Improving QoS in VANET

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Abstract

The Vehicular Ad Hoc Network (VANET) is a novel and auspicious performance within the Intelligent Transportation Systems (ITS) field. Numerous scholars endeavoured to enhance the VANETs' Quality of Service (QoS) by creating routing procedures that were reliable, scalable, and efficient. One of the most significant issues of vehicular networks is building a routing protocol that guarantees a specific level of quality of service (QoS), as VANETs are distinguished by special properties, including constrained mobility, a very dynamic topology, and high node speed. For drivers to be able to make the right decisions, communication between vehicular nodes must be highly reliable. Link breakdown issues typically lower the quality of service (QoS) of a vehicular ad hoc network (VANET). This, in turn, lowers the following parameters that influence the QoS. This method depends on a for parameter Packet parameter of Delivery Ratio (PDR), Packet Loss, Delay of End to End, and Throughput. The simulation results show that the proposal protocol has increased the longevity effectiveness of the network by around (PDR) 93%, Loss of packet 6%, (E2ED) 45.6 seconds, and Throughput 1500/ bps.

Keywords- Vehicular Ad, Hoc Network, Routing protocols, QoS.

I. Introduction

A. *Overview of Vehicular Ad-hoc Network (VANET)*

In most cities worldwide, vehicular ad hoc networks have been established and created In the past few years. Wireless communications between the road network's components allow VANET to add information to it [1]. The growing number of vehicles on the road has substantially increased traffic congestion and road accidents. Smart cars are poised to represent the future of the automotive sector. Most newly manufactured vehicles are now equipped with communication modules that facilitate the transmission and reception of data for various functions, including insurance requirements, vehicle security, and safety enhancements[2]. Vehicular networks are a subclass of Mobile Ad Hoc Networks (MANETs), which can establish themselves on their own without requiring any pre-planned infrastructure[3][1]. VANETs, however, are ad hoc networks and capable of opportunistically communicating with Roadside Unit (RSU) infrastructure. The infrastructure of the designed network has become a vital component for numerous IT organizations. There is an urgent need to facilitate future expansion in a reliable, scalable, and secure manner. Consequently, the design process necessitates that the designer thoroughly assess the client's specific context, including the current technology, applications, and data architecture[4]. The concept of infrastructure-to-vehicle communication is relatively nascent and remains in its early stages of development. This technology is anticipated to revolutionise transportation, improving travel safety, efficiency, and air quality. Current wireless communication standards employed in infrastructure-to-vehicle (I2V) communication systems encompass Wi-Fi, Bluetooth, Radio Frequency Identification (RFID), and Dedicated Short-Range Communication (DSRC)[2]. These letters provide access to local or online databases[5]. In a VANET, automobiles use Dedicated Short Range (DSRC) and other cutting-edge wireless technologies to interact with one another by acting as a router[6]. As demonstrated, these DSRCs are devoted to Vehicles to Infrastructures (V2I), Vehicles to Vehicles (V2V), and Mixture Communication. Fig 1. Quality of service is considered one of the hardest challenges in VANET. Due to changes in network topology, It is challenging to ensure QoS criteria, and the state information that is currently available for routing is inaccurate. Researchers took into consideration several levels of the VANET protocol stack in order to achieve QoS.. They focused mainly on addressing QoS by developing strong routing protocols for automobile networks and

VANET QoS optimisation. The primary goal of the QoS routing protocol is to ensure the caliber of the executed performances. Measures for VANET QoS must be made clear.[5].

