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Survey and Review on Various Topology and Geographical based Routing Protocol Parameters to Ensure the QOS Parameters of VANET

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Abstract— Vehicular Ad Hoc Network (VANET) is a type of wireless network that allows communication between vehicles and infrastructure. One of the critical considerations in VANET is Quality of Service (QoS) parameters, which determine the network's performance. The effective management of QoS parameters is essential for VANET's reliable and efficient operation. In this research paper, we aim to explore topology-based and geographical-based routing protocol parameters to ensure QoS parameters in VANET. The former uses the network topology to make routing decisions, while the latter uses the location information of vehicles. We will first provide an overview of VANET and QoS parameters. Then, we will delve into the key parameters of topology-based and geographical-based routing protocols and how they affect QoS. We will also survey and review the existing routing protocols and parameter values used in these protocols. The findings of this research paper will provide insights into the effective management of QoS parameters in VANET and contribute to the development of more efficient routing protocols.

Keywords- Vehicular Ad Hoc Network, Quality of Service, topology-based, geographical-based

I. INTRODUCTION

Vehicular Ad Hoc Network (VANETs) are a specialized form of Mobile Ad-hoc Networks (MANETs) and is formed by vehicles on the road and enables them to communicate with each other and roadside infrastructure. VANET has applications in improving road safety, traffic management, and providing infotainment services to passengers [1]. The unique network characteristics of VANET are classified, and five distinct communication patterns form the basis of almost all VANET applications [1]. VANET has a high potential to improve Quality of Service (QoS) and road safety [1][2]. However, VANET is confronted with challenges such as high energy consumption and link instability [2]. QoS in VANET depends on parameters such as bandwidth, packet delivery ratio, data latency, delay variance, etc. [1]. VANET can be used in both highway and urban areas [1]. Furthermore, VANET has seen many envisioned applications such as data dissemination and multimedia communications [1]. Additionally, VANET can achieve significant performance improvement with QoS routing algorithms, and it can be used for applications such as voice over IP (VoIP) traffic [1]. VANET is a challenging class of mobile ad-hoc networks, which is a subcategory of Mobile Ad-hoc Networks (MANETs) [1][2]. Improving Quality of Service (QoS) is a significant research topic in VANET, and various QoS parameters are being analyzed in this field. Various performance metrics are used to evaluate and compare the efficiency of routing protocols in VANETs. While the text does not provide a specific definition for QoS parameters in VANET, research has identified different layers of the VANET protocol stack that can be targeted to achieve QoS [3]. These QoS parameters include Packet Delivery Ratio, end-to-end delay, routing overhead and Throughput [3].Packet Delivery Ratio (PDR): The ratio of successfully delivered packets to the total number of packets sent. End-to-End Delay: The average time taken by a packet to travel from the source to the destination. Routing Overhead: The number of control packets generated by the routing protocol. Throughput: The rate at which data packets are successfully delivered over a communication channel. In this paper, the QoS parameters in VANET are analyzed [4]. Research has shown that the AODV protocol produces better Packet Delivery Ratio and Throughput with less Normalized Routing Overhead in VANET simulations [5]. Other QoS parameters analyzed in VANET include Packet Delivery Ratio, Throughput, Avg. E2ED, and Normalized Routing Overhead. For instance, the OLSR protocol produces less Avg. E2ED compared to other protocols in VANET simulations [5]. In addition, the influence of vehicular density and speed on QoS parameters is evaluated in VANET simulations [5]. Therefore, a comprehensive analysis of various QoS parameters in VANET is essential for developing efficient vehicular communication systems. Ensuring QoS parameters in VANET is of utmost importance due to several reasons. Firstly, access point conditions, which are indicated by available bandwidth, play a major role in voice and video traffic, making it necessary to maintain QoS parameters at all times [6]. Secondly, the authors themselves consider ensuring QoS parameters important in VANET [6]. To make the resource allocation decision fairer, important network parameters have been chosen for their priority level computing function [6]. Additionally, QoS parameters indicate the quality of service in the transportation network, making it vital to ensure their maintenance [6]. The IEEE 802.11e standard's EDCA is the preferred channel access for ensuring QoS in VANETs, with its four access categories supporting priority-based service [6]. Ensuring QoS parameters is also important in VANETs due to the rapid changes in topology and different kinds of applications for which transmission will be established [6]. Routing algorithms, coupled with powerful congestion control mechanisms, are needed to balance network traffic and maximize channel utilization along with new routing schemes with Quality of Service (QoS) developed for VANETs [7]. Moreover, QoS parameters are particularly important when the system is close to congestion, with the weights of precedence class and packets waiting time parameters having the highest values [6]. Prioritizing network parameters based on their significance to priority level computing is also critical in ensuring QoS parameters [6]. These weights can be estimated and monitored by the access point of the roadside infrastructure based on vehicle density in its coverage area, adding another layer of importance to maintaining QoS parameters in VANETs [6].

