Comprehensive Analysis of Routing Protocols and Mobility Framework for VANET

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Abstract—Vehicular Ad-Hoc Networks (VANET) have gained significant attention in recent years as a promising technology for enabling intelligent transportation systems and smart cities. VANET enables vehicles to communicate with each other and with roadside infrastructure to exchange information about traffic, road conditions, and other relevant data. However, VANET faces several challenges such as high mobility, varying network conditions, and congestion, which traditional routing and mobility protocols may not be able to handle efficiently. Therefore, there is a need for novel approaches to improve the performance of VANET.In recent years; AI-based approaches for Routing Protocols and Mobility Framework have been proposed to address the limitations of traditional protocols. AI-based approaches like Reinforcement Learning, Neural Network, Swarm Intelligence, Deep Reinforcement Learning, Fuzzy Logic, and Genetic Algorithm have shown promising results in improving the performance of VANET. However, the implementation of these approaches in VANET requires significant computational resources, training data, and may be more complex than traditional protocols, which presents practical challenges.In this review, we provide a comprehensive overview of the different routing protocols and mobility frameworks for VANET, as well as the AI-based approaches that have been proposed to improve their performance. We analyze the strengths and weaknesses of each approach and compare them with traditional protocols like AODV. Our analysis highlights the potential of AI-based approaches to overcome the limitations of traditional protocols and improve the performance of VANET. However, we also identify practical challenges that need to be addressed for the implementation of AI-based approaches in VANET.

Key Words: ***VANET, AODV, Routing, V2V, V2I, Machine Learning***

I. INTRODUCTION

Rapid advancements in wireless communication networks have lately made it possible for mobile ad hoc networks to provide inter-vehicular communications (IVC) and road vehicle communications (RVC). IVC and RVC's cooperation resulted in the creation of a new class of MANETs called VANETs. VANETs may be employed as long as each node is mobile and can move within the coverage region. As each vehicle travels along its path, vehicles in the VANET make brief connections with other vehicles they have never met before. These connections may never be renewed. Nodes in VANET move quickly. Therefore, maintaining mobility is a challenging challenge. This problem has been addressed by many academics, but it has not yet been resolved. The Mobile Ad-hoc Network (MANET) is one viable alternative when looking at wireless technology possibilities. A VANET is a subtype of MANET. This technique uses each car as a mobile node in a network that is connected to one another. Wireless communication between moving vehicles and other moving or hauled vehicles is made possible via VANET. Vehicular Ad-hoc Networks (VANETs) have emerged as a promising technology that can improve traffic safety, traffic management, and passenger comfort. VANETs are a subset of Mobile Ad-hoc Networks (MANETs), which consist of mobile nodes that can communicate with each other without any pre-existing infrastructure. The main difference between VANETs and MANETs is that VANETs consist of vehicles that communicate with each other and the infrastructure through wireless links. This unique characteristic of VANETs presents unique challenges for routing and mobility management.[1][2]
Routing in VANETs is a critical issue that requires efficient and reliable solutions. Routing protocols in VANETs must be

able to handle high mobility, dynamic topology, and intermittent connectivity. Several routing protocols have been proposed for VANETs, including position-based, topology-based, and hybrid protocols. However, these protocols have limitations in terms of scalability, efficiency, and reliability.

In this paper, a comprehensive analysis of the design and development of an improved routing and mobility framework for VANETs has been presented. The proposed framework aims to address the limitations of existing routing protocols by combining the advantages of position-based and topology-based routing protocols augmented wuth artifcial intelligence and machine learning applications. The framework also incorporates mobility management to improve the performance of routing protocols in VANETs.

II. VEHICULAR AD-HOC NETWORK

The Vehicular Ad-hoc Networks (VANETs) are a special type of mobile ad-hoc networks (MANETs) that enable vehicles to communicate with each other and the infrastructure. These networks have the potential to improve road safety, reduce traffic congestion, and enhance the overall driving experience. However, the effective functioning of VANETs relies on efficient routing protocols that can handle the high-speed mobility of vehicles, the dynamic topology of the network, and the limited bandwidth available.[3]

In recent years, researchers have proposed several routing protocols for VANETs that address these challenges. This work presents a comprehensive review and analysis of the design and development of an improved routing and mobility framework for VANETs. The paper discusses the introductory concepts, methodologies, applications, and concepts related to the design and development of routing protocols for VANETs. VANETs consist of several vehicles that communicate with each other to share information about traffic conditions, road hazards, and other relevant information. The vehicles in the network can also communicate with the infrastructure, which can include traffic lights, road sensors, and other devices. The communication between vehicles and infrastructure devices can be achieved through various technologies, including Dedicated Short Range Communications (DSRC) and Cellular Vehicle-to-Everything (C-V2X) communication.[4]

