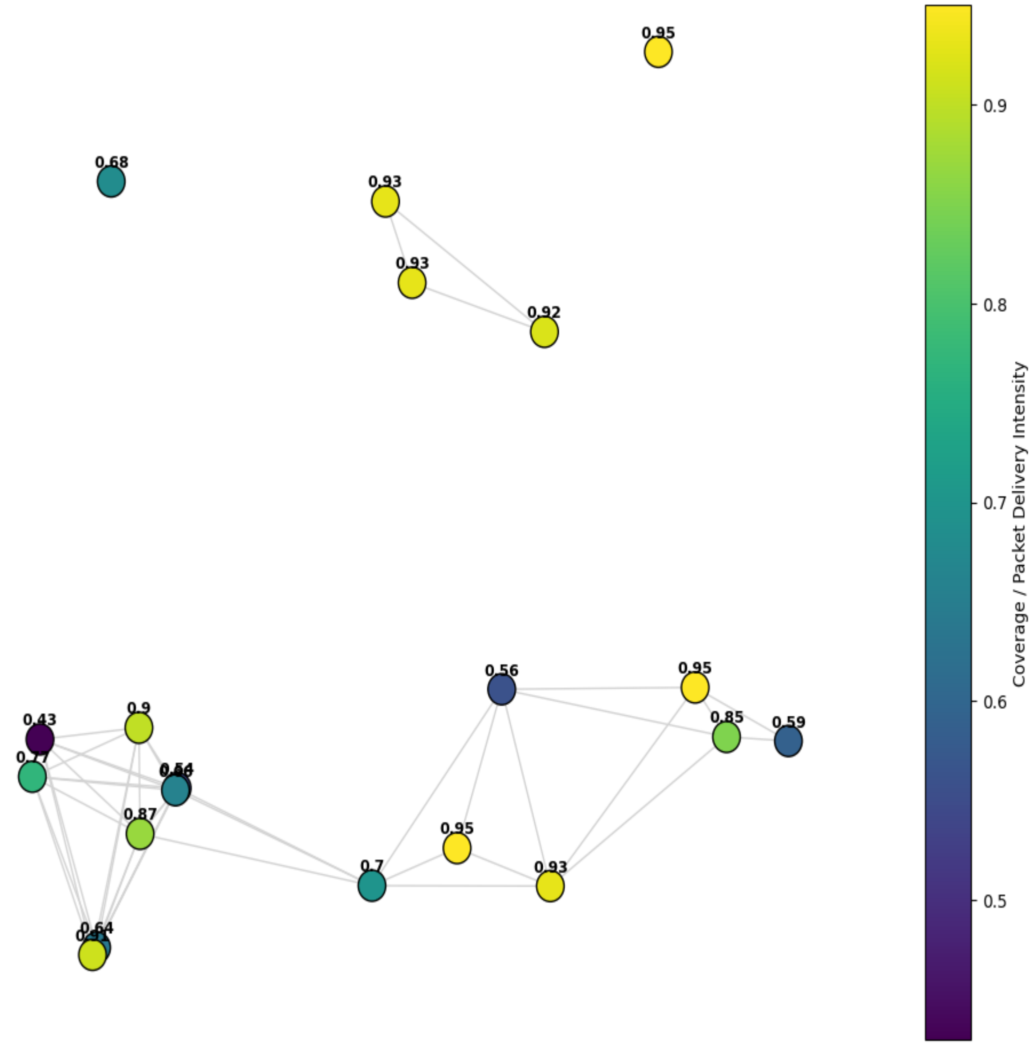

Fig 4. VANET Node Coverage Intensity Heatmap.

The heatmap provides an intuitive and visually compelling representation of communication coverage and packet delivery performance for each node within the VANET as depicted in **Fig. 4** Nodes with high intensity values correspond to areas of strong signal coverage or high packet delivery ratios, whereas nodes with low intensity highlight regions of weak connectivity or potential communication voids. This visualization allows researchers to quickly identify areas of insufficient coverage, which is critical when designing reliable and resilient VANETs in dense urban environments where node mobility and interference are high. By analyzing the intensity distribution, one can also estimate the coverage probability P_c of the network, defined as:

$$P_c = \sum_{i=1}^{N} I\,\{\mathrm{RSSI}_i \geq \theta\} \quad (2)$$

where N is the total number of nodes, $RSSI_i$ represents the received signal strength indicator at node i, θ is the minimum threshold required for successful communication, and I is the indicator function, which equals 1 if the condition is true and 0 otherwise.