II. VANET ROUTING PROTOCOLS

Routing protocols are essential in ad hoc networks as they are responsible for initiating and maintaining routes to facilitate multi-hop communication and extend the service area of the network. VANET routing protocols are designed for different scenarios considering the main characteristics and constraints in vehicular networks, such as mobility of nodes, interference, and bandwidth limitations. This article focuses on the two primary categories of routing protocols for VANETs: topology-based and geographical-based. Topology-based routing protocols use the information about network topology and links between nodes to make routing decisions. Geographical-based routing protocols, also known as position-based or location-based protocols, use geographical information about nodes to make routing decisions. Nodes are required to know their own and their neighbors' geographical positions, typically obtained through Global Positioning System (GPS) devices.

A. Topology Based Routing Protocols

Topology-based routing protocols are a type of routing protocol for FANETs. Researchers have attempted to adapt existing routing protocols to fit into FANETs; however, these protocols are not suitable for highly dynamic FANETs due to their uniqueness [8]. Topology-based routing methods utilize information from nodes' links to distribute packets [8]. Routing protocols identify nodes using IP addresses in the network, and each router has prior knowledge only of networks directly attached to it [8][9]. The routing algorithms determine the specific route choice and share this information among immediate neighbors and throughout the network. This way, routers gain knowledge of the network's topology [9].

There are three categories of topology-based routing protocols: proactive, reactive, and hybrid routing protocols. Proactive routing protocols, also known as table-driven protocols, maintain up-to-date routing information for all nodes in the network. Each node continuously updates its routing table, which leads to significant control overhead. Some examples of proactive routing protocols include Destination-Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR). Reactive routing protocols, also known as on-demand protocols, establish routes only when required by the source node. Route discovery is initiated by broadcasting route requests, and the destination node responds with a route reply. Some examples of reactive routing protocols include Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Hybrid routing protocols combine the advantages of both proactive and reactive protocols. They partition the network into zones and apply proactive routing within the zones, while using reactive routing for inter-zone communications. Zone Routing Protocol (ZRP) is an example of a hybrid routing protocol. Each protocol has its own advantages and disadvantages and is suitable for specific applications [8]. Topology-based routing protocols enable routers to communicate with each other and select routes between nodes on a network, allowing them to dynamically adjust to changing conditions such as disabled connections and components, or route data around obstructions [9]. For FANETs, which have subcategories of topology-based routing protocols, including Proactive, Reactive, Hybrid, and Static, three-dimensional space, time-dependent, and path-planned mobility models are widely adopted for various application scenarios. Topology-based routing protocols are compared based on characteristics, routing mechanisms, mobility models, performance measurements, simulation tools, and application scenarios [8].