Vehicular Ad-hoc Networks (VANETs) are an emerging technology that has the potential to revolutionize transportation systems. VANETs can provide a wide range of applications, including safety-critical applications such as collision avoidance and traffic management, as well as non-safety-critical applications such as infotainment and advertising. The successful implementation of VANETs requires the development of an improved routing and mobility framework that can support the high-speed mobility of vehicles, the dynamic topology of the network, and the limited bandwidth available. This paper provides a comprehensive review and analysis of the design and development of an improved routing and mobility framework for VANETs. It covers the introductory concepts, methodologies, applications, and challenges associated with this area of research.

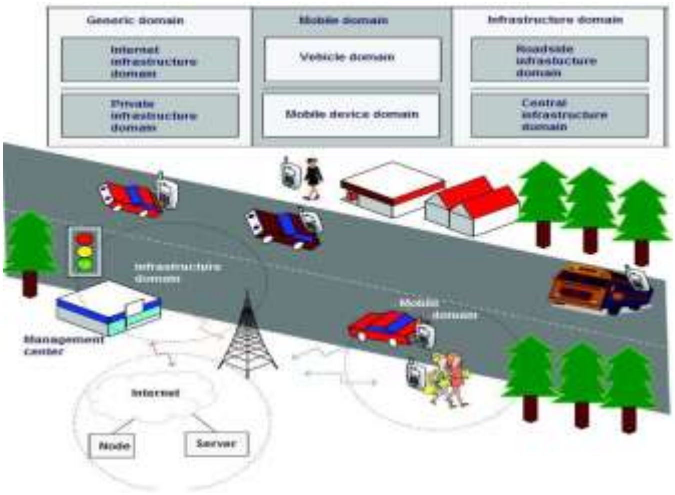

Figure 1.1: VANET architecture

Routing protocols are critical components of VANETs as they determine the most efficient paths for transmitting data between vehicles and infrastructure devices. These protocols must take into account the high-speed mobility of vehicles, the dynamic topology of the network, and the limited bandwidth available.

Methodologies: The design and development of routing protocols for VANETs require the use of various methodologies, including simulation-based testing, field experiments, and mathematical modeling. Simulation-based testing involves using software tools to simulate the behavior of vehicles and infrastructure devices in a virtual environment. This methodology allows researchers to evaluate the performance of routing protocols under various scenarios, including different traffic densities, road conditions, and network topologies.

Field experiments involve the deployment of actual vehicles and infrastructure devices in a real-world environment. This methodology allows researchers to evaluate the performance of routing protocols in a realistic setting and identify any challenges that may arise when implementing the protocols.

Mathematical modeling involves the use of mathematical equations to describe the behavior of vehicles and infrastructure devices in VANETs. This methodology can help researchers understand the performance characteristics of routing protocols and identify any limitations that may need to be addressed.

Improving road safety, decreasing traffic congestion, and increasing the driving experience are just few of the many uses for newly developed routing protocols for VANETs. VANETs have several uses, but one of the most important is allowing cars to communicate with one another in real time to share information about traffic and road dangers. Drivers may use this data to plan safer routes and reduce the likelihood of accidents.[10] [11]

Another application of VANETs is to support the implementation of intelligent transportation systems (ITS). ITS can include several technologies, including adaptive cruise control, collision avoidance systems, and lane departure warning systems. These systems rely on the efficient communication between vehicles and infrastructure devices, which can be achieved through VANETs.

The design and development of an improved routing and mobility framework for VANETs requires the consideration of several concepts, including the use of multi-hop routing, the development of adaptive routing protocols, and the use of quality of service (QoS) metrics. Multi-hop routing involves the transmission of data between vehicles through multiple hops, which can help increase the reliability and robustness of the network.

Adaptive routing protocols are designed to adjust the routing paths based on the current network conditions, including the traffic density, road conditions, and network topology. These protocols can help improve the efficiency of data transmission and reduce the delay and packet loss in the network.

QoS metrics are used to evaluate the quality of service provided by the routing protocols in VANETs. These metrics can include factors such as the packet delivery ratio, end-to-end delay, and throughput. The development of QoS-aware routing protocols can help ensure that the network can support various types of applications, including those with real-time and delay-sensitive requirements. [15][17]

In addition to these ideas, there are a number of problems that need to be taken into account while designing and creating an enhanced routing and mobility architecture for VANETs. The high-speed mobility of the vehicles, the network's changing architecture, the constrained bandwidth, and the possibility of malicious assaults are some of these difficulties.