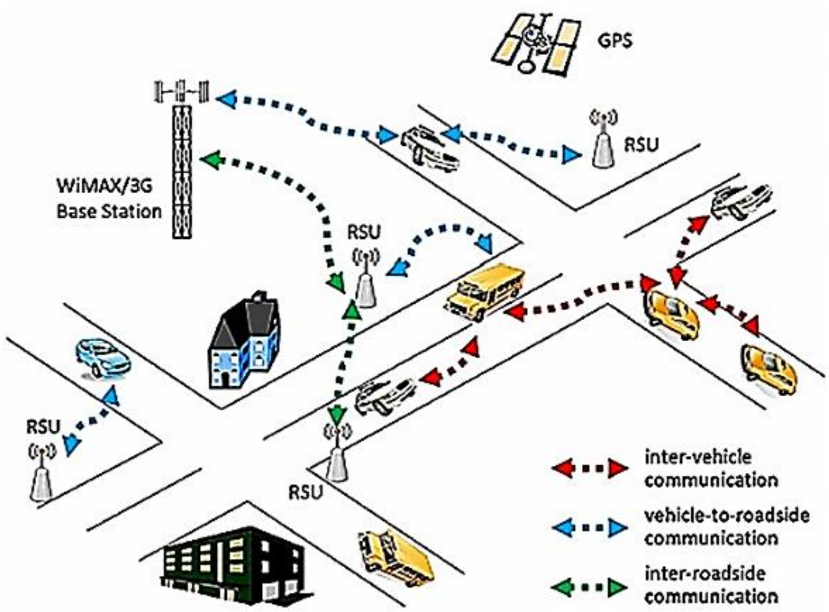

Figure 1. Architecture of VANETs[1]

B. *Quality of Service in VANET*

The network's ability to offer the best feasible service for the specific network traffic is indicated by Quality of Service (QoS). It represents the whole outcome of assistance provision that assesses the degree of satisfaction of a service consumer. Each network layer has a unique set of configurations. Working with QoS is one of the most difficult tasks in the VANET because of poor route selection, insufficient estimation methods, and less accurate QoS. QoS evaluation is crucial for a lot of VANET uses. An app for emergency warnings[7]. The following are a few routing metrics taken into account while assessing VANET QoS routing protocols:

1) End-to-End Delay (E2ED): is used to describe how much time is needed for a package to obtain from the origin to its destination. Network congestion causes delays to grow, which lowers QoS[1].
2) Packet Delivery Ratio (PDR): It is represented as a proportion between the total number of packets sent by the source and the proportion of data packets that reach their destination successfully [8].
3) Packet Loss (PLoss): refers to the inability to comprises one or more packets that were sent to reach their intended recipient; network congestion or data transmission faults are the causes of this problem. The fraction of lost packets compared to sent packets is used to calculate the loss of packets [9].
4) Throughput: is used to describe the average number of successfully transmitted bits during a communication channel's time slot. The transmission range, number of hops, and node mobility are the factors influencing the Throughput [10].
5) Bandwidth: The speed at which packets may be moved via a network channel or connection is measured by its bandwidth [1].
6) Jitter: It speaks about the variance of the delay, or the difference between the highest and least (E2ED) delays. The variation in consecutive packet queuing delays is what causes it [9].
7) Overhead: Because data packets and routing packets frequently share network bandwidth, routing packets are regarded as a network overhead [1].
8) Connectivity Probability (CP): The metric that may quantify the effect of node mobility on network connectivity is the connectivity probability. It is capable of capturing the crucial characteristics of a network when node positions and connection statuses fluctuate over time[1].
9) Network load(NL): Its definition is the proportion of cars that receive duplicate copies of messages and the total number of hello messages needed to transfer a packet [1].
10) Normalised Routing Load (NRL): It shows the proportion of data packets delivered at the destination to routing packets transmitted; Each hop is counted independently [11].
11) Normalised overhead Load (NOL): The ratio of the total number of routing packets to the total number of properly delivered data packets is shown by this statistic. NOL indicates the additional bandwidth used as a result of routing packets [12].
12) Average Routing Replay ratio (ARRr): The mean proportion of route response packets transmitted from all network nodes if they are route request destination to all route requests made by all source nodes is what's meant to be understood [13].

13) Average Routing Discovery time (ARDt): It shows the typical amount of time that elapses between submitting a route inquiry and getting a route reply from a certain location[13].

14) Routing Request Rate(RReq): the rate of all proportion inquiry sent to all packets effectively received at the intended vehicle [14].
15) Link Failure (LF): It speaks of the typical quantity of link failures that occur during routing. This indicator demonstrates how well the routing mechanism prevents link failures [14].
16) Percentage idle time: It is the mean inactivity, expressed in seconds, that a node senses. When a node neither sends nor receives packets, it considers the channel idle [15].

QoS evaluation metrics In studying this network, (E2ED), (PDR), (PLR) and Throughput were relied upon because they are the most common and used in networks as well as in research.

