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A Survey of Different VANET Routing Protocols

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Abstract: Vehicle nodes can join or exit the VANET, which is a decentralized sort of network. Due to the network's dynamic nature, reactive routing methods are used for path establishment from source to destination. Reviewing current protocols that are regularly utilized in various proposals and application scenarios is the goal of this work. This review helps when developing selection criteria or metrics for a new protocol. The systematic literature review (SLR) is used in this survey on VANET routing protocols to analyze the most recent state-of-art recommendations. Additionally, in this study, a number of proactive routing and reactive routing protocols are defined. Reactive routing protocols construct a route from source to destination using the most recent network data. The proactive routing protocols establish paths using network-defined information. Routing tables are used by proactive routing technologies to construct paths. Analysis shows that reactive routing strategies outperform proactive routing techniques. The research shows that speed and distance are the most frequent and adaptable metrics in a procedure. Finally, the application of various methods is discussed along with some feasible directions for further research.

Keywords: Bio-Inspired Routing Protocol, Clustering Based Protocol, Geographic Routing Based Protocol, General Protocol, Traffic Aware Routing Protocol, VANET.

1. Introduction

1.1 VANET

The Fifth Generation (5G) era is quickly approaching. Human transportation is being modified by intelligence and networking as the Internet of Vehicles and "Internet+" technology are being applied more and more. There are several difficulties associated with the increased demands for transport efficiency, safety, and the environment at the same time. The Internet of Vehicles technologies is promoted and given a lot of attention thanks to internal and external forces. Because of the advancement of car safety technologies, trafficaccidents have recently become a significant issue. According to several studies, 60% of traffic accidents can be prevented if warning information is given to drivers in advance [1-10].

VANET is a variation of MANET. VANET makes it easier for mobile vehicles to share information. Vehicle communication is crucial to VANET's ability to effectively improve traffic comfort and safety. The majority of automobiles will soon have onboard VANET connection technology, according to the projection. Fig. 1 shows the Vehicular Ad Hoc Network schematic diagram.

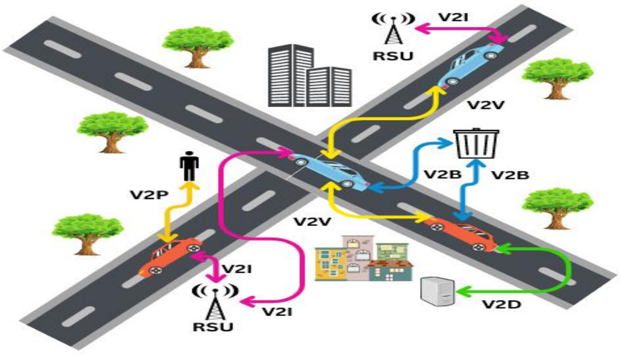

Fig. 1. VANET Schematic Diagram

Fig. 1. shows that the VANET is made up of a collection of vehicles, each having an OBU device fitted, and fixed units that are paved alongside the road. Some RSUs (Roadside Units) can be connected to other networks, including the Internet, to access resources. Each OBU has an integrated wireless network that allows for direct connection with other vehicles, and RSUs are offered with a variety of effective connectivity options.“Vehicle-to-Vehicle”,“Infrastructure-to-Vehicle”, “Broadband-to-Vehicle” and “vehicle-to-everything” communication are some of the applications employed in the VANET for traffic optimization, road safety, and

passenger infotainment. Fig. 2 shows the general work structure of VANET.

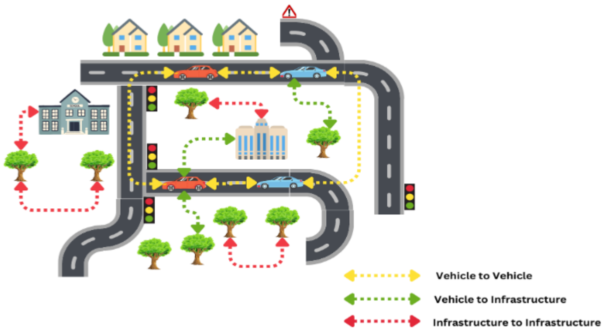

Fig. 2. Overview of the network dedicated to cars

This is the main factor that has made VANET so popular in the government, academic, and industrial sectors [3,4].

2. Architecture of Network

The VANET architecture, which concentrates on forming communication between nearby automobiles and machinery that is utilized statically on the side of the road, results in three choices. Three types of VANET architecture exist i.e. ad hoc, infrastructure, and hybrid. These categories are depicted in Fig. 3.