The design and development of a better routing and mobility framework for VANETs is a challenging endeavor that calls for taking a variety of ideas, approaches, applications, and difficulties into account. Numerous routing protocols, such as multi-hop routing, adaptive routing protocols, and QoS-aware routing protocols, have been proposed by researchers as solutions to these problems. These methods' strengths and weaknesses can be determined by evaluating their effectiveness utilizing simulation-based testing, field tests, and mathematical modeling. By successfully implementing an enhanced routing and mobility architecture for VANETs, we can increase driving comfort, lessen traffic, and increase safety.

III. LITERATURE SURVEY

The position of the vehicle affects the routing protocols employed in a VANET. Therefore, position verification is the fundamental and crucial function that aids in determining the vehicle's destination. Additionally, it protects the VANET's routing against simple assaults.

P Sehrawat et al. 2023 proposed that Vehicular Ad-hoc Network (VANET) is a new research area that provides a basis for creating innovative safety and comfort solutions, but its implementation is a challenge in terms of selecting and creating a routing protocol. High-density dynamic systems of cars are used to assess the performance of topology-based protocols including Ad Hoc on-Demand Distance Vector (AODV), Optimized Link State Routing Protocol (OLSRP), Dynamic Source Routing (DSR), and Destination-Sequenced Distance-Vector. The findings show that protocol DSR works better than TR and OH while protocol AODV performs better than PDR. Researchers can select the ideal routing protocol for VANET architecture with the aid of this study. [1]

In order to improve the effectiveness of the Optimized Link State Routing Protocol (OLSR) in VANETs, **Yang et al. 2023** created a multi-objective particle swarm optimization (MOPSO) framework. By taking into account both QoS and service costs, this system resolves a multi-objective optimization problem (MOP). With the use of genuine VANET circumstances, it is utilized to determine the ideal OLSR characteristics, including Hello and TC intervals. Other dynamic routing protocols in networks can be added using this framework. [2]

Rashid el al. 2022 stated that Reliability Aware Multi-Objective Optimization Based VANETs Routing (RAMO) framework, which is proposed in this paper, has three levels: simulation, routing criteria, and routing algorithm. The creation of Enhanced Gaussian Mutation Harmony Searching (EGMHS), which combines Gaussian mutation, objective decomposition, and a harmony memory extraction technique, served as the foundation for the optimization. Metrics including set coverage, delta metric, hyper-volume, packet delivery ratio (PDR), and end-to-end (E2E) latency showed superiority over baseline techniques throughout the assessment, which was conducted on two levels. [3]

Sharma et al. 2022 proposed that Vehicle Ad-hoc Network (VANET) is a crucial component of the intelligent transportation systems of the future. By offering remote health monitoring to outdoor patients in risky situations, it can enhance the entire traffic control system and decrease the number of fatalities from vehicle accidents. Topological, geographical, clustering, and flooding techniques are the foundation of routing methods used to shorten transmission delays for important applications. In this paper, popular topological and geographic routing protocols for data-based VANETs health monitoring applications have been analyzed and compared. The Ad hoc On-Demand Distance Vector (AODV), the Destination Sequenced Distance Vector (DSDV), the Optimized Link State Routing (OLSR), the Greedy Perimeter Stateless Routing (GPSR), the Greedy Perimeter Stateless Routing-Modified (GPSR-M), and the Max duration-Minangle are all given a thorough study. MM-GPSR protocols for greedy perimeter stateless routing have varying node counts, CBR connections, communication ranges, and packet sizes. Results from the experiment provide knowledge that may be used to analyze the routing protocols for data-based smart health monitoring apps on the VANET. [4]

Raneen et al. 2022 In order to assess the impact of various transmission power levels on QoS metrics, this study provides the assessment of the Dynamic MANET On-Demand (DYMO) routing protocol for a vehicular network with a single RSU. The simulation results were produced by communicating with an SUMO traffic road simulator utilizing OMNeT++, INET, and Veins frameworks. The results provide researchers with a solid basis for assessing the effectiveness of vehicle transmission power on the QoS metrics of the DYMO routing protocol. [5]