C. Routing Protocols That Aim to Improve QoS

Routing protocols is classified into three different categories[16]:

1) Proactive Protocol: These protocols, also known as table-driven protocols, keep track of each node using the routing table. The routing table specifies the road to use for sending packets over. Even though packet transmission is just momentary, routes must be set before packets are transmitted, increasing the overhead routing. Consider DSDV and OLSR.
2) Reactive protocol: Another name for these protocols is "on-demand protocols." when routing paths are not defined. A source node encourages the route discovery phase to find the new path whenever a transmission is necessary. DSR.
3) Hybrid Protocol combines proactive and reactive elements, leveraging their respective benefits.

This approach simulates movement and dynamically updates neighbours to account for vehicle mobility, which is important in a VANET context where node mobility and topology change quickly. This aligns with the difficulties encountered. By reactive protocols.

The aim of our suggested protocol, as previously mentioned, is provided below:

1) The QoS (Quality of service) is also enhanced because the Packet Delivery Ratio(PDR) increase implies better communication reliability and reduced packet loss and reduced delay influenced by factors like vehicle number, network congestion, varying transmission distances and vehicle mobility.
2) Determining a reliable connection between the source vehicle and neighbouring vehicles
3) Identifying a parent-neighbouring list of vehicles

The remaining portions of the text are arranged as follows: Review relevant literature in section two. Section 3 details the suggested course of action. Sections 5 and 6 contain the simulation results and performance metrics, respectively. The conclusion is provided in portion 7, the last portion.

II. RELATED WORK

Numerous routing protocols have been suggested to enhance QOS in VANETs. Several recommended routing protocols are covered in this section.

Akshat Srivastava et al.(2020) [17] The quality of service (QoS) literature for vehicular ad hoc networks (VANETs) is discussed in this research. The application of Multiprotocol to increase end-to-end latency and decrease packet loss is mentioned as a way to improve QoS. A technique for improving path allocation performance that addresses problems like poor performance and packet transmission delays is the Dynamic Source Routing Protocol.

Arindam Debnath et al.(2021) [18] When compared to other existing methods, this novel strategy that is being presented enhances the Quality of Service (QoS) during the V2V connection, hence lowering the (E2ED), increasing the (PDR), and reducing the number of Control Packet Overhead. Furthermore, this proposed method illustrates the greatest data transfer compared to all other approaches.

Alvaro T et al.(2022) [19] This research article examines and assesses vehicle network routing methods, emphasising high-density warning message transmission. Few studies have concentrated on warning messages, while many have examined VANET protocols in sparse networks for noncritical information delivery. The difficulties that DTN protocols encounter in high-density situations are highlighted in the study. Evaluation measures were utilised to assess the performance of DTN and VANET protocols in various scenarios, including Delivery Rate, (E2ED), Overhead, and Average Number of Nodes.

Chang Guo et al.(2022) [20] suggested an adaptive V2R communication technique in which the data delivery time is considered as a performance indicator throughout the RSU selection process. We have developed a novel method that considers dynamic elements including vehicle moving distance, RSU coverage, and traffic density during uplink. Moreover, the derived optimisation model expanded the suggested approach to a broader context. In the fundamental case of two RSUs, our suggested adaptive V2R communication technique achieves better packet delivery proportion and data delivery time than the random and shortest distance selection algorithms.

Hafida Khalfaoui et al.(2022) [21] This suggested using a Fuzzy-Bayesian (FB) technique to measure the quality of service (QoS) in

VANETs. To develop a tool for anticipating issues that could interfere with the network's functioning ability, the latter begins by analysing the risks associated with VANET. As a result, this method makes it possible to investigate how input parameters, such as data processing, routing, and security, affect VANET QoS. Subsequently, the risk can be mitigated or completely removed to protect system connectivity and prevent issues with transport disruption that could result in extra expenses, distribution delays, and eventually, discontent.

Ref. And year	Objectives
2020[17]	To review quality of service (QoS) in VANETs. Explain challenges facing QoS in VANETs. Provide a review of data dissemination types.
2021[18]	To enhance Quality of Service (QoS) in VANET. Minimise link breakage between source and forwarding vehicles. Define an Effective Region (E-Region) for vehicle selection. Maximise data transmission rates in high vehicle density. And improve Packet Delivery Ratio (PDR) in the network.
2022[19]	To assess DTN and VANET protocols for warning message transmission. Evaluate performance in high vehicular density scenarios. Analyse the impact of transmission range on communication. And compare delivery rate, delay, overhead, and hops metrics.
2022[20]	To analyse data delivery delay quantitatively in V2R communication. Propose an adaptive V2R communication strategy for routing choice. Minimise total data delay in V2R communication procedures. And evaluate the performance of the proposed algorithm through simulations.
2022[21]	To measure QoS in VANET using a Fuzzy-Bayesian approach, study input parameters' influence on QoS in VANET. Identify risks affecting QoS in VANET and propose a model for predicting QoS issues.