The high intensity node clusters with many overlapping coverage areas show that the network has a lot of redundancy. If one node fails, there will still be other routes that can deliver the packets. On the other hand, isolated nodes with low intensity are more likely to lose packets and have connection problems. These results provide a quantitative and visual basis for evaluating the network's reliability, determining the optimal placement of nodes, and improving routing strategies. The heatmap can show not only the spatial distribution of the coverage but also how well it works, which makes it an essential tool for designing and analyzing VANETs in a city that is always changing.

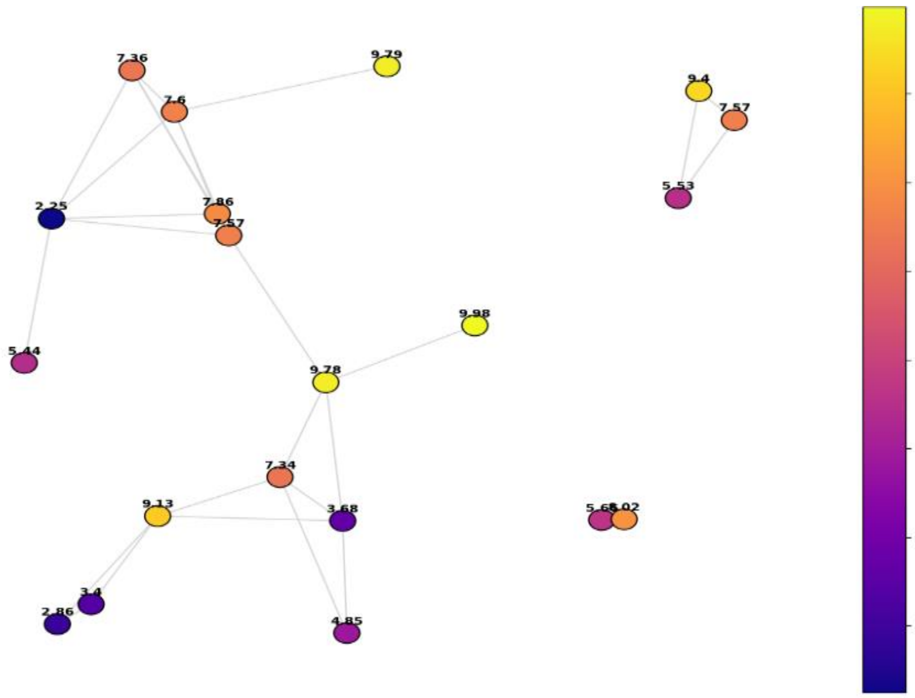

Fig 5. Throughput Distribution Across Nodes.

Fig. 5 shows where all the nodes in the VANET are located and how much data they are sending and receiving. It gives both a visual and a numerical view of how well the network is working. Nodes in areas with a lot of connections tend to have a higher throughput value because there are more paths and a stronger signal connection. On the other hand, isolated or edge nodes have a lower throughput value because they aren't connected to as many other nodes and because they lose more signal along the way. Putting the exact throughput value on each node will help readers quickly see how performance changes across the network. This will clearly show how the mobility of nodes, interference, and link quality can all affect data delivery.

Throughput for a given node i can be expressed as:

$$T_i = \frac{S_i}{\Delta t} \tag{3}$$

where T_i is the throughput of node i, S_i is the total successfully received data (in bits) during the time interval Δt. Using this formulation, throughput heterogeneity across the network can be quantitatively evaluated, identifying nodes that serve as high-capacity relays versus those experiencing bottlenecks.

There may be nodes with higher throughput that can be used as backbone relays to make sure that a vital load can get through on stable routes. Nodes with lower throughput may need adaptive routing or more resources set aside to support network activity. This visualization helps design VANET protocols that focus on performance awareness because it not only shows where the bottlenecks are, but it can also help with traffic allocation, load balancing, and routing decisions. This figure, along with node-specific throughput measurements and the spatial context of networks, can give you a clear and useful picture of the network's capacity, efficiency, and where you can make improvements in dynamic urban VANET conditions.