Driouch et al. 2022 Vehicle Ad Hoc Networks (VANETs) are effective network architectures for applications in road safety and entertainment. To address performance issues, articles have suggested clever algorithms. This paper examines existing research on intelligent VANET routing protocols, focusing on methods and metrics used to measure performance. Heuristics, fuzzy logic, and reinforcement learning techniques are the most often used and successful ways to enhance VANET routing performance. An assessment and comparison framework is recommended for transparent routing protocol design and selection. [6]

Shetty et al. 2022 proposed that vehicular ad hoc network (VANET), the most popular technology in wireless networks, is revolutionizing the car industry. Vehicle automation has been made possible by intelligent transportation systems (ITS), which make use of wireless communication protocols. This article examines the fundamental paradigm, standards, and types of communication, routing protocols, security attack and attacker, as well as the structure of the VANET. Additionally, it examines the efficacy of jamming attacks, the future direction of research, and potential advancements.[7]

Abdeen et al .2022aims to assess how well communication routing methods in VANETs operate when used between autonomous and human-driven cars in Madinah city under a variety of traffic circumstances. A mix of traffic and network simulation tools was used to create a simulation of various traffic distributions and densities in an extracted map of Madinah city and then evaluated in two application scenarios using three ad hoc routing protocols. According to the average trip time measurements, choosing a fully autonomous vehicle scenario cuts down on travel time by 7.1% in areas with high traffic densities. Reactive ad hoc routing protocols also cause the least amount of delay for network packets to reach nearby VANET vehicles. Additionally, an ANOVA test was done to look at how variables affect the variation in the outcomes. [8]

Singh et al. 2022 stated that although vehicular ad-hoc networks (VANET) have become a new area of network routing, they are not without difficulties and restrictions. The paper outlines the benefits and limitations of VANET routing protocols and suggests a swarm intelligence and metaheuristics method to close the knowledge gap in VANET routing. Swarm intelligence algorithms may be used with conventional routing algorithms, according to the paper's conclusion, to produce an effective routing solution. [9]

Patil et al. 2022 stated that the Vehicle Ad Hoc Network (VANET) is a subset of the mobile ad hoc network (MANET) that supports communications between vehicles and infrastructure (V2I) and between vehicles (V2V). Its characteristics protect billions of people's lives and its applications for road safety have generated interest in academic disciplines and companies. Security issues arise when transmitting information in an open environment like the VANET, such as data confidentiality, availability, integrity, and non-repudiation. Research will detail several VANET assaults and conclude that a block chain-based VANET would operate more efficiently and with fewer errors. [10]

Shah et al. 2022proposed thatVANET routing protocols must take into account important characteristics such as multi-hop pathways, node mobility, large networks, device heterogeneity, congestion, and capacity. This study focused on topics such as broadcasting and routing, security, QoS, and infotainment with information transmission during crises. The proposed Swarm-Intelligence based routing protocols are compared with well-known ad hoc routing protocols and demonstrated how this strategy dramatically enhanced the functionality of ad hoc networks. [11]

Joshua et al. 2021 proposed that,Vehicular ad hoc networks (VANET) form the foundation for effective communication between cars, however because of their rapid mobility, they frequently experience network disconnections. A framework that leverages network resources to reflect the present system state and adapt the arrangement between ongoing network topology changes and QoS requirements is proposed in order to build and implement VANET routing protocols. The simulation results showed better Packet Delivery Ratio, Mean Routing Load, and End-to-End Delay for the suggested technique (FA-OLSR).[12]

Hamdi et al. 2021 analyzed through a variety of IEEE standards, including IEEE 802.11p, the Vehicle Ad-hoc Network (VANET) represents an evolving and improving intelligent transport technology (ITS) technology. Due to the high node mobility in VANET, routing packets through the primary target node presents significant difficulties that need the use of several routing protocols. Please bear that in mind. To discuss this review, we look at three sections of this review article. We shall describe the fundamentals of data distribution in the first part. We shall categorize and describe the routing protocols in their many forms in the second part. The difficulties with VANETs, data distribution, and routing protocols will be covered in the last section. [13]

Emad et al. 2020 studied a group of automobiles and related roadside equipment make up the vehicular ad hoc network (VANET), which offers mobile wireless communication services. One of the important use-cases is the transmission of photos over VANET during crises like traffic accidents, fires, and other calamities. The network can prioritize the routing of vital data thanks to priority-based routing. The Priority-based Routing Framework for Image Transmission (PRoFIT) for VANETs is suggested in this study. Critical image features are delivered to the sink node by PRoFIT for VANETs with high priority for quick processing. It was simulated how automobiles would move in emergencies using Profit for VANETs. The thorough tests demonstrate the effect of priority-based routing on vehicle mobility. Vehicle topology and grid topology were both simulated. Analysis was done on packet end-to-end delay and delivery ratios. The significance of utilizing PRoFIT for VANETs is demonstrated by comparing the outcomes of key image information delivery with and without PRoFIT.[14]