III. PROPOSED PROTOCOL

A. *Proposed Design Assumptions*

This document presents a simulation framework designed to replicate a VANET network scenario with a focus on observing high Quality of Service (QOS) degradation. designed to improve QoS It is implemented in VANET to improve (PDR), Packet Loss (PLoss), (E2ED) Delay and Throughput. The following are the assumptions used in the network model:

1) the messages send dynamically from sender to receiver which aligned with how reactive protocols acting by finding routes on Demand without depending on routing table
2) the vehicles send the message and updated their neighbors which make the route dynamic
3) Unlike proactive protocols that periodically update routing tables, your implementation does not involve maintaining and updating a global routing table at each node. Instead, routing decisions are made when needed.
4) The implementation accounts for vehicle mobility by dynamically simulating movement and updating neighbors, which is crucial in a VANET environment where node mobility and topology changes are rapid. This is consistent with the challenges addressed by reactive protocols.

B. *Initial Stage*

As illustrated in Fig 2.this document delineates the process of data transmission within a vehicular communication network. Initially, defining the number of variables involved is essential, specifically the number of vehicles (V) and the number of Road Side Units (RSUs). Vehicles disseminate their information to neighboring nodes, which may include other vehicles or RSUs. The system evaluates whether the communication range between vehicles is less than or equal to 10 meters. If this condition is met, vehicles transmit packets directly to other vehicles within the specified range. Conversely, if the vehicles are outside the range, packets are relayed through the RSUs.

Following packet transmission either directly to neighboring vehicles or via RSUs the system updates the status of the receiving nodes. Subsequently, the system updates the positions of the vehicles within the network at each time step to accurately reflect their mobility.

Additionally, the status of the RSUs is updated in accordance with their operational status and connectivity. Finally, several key network metrics are calculated, including:

1) Packet Delivery Ratio (PDR): This metric represents the ratio of successfully delivered packets to the total packets transmitted.
2) Packet Loss Rate: This percentage quantifies the proportion of packets lost during the transmission process.
3) End-to-End Delay: This refers to the duration required for a packet to traverse from the source to the destination.
4) Throughput: This metric indicates the rate at which data packets are successfully transmitted across the network.