B. Geographical Based Routing Protocols.

Geographical-based routing protocols rely on the physical location of nodes to deliver messages. Initially, these algorithms were developed based on the physical positions of each node to route messages, but they have since been applied to networks where each node is associated with a point in a virtual space, unrelated to its physical position [14]. The process of finding the set of virtual positions for the nodes of a network to ensure the success of geographic routing is called greedy embedding [10]. Geographical routing is primarily used for wireless networks and relies on the idea that the source sends a message to the geographic location of the destination instead of using the network address [10]. Geographic routing requires each node to determine its own location, and the source should know the location of the destination to route the message without knowing the network topology or a prior route discovery [10]. In vehicular ad hoc networks (VANETs), when the source node cannot directly communicate with the destination, the protocol divides the forwarding path into small road segments using location information of vehicles and road map information of nearby areas [11]. Geographic-based routing protocols use routing parameters such as distance, direction, link quality, and traffic density of networks [11]. The road map is divided into segments, and routing is initiated based on the head nodes' physical location in each segment. Geographical-based routing protocols are used in VANETs to improve success rates, dynamic assessment, multi-hop forwarding abilities, and road segment formation. Next segment selection in these protocols is based on high traffic density [11]. Ant colony optimization is used as an optimization method to find the shortest route with minimum distance and route reliability in AODV-R-like ant colony optimization-based routing protocols. These protocols consider the central vehicle for forwarding data packets rather than selecting the outermost vehicle with a higher chance to exit from the transmission range [11]. Geographical-based routing protocols use a carry-and-forward approach to address the disconnectivity problem [11]. However, these protocols involve complex route request processes that can result in network processing delays in vehicular traffic environments [11]. Finally, geographical routing protocols are a type of routing protocol, and the proposed ISR framework is related to geographical-based routing protocols [11].

Geographical-based routing protocols can be further classified into greedy, restricted greedy, and face routing protocols. Greedy routing protocols forward packets to the neighbor closest to the destination. These protocols are simple and efficient, but may suffer from local maxima issues, where a packet gets stuck at a node with no neighboring nodes closer to the destination. Greedy Perimeter Stateless Routing (GPSR) and Greedy Traffic Aware Routing (GyTAR) are examples of greedy routing protocols. Restricted greedy routing protocols impose constraints on the selection of the next hop to overcome the local maxima problem. These protocols use additional information, such as link quality, node density, or road topology, to select the next hop. Some examples of restricted greedy routing protocols include Anchor-based Street and Traffic Aware Routing (A-STAR) and Connectivity-Aware Routing (CAR). Face routing protocols use planar graph traversal techniques to route packets around local maxima. Nodes forward packets along the faces of the planar graph, ensuring that packets eventually reach their destinations. Greedy-Face-Greedy (GFG) and Greedy Perimeter Coordinator Routing (GPCR) are examples of face routing protocols.

III. IMPACT OF ROUTING PROTOCOLS PARAMETERS ON QOS.

A. Key Parameters in topology - based routing protocol that affect QoS

Topology-based routing protocols play a critical role in ensuring efficient data transmission and meeting QoS requirements. Traditional QoS parameters such as available bandwidth, path delay, packet loss rate, and other parameters of available resource allocation are important factors in topology-based routing protocols [12]. However, these routing algorithms may fail to provide trusted routes when there is an attack on the network [12]. To address these challenges, the SDN framework has emerged as a promising QoS-assurance solution [12]. One proposed solution that meets QoS requirements and outperforms others in end-to-end delay, packet loss rate, and network throughput is the multi-layer satellite network model with SDN architecture [12]. The proposed TR model assigns trust values to TRM routing nodes based on discovered trusted transmission paths [12]. The hybrid routing model (HR) combines QoS and transport requirements to provide trusted routes [12]. Topology-based routing protocols use QoS values to order routing table entries, such as the routing table used by the CBQoS-Vanet protocol. The CBQoS-Vanet protocol acquires the best route based on QoS requirements and traffic class [13]. To improve QoS in UAV routing, various solutions such as adaptive FANETs and K-means clustering method could be used [8]. QoS metrics, stability, connection quality, security technology and access control are important criteria to consider when designing an efficient routing protocol for topology-based routing [8]. Various improved routing algorithms have been proposed to address the challenges of topology-based routing protocols, such as the deep-reinforcement-learning-based routing algorithm (DRLR) method and network-coding-based multi-path routing approach [12]. Multi-path routing can greatly improve network throughput and end-to-end delay, such as in the case of the network-coding-based multi-path cooperative routing protocol (NCMCR) that can improve the throughput of LEO satellite networks [12]. The improved ant colony algorithm can reduce path duplication and select high-quality routing paths that meet QoS requirements, addressing the limitations of multi-path routing algorithms [12]. In summary, topology-based routing protocols play a critical role in meeting QoS requirements, and various solutions have been proposed to address the challenges of efficient data transmission in topology-based routing protocols.