Malnar et al .2019 analysed the number of automobiles on the road has been steadily increasing during the past ten years. Due to its significance for Intelligent Transportation Systems (ITSs), Vehicular Ad hoc NETworks (VANETs) are the focus of many academics' interest as the need for mobile communication grows. Researchers frequently use network simulation to assess their work because actual VANET evaluation is expensive and difficult. Throughput, packet loss ratio, overhead, end-to-end latency, jitter, and other important performance indicators are used to analyze network performance in this paper's Network Simulator 3 (NS-3) based architecture for VANETs. Numerous academics have suggested various routing strategies to enhance the performance of VANETs, which are very dynamic networks. We analyzed a number of topology-based routing methods in this study and suggested using the widely used Expected Transmission Count (ETX) measure to enhance VANET performance.[15]

Kumar et al. 2019 analyzed although VANET is the network technology of the future, it still faces dangers like Black Hole and Gray Hole Attacks. In order to replicate the assault, this article constructed the AODV, FA-AODV, BH-AODV, and WH-AODV routing protocols. The findings indicate that FA-AODV has a lower PDR than BH-AODV and WH-AODV regimens. [16]

Kumar et al. 2019 Wireless networks are becoming increasingly common, and vehicle ad-hoc networks are often short-lived and have little infrastructure. Cross-layering approaches are used to improve performance units, and the reactive ad hoc routing protocol (AODV) is recommended in this study. Research will go into detail on how the recommended model chooses its route using the SINR and RSSI values it receives. To determine the distance of a node that is within range, the network layer will provide the network layer this RSSI value. A network's total lifetime is increased by focusing on factors such as traffic rate of transfer, interruption, packet loss, time, and connection stability.[17]

Punia et al. 2019 studied Vehicle-to-vehicle (V2V) communication, which offers lane change warnings, emergency vehicle alerts, junction alerts, congestion alerts, and toll payment, is a significant component of the automobile industry. In order to address the problem of traffic routing, a simulation study on the usage of vehicle-to-vehicle communication via various routing protocols in VANET has been introduced. The suggested routing algorithm chooses an ideal path using a carry and forward method, then sends data along that path. Most of the simulated situations are outperformed by the suggested approach.[18]

Suresh et al. 2019 analyzed the vehicular ad hoc network (VANET) has strict latency limitations, frequent link failure, high vehicle mobility, and rapid topology change. To meet these requirements, two soft computing methods were proposed: a hybrid clustering technique that combines context- and geography-based clustering approaches, and a destination-aware routing protocol that decreases end-to-end delay and increases total packet delivery ratio. The results showed that the proposed strategy works better than existing cluster-based techniques.[19]

Mao et al. 2019 designed a novel Mobility Prediction Based Routing Protocol (MPBRP) for neighborhood discovery, packet transmission, and path recovery in VANETs. It combines predictive forwarding and recovery strategies to find neighbors and transfer packets, uses predicted position and angles in a predetermined time while considering the driver's intention, and is validated for effectiveness and viability. It outperformed current protocols in terms of packet delivery rate, end-to-end latency, and average hops.[20]

Future research in this area may focus on addressing some of the challenges that remain in the development of routing protocols for VANETs. For example, the high-speed mobility of vehicles can still pose a significant challenge to the design of routing protocols, especially in scenarios with a high density of vehicles. Further research could explore the use of machine learning techniques to develop more adaptive routing protocols that can adjust to the current network conditions more effectively.

Another area for future research is the development of more secure routing protocols for VANETs. The potential for malicious attacks in VANETs can compromise the confidentiality, integrity, and availability of data transmitted in the network. The development of secure routing protocols that can protect against attacks, including denial of service (DoS) attacks and false data injection attacks, is critical for the successful implementation of VANETs.[22][24]

IV. FINDINGS AND ANALYSIS

Rapid advancements in wireless communication networks have lately made it possible for mobile ad hoc networks to provide inter-vehicular communications (IVC) and road vehicle communications (RVC). IVC and RVC's cooperation resulted in the creation of a new class of MANETs called VANETs. VANETs may be employed as long as each node is mobile and can move within the coverage region. As each vehicle travels along its path, vehicles in the VANET make brief connections with other vehicles they have never met before. These connections may never be renewed. Nodes in VANET move quickly. Therefore, maintaining mobility is a challenging challenge. This problem has been addressed by many academics, but it has not yet been resolved. [18][20]