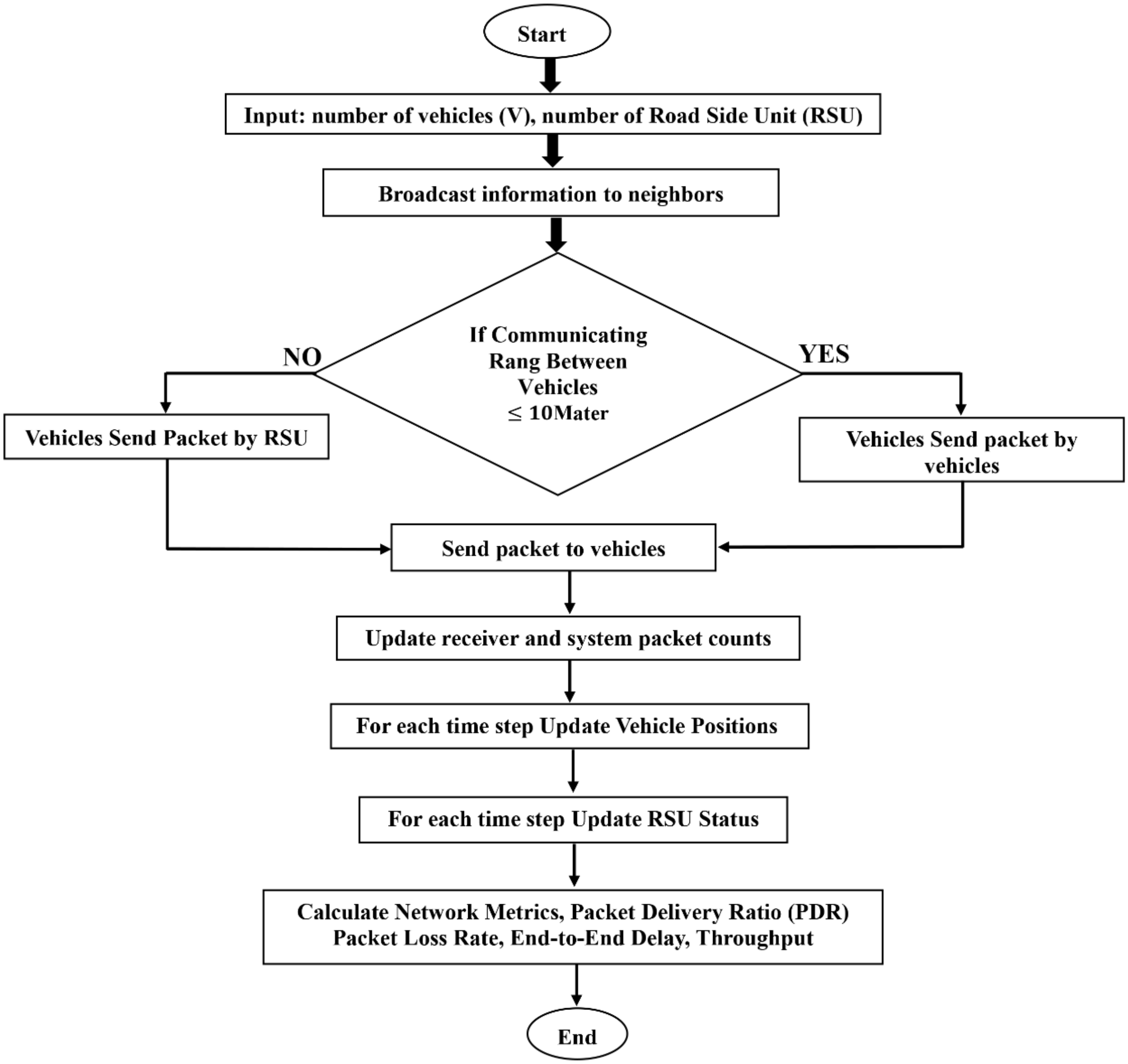

Figure 2. The proposed system architecture in the VANET environment.

The proposed protocol utilises a more selective forwarding mechanism, encompassing strategies such as identifying the top V neighbours and implementing a dynamic broadcast probability to enhance reliability. The forwarding decisions are informed by metrics such as the distance to the destination and speed alignment, necessitating computations and comparisons. Furthermore, the protocol incorporates a retry mechanism for packet retransmissions and acknowledgement exchanges, which contributes to improved delivery rates, as evidenced by the results of the packet delivery ratio (PDR) analyses.

IV. SIMULATION RESULTS AND ANALYSIS

A. simulation parameter

The code simulates a VANET environment using Python, incorporating classes for vehicles, roadside units (RSUs), and the network itself. It leverages the NetworkX library for graph-based network representation and Matplotlib for visualization.

Table (1) : Simulation Parameter

Component	Description
Number of vehicles	10
Number of RSU	2
Number of side	2
Max delay	0,01
Distance between vehicles	Less than 5

B. QoS evaluation metrics

To implement the proposed routing protocol, a network environment consisting of four parameters:

Packet Delivery Ratio (PDR): It can be defined as the proportion of data packets transmitted by the source to data packets that have reached their destination successfully [22].

$$PDR = \frac{Number\ of\ packets\ received\ at\ sink}{Total\ number\ of\ packets\ sent} \quad (1)$$

Packet Loss Rate (PLR): is the ratio of the total number of packets sent by the source to the total number of packets received by the sink. It's established as [22].

$$PLR = \frac{\text{total number of sent packets} - \text{total number of received packets}}{\text{total number of transmitted packets}} \times 100\% \quad (2)$$

End-to-End Delay (E2ED): is the interval of time between the time a packet is generated at the source and the time it is received at the sink [22].

$$ETE = \text{Short Range Communication packet time} - \text{Dest packet time} \quad (3)$$

Throughput: The ratio of the number of packets transmitted and received to the total time needed is referred to as throughput[23].

$$\text{Throughput} = \frac{\text{total number of sent packets and received packets}}{\text{Time}} \quad (4)$$

C. Results of scenarios

two scenarios are designed in the proposal protocol. The performance parameters adopted in the evaluation are (PDR), Packet Loss (PLoss), (E2ED) and Throughput.