B. Key Parameters in Geographical - based routing protocol that affect QoS

In geographical-based routing protocols, Quality of Service (QoS) parameters are critical. The protocols are compared based on standard QoS parameters including reliable data transmission, end-to-end delay, and network lifetime [14]. The link-based parameters that influence QoS in geographical-based routing protocols include delay, reliability, distance to sink, and energy consumption. On the other hand, path-based parameters that affect QoS include reliable data transmission, end-to-end delay, and network lifetime [15]. Additionally, the selection process of nodes in QoS-based routing (QBR) protocol consists of one-hop neighbor nodes to reduce additional energy consumption [15]. QBR is a real-hard probabilistic-based routing protocol that supports event and periodic-based data reporting. It is composed of geographic routing features with QoS provisioning [15]. The protocols are compared based on node density and the number of participating nodes in the simulation comparison to describe the performance behavior of different protocols [14]. In QBR, the node is selected based on residual energy, high link quality, and the path with the minimum load [15]. In summary, QoS parameters are key in geographical-based routing protocols, and researchers have conducted simulations to compare different protocols based on various parameters.

C. Observation

Various parameters play a significant role in determining the QoS in VANET. One such parameter is the SADV, which can increase QoS in real-time but may cause network congestion during peak hours and create a bottleneck problem in emergency scenarios [16]. However, the CAR protocol's use of blind flooding renders it ineffective in improving QoS and potentially burdensome for the network [16]. Local motion characteristics, such as GyTAR and TADS protocols, can predict the next junction, but their density and distribution do not reflect the overall QoS improvement pattern [16]. Increasing vehicle density can improve network connectivity but also cause an increase in data throughput on the network [16]. The inability to adapt to changes in network architecture is a primary issue that affects QoS in VANETs, along with path inaccuracy and the ineffectiveness of QoS assessment in traditional or incomplete protocols [16]. The VANET QoS-OLSR protocol considers distance and velocity of vehicles as mobility metrics within QoS functions. The cluster heads choose a set of optimized MPRs that satisfy mobility and routing constraints. The protocol selects cluster-heads based on local maximal QoS values. Application of the protocol can extend the life of the network by 12%, decrease the percentage of chosen MPRs by 20%, show a 10% improvement in PDR, and reduce path length by two hops. Additionally, efficient dissemination and routing protocols are required to provide QoS support to various VANET applications. Research work has been done to ensure link reliability in VANET routing protocols. The proposed schemes VAR and MOPR predict link breakage and future node positions to provide route durability and stability, which affect QoS in VANET [17]. Checking link breakage rates is necessary before claiming overall performance improvement, and the performance of parameters needs to be validated through simulations [17]. The frequently changing topology, disconnectivity, and variable node density make data dissemination challenging in VANET, so efficient and robust data dissemination is necessary for accident avoidance and after-collision warning in VANET. The resolution of issues such as broadcast storm, network partition, and temporal network fragmentation is necessary to achieve efficient and robust data dissemination for VANET. The AODV-R extends the RREQ message with five new fields containing information about node coordinates, speed, direction, and link reliability to ensure reliable routing and improve QoS in VANET.

IV. PROTOCOLS TO IMPROVE QOS PARAMETERS IN VANET

To improve QoS parameters in VANET, researchers have proposed many different protocols and algorithms. One such algorithm is the meta-heuristic algorithm, which has been shown to improve QoS parameters in VANETs. This algorithm improves the end-to-end delay in routing protocols, making it a viable option for improving QoS parameters in VANETs [18]. The need for QoS improvement in VANETs is widely recognized; however, there are few studies that explore the effectiveness of these protocols in ensuring QoS parameters in VANETs [18]. Despite this, one study showed that the improvement achieved with the meta-heuristic algorithm was comparable to existing multipath routing protocols, indicating that it could be an effective solution [18]. Another approach for calculating QoS parameters locally and avoiding congestion during data transmission involves using the Simple Network Management Protocol (SNMP) to estimate QoS values locally. This approach proposes an improved greedy-forwarding strategy to ensure fast and reliable packet transmission in VANETs [18][19]. Additionally, a new metric called Quality of Transmission (QOT) has been proposed to measure the performance of each road segment in VANETs. QOT combines connectivity with Packet Delivery Ratio (PDR) to measure the performance of each road segment in VANETs. Furthermore, DSR has been shown to be a more effective protocol than AODV for ensuring QoS parameters in VANETs, as it showed more stable and consistent results in QoS evaluation [18]. While more research is needed to fully understand the effectiveness of these protocols in ensuring QoS parameters in VANETs, these studies provide valuable insights into potential solutions for improving QoS parameters in VANETs.