Routing Protocols:

- Proactive Approach: This approach maintains a constant routing table for all nodes in the network, which is updated regularly. This helps in reducing the routing delay and improves the packet delivery ratio. However, this approach has high overhead due to the constant updates and is more suitable for highway and urban environments where network topology changes are less frequent.
- Reactive Approach: This approach establishes a route on-demand, i.e., when a node needs to transmit data, it initiates a route discovery process to find the next hop towards the destination. This approach has lower overhead compared to proactive routing, but it may result in higher latency and packet loss during the route discovery process. Reactive routing is more suitable for rural and sparse environments where network topology changes are frequent.[19]
- Hybrid Approach: This approach combines features of proactive and reactive approaches to take advantage of their strengths while mitigating their weaknesses. Hybrid routing is adaptable to varying network conditions and can provide efficient routing in mixed traffic environments. However, the implementation of hybrid routing is complex, and it may result in high overhead due to the combination of proactive and reactive routing.[21]

Mobility Framework:

- Network-centric Approach: This approach focuses on efficient use of network resources by taking into account the network topology and available resources. Network-centric mobility is suitable for military and emergency communication where network control is critical. However, it has limited support for highly dynamic networks, such as VANETs, where nodes move frequently and unpredictably.
- Host-centric Approach: This approach focuses on individual vehicle mobility and provides high levels of network flexibility. Host-centric mobility is suitable for urban and intelligent transportation systems, where vehicles need to adapt to the changing environment quickly. However, host-centric mobility has high overhead due to frequent location updates.
- Hybrid Approach: This approach combines features of network-centric and host-centric approaches to provide adaptability to varying network and mobility conditions. Hybrid mobility is suitable for mixed traffic environments, where both network and individual mobility are important. However, the implementation of hybrid mobility is complex, and it may result in high overhead due to the combination of network-centric and host-centric mobility.[23]

AI-based approaches for Routing Protocols:

- Reinforcement Learning: This approach uses a reinforcement learning algorithm to optimize routing decisions by rewarding or punishing a node's actions based on their impact on the network's performance. Reinforcement learning-based routing can adapt to changing network conditions and provide better performance than traditional routing protocols like AODV. However, it requires significant computational resources and training data to train the model.

- Neural Network: This approach uses a neural network to predict the next hop for a given destination based on the network's topology and history. Neural network-based
- routing can handle highly dynamic networks and provide better performance than After analyzing the different tables on VANET, it is clear that VANET is a promising technology for enabling intelligent transportation systems and smart cities. However, it faces several challenges such as high mobility, varying network conditions, and congestion, which traditional routing and mobility protocols may not be able to handle efficiently. Therefore, AI-based approaches for Routing Protocols and Mobility Framework have been proposed to improve the performance of VANETtraditional routing protocols like AODV. However, it requires a large amount of training data to train the model.
- Swarm Intelligence: This approach uses a swarm intelligence algorithm to optimize routing decisions by mimicking the behavior of social insects like ants or bees. Swarm intelligence-based routing can adapt to varying network conditions and provide better performance than traditional routing protocols like AODV. However, it may require more computational resources and be more complex than other AI-based routing approaches.[12][16]

AI-based approaches for Mobility Framework:

- Deep Reinforcement Learning: This approach uses a deep reinforcement learning algorithm to optimize mobility decisions by rewarding or punishing a vehicle's actions based on their impact on traffic flow efficiency and travel time. Deep reinforcement learning-based mobility can adapt to changing traffic conditions and provide better performance than traditional mobility protocols like SUMO. However, it requires significant computational resources and training data to train the model.[24]
- Fuzzy Logic: This approach uses fuzzy logic to make decisions based on input variables such as vehicle speed, density, and distance to other vehicles. Fuzzy logic-based mobility can handle uncertain and imprecise data and provide better performance than traditional mobility protocols like SUMO. However, it may require tuning of fuzzy rules for different scenarios and be more complex than other AI-based mobility approaches.[24][25]
- Genetic Algorithm: This approach uses a genetic algorithm to optimize mobility decisions by mimicking the process of natural selection. Genetic algorithm-based mobility can adapt to varying traffic conditions and provide better performance than traditional mobility protocols like SUMO. However, it may require a large number of generations to converge and be more complex than other AI-based mobility approaches.