The routing overhead plot shows a detailed distribution all of the control traffic on all nodes within the VANET. The contribution of each node to routing overhead is visualized, and it is possible to determine the areas where control messages are concentrated as presented in **Fig. 6** Nodes of greater overhead can become a very important factor in sustaining network connectivity e.g. by being used as intermediates on several routing paths. Nevertheless, over-scheduling of traffic at these nodes may cause resource wastage, possible traffic congestion and higher energy consumption especially in congested or overly dynamic urban VANET situations. The visual emphasis of these high-overhead nodes makes the figure useful in identifying potential areas to eliminate routing protocol inefficiencies and optimization opportunities.

where O_i is the total routing overhead for node i, C_{ij} represents the number of control packets sent or forwarded by node i for communication with node j, and N is the total number of nodes in the network. This metric enables the analysis of how control traffic is distributed spatially and identifies nodes that may become bottlenecks due to excessive routing activity.

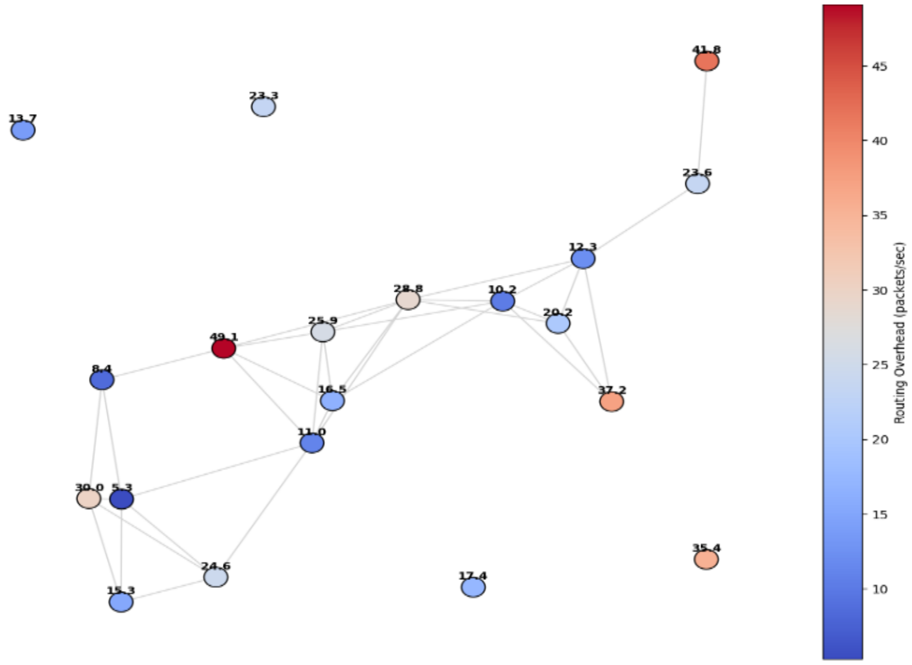

Fig 6. Routing Overhead Spread Across Nodes.

Quantitatively, the routing overhead for a node i can be expressed as:

$$O_i = \sum_{j=1}^{N} C_{ij} \tag{4}$$

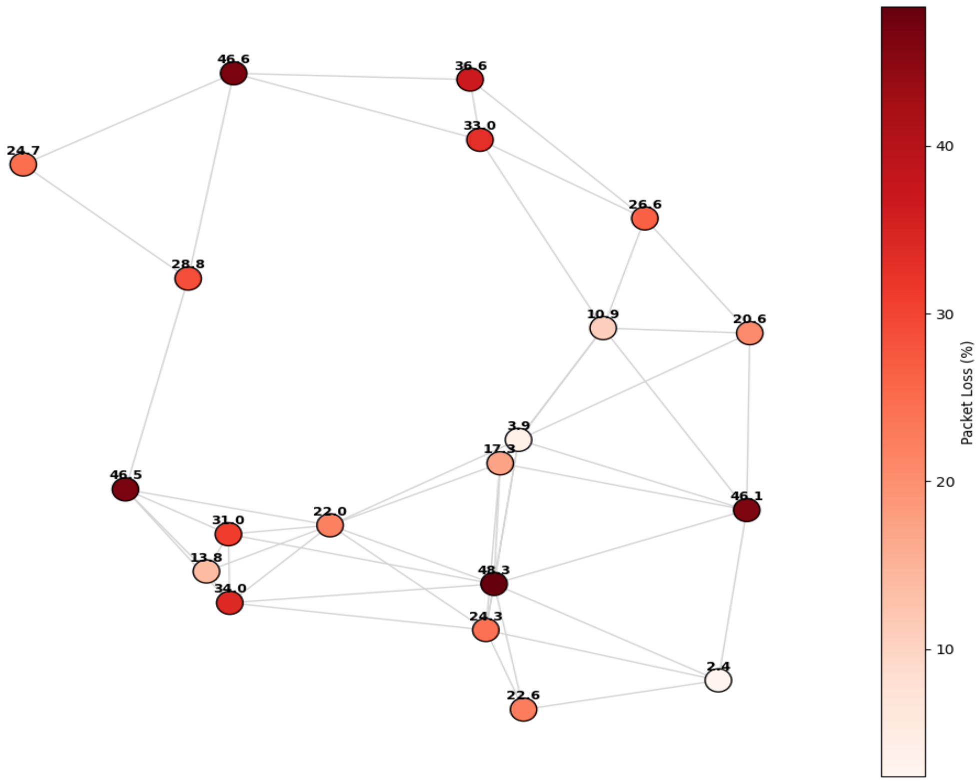

Fig 7. Packet Loss Hotspots.

The nodes that have high overheads tend to indicate regions that experience many changes in topology or regions that have many connections, meaning that the update is proactive or requires the discovery of the routes frequently. The suggested model reduces the needless control traffic through the choice of the more stable and efficient routing paths to attain robust connectivity with the minimal overhead reduction. In general, the figure does not only visually depict control traffic hotspots but also contributes to the efficiency of intelligent routing mechanisms in efficient resource and network performance in dynamic VANET settings.

This heatmap provides a clear and intuitive visualization of packet loss distribution across all nodes in the VANET, effectively highlighting areas of network vulnerability as depicted in **Fig. 7** Nodes exhibiting higher packet loss are often located at the network edge or in sparsely connected regions, where connectivity is weaker and path diversity is limited. By directly annotating nodes with packet loss percentages, the figure allows readers to quickly identify critical performance bottlenecks and areas that may require optimization, such as enhanced routing strategies or improved signal coverage.

Packet loss for a given node i can be mathematically expressed as:

$$PL_i = \frac{T_i}{L_i} \times 100 \quad (5)$$

where PL_i is the packet loss percentage for node i, L_i represents the number of packets lost, and T_i is the total number of packets transmitted or expected to be received by the node. This formulation provides a quantitative basis for assessing the reliability of each node and the network as a whole.

High-loss nodes often correlate with low connectivity, longer routing paths, or areas with high node mobility, which can increase the probability of link failures and dropped packets. Analyzing the spatial distribution of packet loss helps in failure analysis, network planning, and protocol optimization, ensuring that critical paths are stabilized and high-mobility areas are adequately supported. The figure also provides evidence for the effectiveness of the proposed model, which demonstrates reduced packet loss by intelligently selecting stable routes and leveraging nodes with higher reliability. Overall, this visualization serves as both a diagnostic and evaluative tool, directly supporting strategies for improving VANET performance in dynamic urban environments.

V. CONCLUSION

The research paper is introducing a new VANET routing framework that aims at enhancing the effectiveness of communication, resource use, and reliability of communication within dynamic city networks. Conventional reactive and proactive algorithms, such as AODV, DSR, or OLSR usually exhibit challenges with high mobility, non-uniform distribution of traffic, and non-uniformity of nodes which leads to length of the end-to-end path, end-to-end delay, control overhead, and packet loss. The suggested model overcomes these issues with the help of intelligent node prioritization, the dynamic path optimization, and the packet loss-sensitive routing. Some metrics used to evaluate nodes with include the throughput, connectivity and the probability of packet loss, which enables the selection of optimal paths that reduce the number of hops and delay at the expense of balancing traffic load. The backbone relays are made using high-throughput nodes, and low-performing nodes are only sidelined which lessens the number of node congestion and enhances the overall performance of the network. The visual presentation of the network and quantitative view of the outcomes of the simulation demonstrates that the proposed methodology is much better than the classical routing algorithms on all fundamental metrics of performance. The approach reduces the routing overhead, packet loss, and less routing overhead with shorter routes, thus surmounting the issues of the approach. These improvements mean that the proposed model can stand a possibility of making the urban VANET more reliable, robust, and efficient. Not only can the performance-aware vehicular communications scalable framework provided by the methodology be utilized in future studies exploring adaptive, context-sensitive VANET routing and yield safer, more efficient, and resilient transportation infrastructures of urban areas, but it can also be applied to further development of the method.

CRediT Author Statement

The author reviewed the results and approved the final version of the manuscript.

Data Availability

The datasets generated during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interests

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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Competing Interests

The authors declare no competing interests.

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