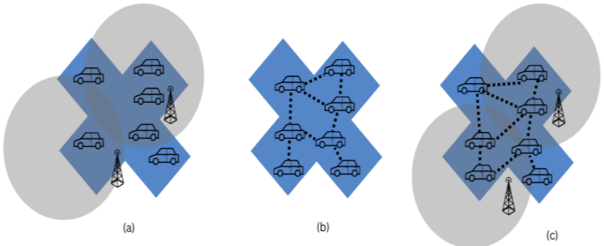

Fig. 3. VANET network architectures (a) Infrastructure (b) Ad hoc (c) Hybrid

Fig. 3(a) shows the V2I infrastructure mode in action ("Infrastructure-to-Vehicle"). In VANET, the stationary access points are used to establish a connection between the cars and the Internet and collect traffic or routing data. The fixed access points and the cars can communicate. The V2V ("vehicle-to-vehicle") ad hoc mode, which employs all cars to build a completely mobile network, is illustrated in Fig. 3(b). For this, information is transferred between each other directly rather than through a centralized access point[11-25].

In order to function as routers and send communications between the origin and target nodes, -e nodes must be capable of collaborating .Fig. 3(c) depicts the hybrid architecture in which infrastructure and ad hoc architectures are comprised and it is implemented in VANETs. Various applications utilize such architecture to exchange the information among one another through the vehicles and to connect with the Internet using the fixed access point.

3. Types of Communication in VANET

Specifically, VANETs support four distinct connection types, which are shown in Fig. 1

a. **Vehicle to Vehicle (V2V):**Ad hoc network-style communication between cars is made possible by this link. Important traffic information, such as reports of accidents or traffic jams, is transmitted, received, or exchanged between cars.

b. **V2I:** This connection is used to communicate and relay important information on the state of the roads and security concerns involving infrastructure and cars. The RSU ("Roadside unit") and automobiles operate together as part of the vehicle-to-infrastructure to provide a link that may be used to access external networks like the Internet. Compared to V2V connections, this communication requires more bandwidth and is least susceptible to assaults.

c. **V2B:** In the VANET, the in-car connection is critical for calculating the vehicle's performance, including the driver's behavior, which is essential for ensuring public safety. To connect the vehicles to the wireless broadband system, this connection uses 4G or 5G networks. As the broadband cloud contains more monitoring data as well as data on traffic and entertainment, the V2B is effective in assisting active driving and tracking the vehicle .

d. **V2P:** This link is used for V2P in order to identify pedestrians and prevent accidents. Smart phone's underlying wireless technologies play a vital role in establishing vehicle-to-pedestrian communication.

e. **V2X:** This system was created to guarantee safe and independent operation[26-31]. Additionally, it is a key component of the self-driving automobiles and smart cities of the future. In this connection, any unit, such as other vehicles or infrastructure along the roadside, is connected to the vehicle. It is broken down into four main parts, including communication between vehicles (V2V), infrastructures (V2I), pedestrians (V2P), and networks (V2N)[60]. In this, automobiles are permitted to communicate instantly with other vehicles as well as critical infrastructure about their speed, coordinates, and acceleration.

4. VANET routing

Vehicles can connect with one another and form the nodes of a big network, thanks to VANETs [61-65]. Given the massive number of cars, VANETs would offer a vast array of advantages. Many additional information (for example, traffic environments, promoting updates, and Ecoupons) can be transmitted between vehicles through VANET as long as modest delays are tolerated in the targeted applications. For instance, to find out the most recent parking information, an automobile may ask for other vehicles nearby. Another intriguing new technology is called infotainment, and it uses vehicle-to-vehicle (V2V) connection to deliver multimedia services to subscription vehicles in a specific area. The availability of effective and efficient message-routing protocols is a crucial requirement for the realization of VANET applications. A router uses routing protocols to determine the best path for communication between nodes[66-70].

a. VANET Routing Protocols

Vehicles might not be able to communicate vital data and utilize cutting-edge VANET technologies without clear and efficient routing protocols.

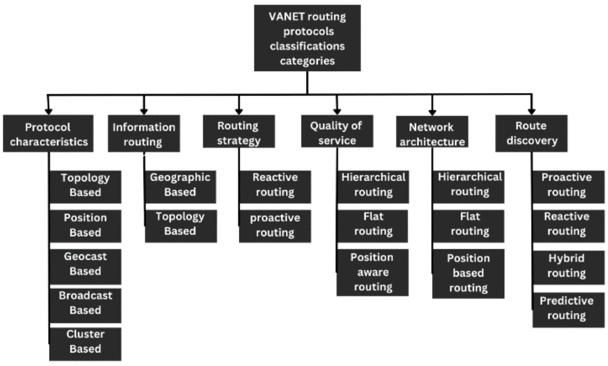

Fig. 4. Categories for classifying protocols

To solve these issues, numerous VANET routing protocols have been created. Routing protocols can be categorized using a variety of factors, such as network design, information routing methods, quality of service requirements, and protocol characteristics[71-80]. VANETs routing protocols can be categorized using a variety of characteristics, as shown in Fig. 4.