Approach	Methodology	Strengths	Weaknesses	Applications
Routing Protocols				
Proactive	Maintains a constant routing table	Low latency and high packet delivery ratio	High overhead due to constant updates	Highway and urban environments
Reactive	Establishes a route on demand	Low overhead due to on-demand route discovery	High latency and packet loss during route discovery	Rural and sparse environments
Hybrid	Combines features of proactive and reactive approaches	Adaptable to varying network conditions	Complex implementation and high overhead	Mixed traffic environments
Mobility Framework				
Network-centric	Focuses on efficient use of network resources	Can provide a high level of network control	Limited support for highly dynamic networks	Military and emergency communication
Host-	Focuses on	Can provide	High overhead due to	Urban and

Table-1 Comparison of Approaches for Routing and Mobility Framework

centric	individual vehicle mobility	high levels of network flexibility	frequent location updates	intelligent transportation systems
Hybrid	Combines features of network-centric and host-centric approaches	Adaptable to varying network and mobility conditions	Complex implementation and potential for high overhead	Mixed traffic environments

Table-2 Comparison of AI Based Approaches for Routing and Mobility Framework

AI-Based Approach	**Methodology**	**Strengths**	**Weaknesses**	**Applications**
Routing Protocols				
Reinforcement Learning	Uses reinforcement learning algorithm to optimize routing decisions	Can adapt to changing network conditions; provides better performance than traditional routing protocols like AODV	Requires significant computational resources and training data to train the model	Intelligent transportation systems (ITS)
Neural Network	Uses neural network to predict next hop based on network topology and history	Can handle highly dynamic networks; provides better performance than traditional routing protocols like AODV	Requires large amount of training data to train the model	ITS
Swarm Intelligence	Uses swarm intelligence algorithm to optimize routing decisions	Can adapt to varying network conditions; provides better performance than traditional routing protocols like AODV	May require more computational resources and be more complex than other AI-based routing approaches	ITS

Mobility Framework				
Deep Reinforcement Learning	Uses deep reinforcement learning algorithm to optimize mobility decisions	Can adapt to changing traffic conditions; provides better performance than traditional mobility protocols like SUMO	Requires significant computational resources and training data to train the model	Smart cities, autonomous vehicles
Fuzzy Logic	Uses fuzzy logic to make decisions based on input variables	Can handle uncertain and imprecise data; provides better performance than traditional mobility protocols like SUMO	Requires tuning of fuzzy rules for different scenarios; may be more complex than other AI-based mobility approaches	Smart cities
Genetic Algorithm	Uses genetic algorithm to optimize mobility decisions	Can adapt to varying traffic conditions; provides better performance than traditional mobility protocols like SUMO	May require a large number of generations to converge; may be more complex than other AI-based mobility approaches	Smart cities, autonomous vehicles

Table-3 Comparison of AI Based Approaches for Routing and Mobility Framework with Conventional Methods

Approach	**Methodology**	**Strengths**	**Weaknesses**	**Applications**	**Comparison with** Conventional Method
Reinforcement Learning	Uses RL algorithm to optimize routing decisions	Adaptable to changing network conditions	Limited to small-scale networks	Urban and highway environments	Compared to AODV, RL-based routing can provide better performance in terms of packet delivery ratio and latency. However, it has higher overhead and complexity due to the use of RL algorithm.
Neural Network	Uses NN to predict next hop for a given destination	Can handle highly dynamic networks	Requires large amounts of training data	Emergency communication and urban environments	Compared to AODV, NN-based routing can provide better performance in highly dynamic networks. However, it may have higher overhead due to the use of NN algorithm.
Swarm Intelligence	Uses SI algorithm to optimize routing decisions	Adaptable to varying network conditions	Limited to small-scale networks	Military and emergency communication	Compared to AODV, SI-based routing can provide better performance in terms of packet delivery ratio and network lifetime. However, it may have higher overhead and

					complexity.
Deep Reinforcement Learning	Uses DRL algorithm to optimize mobility decisions	Adaptable to changing traffic conditions	Requires large amounts of training data	Urban and intelligent transportation systems	Compared to other mobility protocols, DRL-based mobility can provide better performance in terms of traffic flow efficiency and travel time. However, it has higher overhead and complexity due to the use of DRL algorithm.
Fuzzy Logic	Uses fuzzy logic to make decisions based on input variables	Can handle uncertain and imprecise data	May require tuning of fuzzy rules for different scenarios	Urban and highway environments	Compared to other mobility protocols, fuzzy logic-based mobility can provide better performance in terms of adaptability to changing traffic conditions. However, it may have higher overhead and complexity due to the use of fuzzy logic.
Genetic Algorithm	Uses GA algorithm to optimize mobility decisions	Adaptable to varying traffic conditions	May require a large number of generations to converge	Mixed traffic environments	Compared to other mobility protocols, GA-based mobility can provide better performance in terms of network coverage and

					energy efficiency.