1) Scenario of ten vehicles and one Roadside Unit(RSU)

This scenario illustrates a functioning vehicular network with some communication delays and packet loss, but well within acceptable limits overall. The distances between vehicles are relatively short, which contributes to low end-to-end delays. However, the packet loss indicates that while the network performs well, there is still room for improvement in reliability.

Fig.3. illustrates a vehicle network with a central Roadside Unit (RSU) connected to various vehicles represented by numbered nodes.

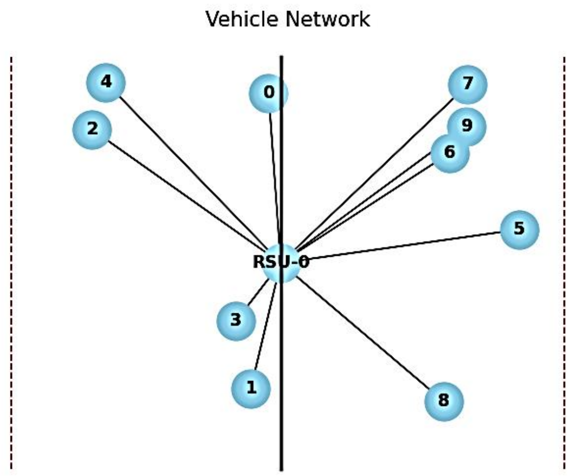

Figure 3. vehicle network of scenarios1

The computed QOS parameter is displayed in Table 1; The table provides performance metrics typically used to evaluate the quality and efficiency of network systems PDR of 83% means that 83% of the packets sent by the source successfully reached the destination. The remaining 17% were lost during transmission. A PDR of 83% is moderate but could be improved depending on the application requirements. A packet loss rate of 17% means that 17 out of every 100 packets sent were lost, likely due to congestion, interference, or other network issues. Packet loss can degrade the performance of real-time applications like video streaming and voice calls, as well as data integrity in critical systems. Reducing the packet loss rate is often a priority in network optimisation. An end-to-end delay of 20.16 seconds is relatively high. This level of delay is unacceptable for real-time applications (e.g., online gaming, video conferencing) but may be tolerable for non-time-sensitive data transfers. Lowering the delay is critical for improving user experience in time-sensitive applications. High delay might indicate congestion, inefficient routing, or low bandwidth.

A throughput of 1000 packets per second indicates that the network can deliver 1000 packets to the destination every second. Higher Throughput reflects better network capacity and efficiency. This metric is critical for assessing the network's ability to handle large data volumes.

Table (2): presents the result of Scenario 1 of the Network

Metric	Value
Packet Delivery Ratio (PDR)	83(%)
Packet Loss Rate	17(%)
End-to-End Delay	20.16(second)
Throughput	1000(pbs)

2) Scenario of ten vehicle and two Roadside Units (RSU)

In this scenario, we are examining a communication network among several vehicles, denoted as Vehicle 0 through Vehicle 9. and with two RSU. The scenario is characterised by good network conditions, meaning that the communication between vehicles is generally reliable.

Fig.4. depicts the network of communication between cars. Automobiles are able to speak with one another. via the RSU or the car next to them. Network for vehicle communication that minimises packet loss and allows efficient message exchanges. Despite the one packet loss incident, the network appears to be operating efficiently in ideal circumstances based on its high packet rate delivery and short (E2ED) latency. The effectiveness of dialogue is also significantly influenced by the distances between cars, with closer cars typically having higher connectivity.