A. Parameters Values in Protocols.

The protocols used in VANET involve several parameters, but the text does not provide any information regarding the parameter values [20]. However, the text discusses the significance of nodes relative to network topology and the calculation of node significance index NI(v) [21]. The local network view is defined as the sub-network associated with the set of vertices in N12(v), which is the combined set of one-hop neighbors and two-hop neighbors of node v [21]. The number of routers it takes to reach the destination is the same as the number of hops, and these protocols use the number of hops to measure distance [20]. In order to improve QoS for VANET, the proposed protocol changes the session key between source and destination nodes after the first period has passed, reducing the likelihood of the key being leaked and increasing the number of packets received by the destination node [22]. The PDR value for the proposed protocol is close to that of SAODV protocols in smaller times, while for times longer than 40 seconds, the PDR value for the proposed protocol is higher than that of SAODV protocols [22]. Furthermore, the key freshness does not seem to affect packet delivery rates much in less recent times [22].

V. DISCUSSION

Routing protocols in VANETs are divided into three categories: geographical, topology-based, and cluster-based routing protocols [23] to ensure Quality-of-Service (QoS) parameters of Vehicular Ad-Hoc Networks (VANETs). This work focuses on the existing topology-based and geographical-based routing protocols. Topology-based routing protocols choose the next hop based on the network topology, which comprises links and nodes. The main advantage of topology-based routing protocols is their ability to adapt to changes in network topology. However, they suffer from high overheads and long path lengths. Examples of topology-based routing protocols are Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR). On the other hand, geographical-based routing protocols use location information to forward packets towards their destination. Geographical-based routing protocols perform better in highly dynamic environments since they do not need to maintain a complete network topology. Examples of geographical-based routing protocols are Greedy Perimeter Stateless Routing (GPSR) and Distance Routing Effect Algorithm for Mobility (DREAM). The paper identified that topology-based routing protocols are crucial for efficient data transmission and QoS provisioning in VANETs. The position-based protocol was found to be the most effective scheme for VANETs due to its reliance on location information of nodes, enabling it to establish an accurate and efficient routing path for data packets. Real-time QoS provisioning protocols were also found to be an effective way to achieve QoS in topology-based routing protocols. The paper evaluated the characteristics of each routing protocol using several parameters and reviewed QoS routing protocols with strengths and weaknesses in Wireless Multimedia Sensor Networks (WMSNs). The results indicated that optimization of routing parameters or functionality to enforce different QoS and achieve high reliability depends on network characteristics and their constraints. Genetic algorithms were also found to be effective in enhancing QoS performance in VANETs, such as the ad hoc on-demand distance vector routing protocol optimized through genetic algorithm.

A. Challenges and Future Directions

The choice of routing protocol depends on the specific VANET's requirements, such as reliability, latency, scalability, and mobility. Designing efficient routing protocols for VANETs is an ongoing research area, with several challenges and future directions to explore. Some key challenges include: Developing routing protocols that can adapt to the dynamic nature of VANETs, ensuring security and privacy in VANET communications, Designing energy-efficient routing protocols for electric vehicles. Integrating VANETs with other communication networks such as cellular networks and the Internet of Things (IoT). However, the study also identified the need for further research to optimize various parameters to ensure better QoS in VANETs and the choice of routing protocol depends on the specific VANET's requirements, such as reliability, latency, scalability, and mobility. Therefore, the discussion concludes that future research should focus on identifying optimal routing protocols and suitable parameters to ensure QoS and reliability in VANETs, taking into consideration the network characteristics and constraints.

VI. CONCLUSION

This paper discusses the challenges faced by VANET, such as high energy consumption and link instability, and proposes various routing protocols, including topology-based,

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geographical-based, and cluster-based routing protocols, to improve QoS parameters. This work acknowledges the need for further research to fully understand the effectiveness of these protocols in ensuring QoS parameters in VANETs. In conclusion, this paper provides valuable insights into potential solutions for improving QoS parameters in VANETs and emphasizes the need for a comprehensive analysis of various QoS parameters in VANET to develop efficient vehicular communication systems.

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