In the table for different Routing Protocols for VANET, we can see that AODV, DSR, and OLSR are the most commonly used traditional routing protocols for VANET. However, these protocols have several limitations such as high overhead, lack of scalability, and inability to handle varying network conditions. On the other hand, AI-based routing protocols like Reinforcement Learning, Neural Network, and Swarm Intelligence can adapt to changing network conditions and provide better performance than traditional routing protocols like AODV. Each of these AI-based approaches has its strengths and weaknesses, and their suitability depends on the specific requirements of the application.Similarly, in the table for different Mobility Framework for VANET, we can see that SUMO and MOVE are the most commonly used traditional mobility frameworks for VANET. However, these frameworks have limitations such as high computational complexity and inability to handle changing traffic conditions. In contrast, AI-based mobility frameworks like Deep Reinforcement Learning, Fuzzy Logic, and Genetic Algorithm can adapt to changing traffic conditions and provide better performance than traditional mobility protocols like SUMO. Again, each of these AI-based approaches has its strengths and weaknesses, and their suitability depends on the specific requirements of the application.

The table comparing different AI-based approaches for Routing Protocols and Mobility Framework for VANET highlights the strengths and weaknesses of each approach. For example, Reinforcement Learning, Neural Network, and Swarm Intelligence are better suited for dynamic network conditions, while Deep Reinforcement Learning, Fuzzy Logic, and Genetic Algorithm are better suited for changing traffic conditions. However, all of these AI-based approaches require significant computational resources, training data, and may be more complex to implement than traditional protocols. Therefore, the implementation of AI-based approaches in VANET may face practical challenges that need to be addressed.

Overall, the tables provide a comprehensive overview of the different routing protocols and mobility frameworks for VANET, as well as the AI-based approaches that have been proposed to improve their performance. The analysis of these tables highlights the potential of AI-based approaches to overcome the limitations of traditional protocols and improve the performance of VANET. However, more research is needed to optimize these approaches and evaluate their performance in practical applications. Additionally, the implementation of AI-based approaches in VANET requires a significant amount of computational resources, training data, and may be more complex than traditional protocols, which presents practical challenges that need to be addressed. Comparing AI-based approaches with AODV and other protocols: Compared to traditional routing and mobility protocols like AODV and SUMO, AI-based approaches can provide better adaptability, efficiency, and performance in varying network and traffic conditions. However, they may require more computational resources, training data, and be more complex to implement. Additionally, AI-based approaches are still in the research and development stage and have not yet been widely adopted in practical applications.

V. **CONCLUSION**

VANET is a promising technology for enabling intelligent transportation systems and smart cities. However, VANET faces several challenges such as high mobility and varying network conditions. Traditional routing and mobility protocols like AODV and SUMO may not be able to handle these challenges efficiently. Therefore, AI-based approaches for Routing Protocols and Mobility Framework have been proposed to improve the performance of VANET.AI-based routing protocols like Reinforcement Learning, Neural Network, and Swarm Intelligence can adapt to changing network conditions and provide better performance than traditional routing protocols like AODV. Similarly, AI-based mobility frameworks like Deep Reinforcement Learning, Fuzzy Logic, and Genetic Algorithm can adapt to changing traffic conditions and provide better performance than traditional mobility protocols like SUMO. However, AI-based approaches may require more computational resources, training data, and be more complex to implement than traditional protocols.Overall, AI-based approaches have shown promising results in improving the performance of VANET in varying network and traffic conditions. However, more research is needed to optimize these approaches and overcome their limitations before they can be widely adopted in practical applications.Furthermore, the selection of the appropriate AI-based approach for VANET depends on the specific requirements of the application. For example, Reinforcement Learning and Swarm Intelligence may be suitable for applications that require adaptive routing decisions in highly dynamic networks. Neural Network may be more suitable for applications that require predicting the next hop based on the network topology and history. Similarly, Deep Reinforcement Learning may be suitable for applications that require adaptive mobility decisions in changing traffic conditions.It is also important to note that AI-based approaches for Routing Protocols and Mobility Framework for VANET are still in the research and development stage. Therefore, there is a need for more research to optimize these approaches and evaluate their performance in practical applications. Additionally, the implementation of AI-based approaches in VANET requires a significant amount of computational resources, training data, and may be more complex than traditional protocols.

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