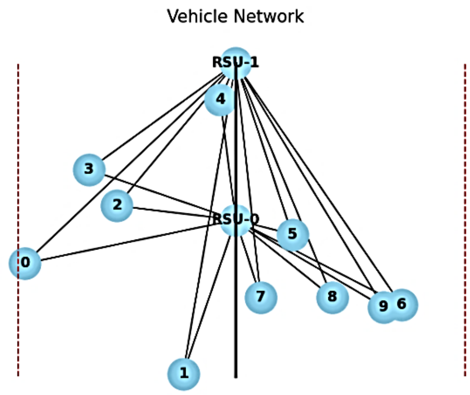

Figure 4. Vehicle network of scenarios2

The computed QOS parameter is displayed in Table 3, a performance metric commonly used to evaluate network or communication system performance. A higher PDR indicates better reliability and network performance. A value of 93% means that 93 out of every 100 packets are successfully delivered to the destination. The network is efficient, with only a small percentage of packets lost during transmission. Packet loss can occur due to network congestion, hardware issues, or errors in transmission. It affects the quality of communication, especially in applications like video conferencing or streaming. A loss rate of 6% is relatively low but may still impact applications requiring real-time data transfer. In applications like video conferencing or online gaming, low end-to-end delay is critical for smooth performance. Higher delay can lead to lag or latency issues. A delay of 45.6 seconds is quite high, which may indicate issues such as network congestion, long transmission paths, or insufficient bandwidth. Higher Throughput reflects better network performance and capacity to handle large data traffic. A throughput of 1500 pbs suggests the network can efficiently transmit a substantial amount of data.

Table (3): presents the result of Scenario 2 of the Network

Metric	Value
Packet Delivery Ratio (PDR)	93(%)
Packet Loss Rate	6(%)
End-to-End Delay	45.6(second)
Throughput	1500(pbs)

Analysis of the metrics collectively provides insights into network performance. The PDR (83%) and Packet Loss Rate (17%)moderate reliability, with room for improvement to enhance packet delivery. The End-to-End Delay (20.16 seconds) suggests high latency, which might affect real-time services. The Throughput (1000 pbs) is decent, but combined with the high delay and loss rate, it suggests the need for optimisation.

D. Stability Period

Stable time frame is one the main performance metrics used for evaluate any technique utilising sensor networks. Fig 5. Presents a system evaluation of metrics for a scenario involving one Road Side Unit (RSU) in a network system. The metrics are analysed based on four The Packet Delivery Ratio indicates the percentage of data packets successfully delivered to the intended receiver compared to the total packets transmitted. A PDR of 83% suggests that most of the packets are successfully reaching their destination, which reflects reasonably good network performance. The Packet Loss Rate represents the percentage of data packets that were lost during transmission. With a loss rate of 17%, the system has some packet delivery challenges, potentially due to interference, congestion, or hardware limitations in the network. End-to-End Delay This measures the average time taken for a data packet to travel from the source to the destination. A delay of 20.16 seconds is relatively high, which might indicate inefficiencies in routing, network congestion, or distance between nodes in the system. Throughput is the rate at which data packets are successfully transmitted through the network. A throughput of 1000 pbs demonstrates a high capacity for transmitting data, which is essential for maintaining system performance in real-time applications.

The system with one RSU shows reasonable performance but has room for improvement, especially in terms of packet loss rate and end-to-end delay. The high Throughput indicates the system is capable of handling a significant amount of data, but the relatively high delay and packet loss may impact time-sensitive applications such as video streaming or real-time communications.

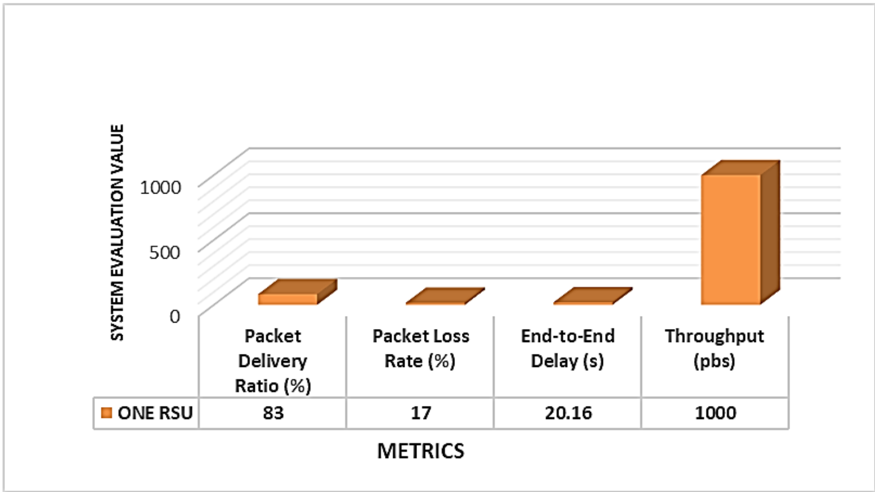

Figure 5. Stability Period system evaluation of metrics of scenarios1.

Fig 6. Represents execute the scenario utilising the same four parameters while assessing the system with respect to two Roadside Units (RSUs). (PDR) (%)This metric indicates the percentage of successfully delivered data packets from the source to the destination compared to the total packets sent. A value of 93% shows that the system is highly reliable in delivering data packets, with only 7% of the packets being lost.and Packet Loss Rate (PLR) (%)This metric represents the percentage of packets that were not successfully delivered to the destination. A low value of 6% complements the high Packet Delivery Ratio, suggesting that the system's communication is efficient with minimal losses.End-to-End Delay (seconds)This metric measures the total time taken for a packet to travel from the source to the destination. The average delay of 45.6 seconds indicates the time lag in the system's communication. While this might be acceptable for some applications, it may be high for time-sensitive systems like real-time monitoring or autonomous driving. Throughput (pbs)This metric quantifies the rate at which data packets are successfully transmitted over the network. A throughput of 1500 pbs signifies high system capacity and performance in handling data traffic.

The performance of the two RSUs seems satisfactory overall, though optimisation might be necessary to reduce the delay further for time-sensitive applications.

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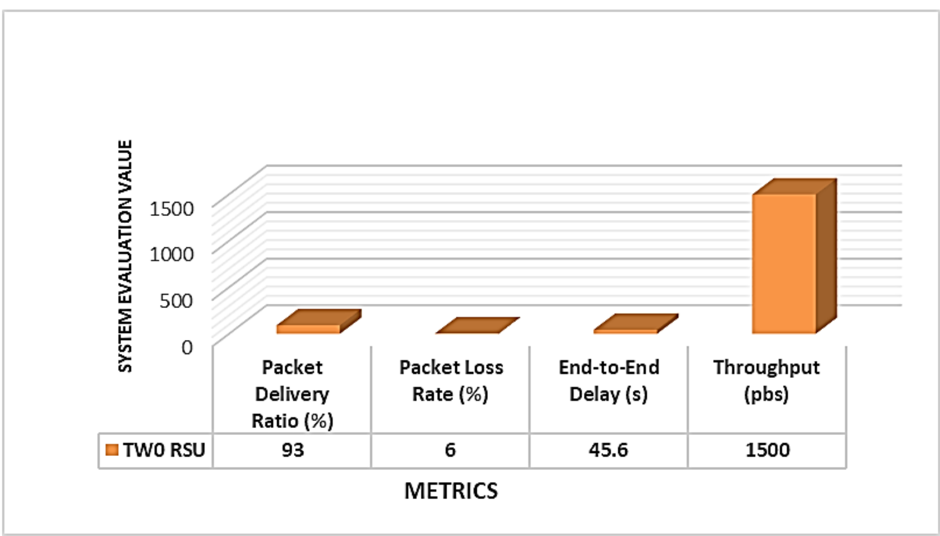

Figure 6. Stability Period system evaluation of metrics of scenarios2.

Through Figure 5,6, we show that expanding the RSU count enhances the network by increasing the number of (PDR), reducing delay, and reducing Packet Loss. It also reduces the distance between the sender and the recipient.

E. Possible Improvements

The possible Improvements are Reducing congestion,. Optimising routing protocols and increasing bandwidth to reduce packet loss and delays. Implement error correction mechanisms to recover lost packets, prioritise critical packets to improve PDR, and reduce delay.and Network Hardware. Upgrade hardware to handle higher data rates efficiently. This detailed evaluation helps understand current network conditions and identify areas for enhancement.

V. CONCLUSION

This paper simulation provides a framework to analyse the performance of VANETs under different network conditions. Topological category protocols are simulated under various test conditions, including vehicle speed and density. The VANET's communication is impacted by QoS. By varying parameters, like packet loss likelihood and network delay, one can study the impact on network performance metrics like PDR, Packet Loss, end-to-end delay, and Throughput. Produces (PDR) 83%, Packet Loss 17% (E2ED) 20.16 seconds, and Throughput 1000/bps. However, after we had only one RSU, while utilising two RSUs, it produced (PDR) of 93%, Packet Loss of 6%, (E2ED) of 45.6 seconds and Throughput of 1500/ bps. The network performs better regarding packet loss, delay, and transmission when two RSU antennas are used.

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