I. Topology Based Protocols

Topology is the idea of connecting different components. In a vehicle ad hoc network, by using these methods, the shortest path between source and destination nodes can be found. A routing table contains all data pertaining to routing. Based on how frequently the routing tables are updated, three different types of topology-based protocols can be divided. The explanations of proactive, reactive, and hybrid routing systems are given below:

a. **Proactive Routing:** Every node in this protocol has a routing table where the routing data is stored. Due to the rapid mobility of nodes, when nodes are added to the network or removed from the network, the most recent routing records must be kept. [81-90]. When a node enters or leaves the network or a link is broken and then repaired, a proactive protocol uses an update step to keep routing tables current and reachable. Increased protocol overhead brought on by this technique has an impact on network throughput as well. DSDV ("Destination Sequence Distance Vector"), OLSR ("Optimized Link State Routing"), and FSR ("Fisheye State Routing") are proactive protocols.

b. **DSDV:** This protocol's foundation is the Bellman-Ford algorithm. With the help of each node, this method focuses on keeping the path as a table to all known destinations[91-100]. To inform neighbors of topology changes, we use rapid ads. The Destination Sequence Distance Vector updates the database progressively when just deltas are transmitted to other nodes by a node, or entirely when all information is transmitted by a node to other nodes.

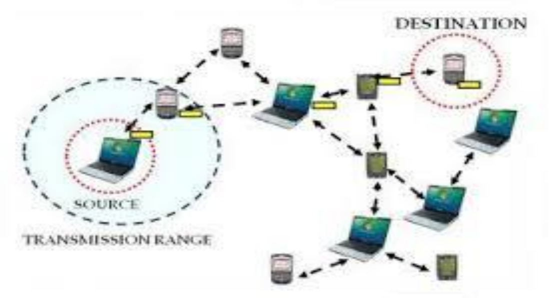

Fig. 5. A picture showing the operation of the DSDV protocol

c. **OLSR:** This protocol creates a list of neighbors that each node keeps and that are periodically reached by one hop and two hops. Then, an MPR is used to reduce and alleviate the need for as many active relays to reach all 2-hop neighbors (Multi-Point Relay). Therefore, if a node is chosen as a relay point through the source node, it transmits a packet. The MPR algorithm was used for this. With the implementation of the chosen relay nodes, the link state packets are transferred to create the routing tables and to keep them in OLSR[101-115]. As a result, after stabilizing the algorithm, active routes to any location in the network are reached.

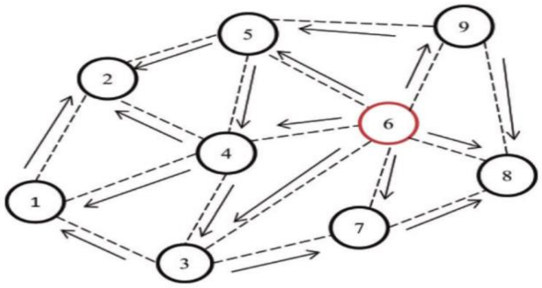

Fig. 6. OLSR Protocol Route Discovery Process

d. **Reactive protocols:** These protocols don't maintain a fresh routing database and only help in route discovery when transferring data packets from an origin node to a destination node . Flooding is used to begin the route discovery process when sending a message to a specific destination is necessary. Once the communication has reached its intended location, an answer message is sent back to the origin. Although the route-finding process takes longer because of these protocols, there is less control message overflow. AODV (“Ad-hoc On-Demand Distance Vector”) routing and AODV+PG routing is an illustrations of a reactive protocol[116-124].

- **AODV:** For MANETs, the AODV routing protocol was primarily created (mobile ad hoc networks). This protocol establishes pathways only when a node requests to send a packet, making it a reactive protocol.

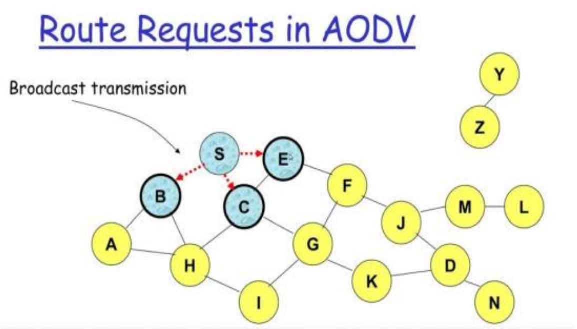

Fig. 7.A picture showing the operation of the AODV protocol

It employs conventional routing tables, an entry for every destination, and sequence numbers to gather up-to-date routing data. AODV saves the routes even though the source wants to transmit the information once a connection between the nodes is active (source-destination). In order to find the destination node, this protocol's main phase of route discovery sends RREQ (Route Request) packets from the input node to other nodes. RREPs (Route reply) packets are transmitted in unicast mode to the RREQ source. For information saving in the middle way molecules with the route in, the absolute path is formed. For preserving data in the middle way motes with the route in the local routing table, the absolute path is generated. Error messages (RERR) are also used to report following a communication failure. A new cycle of route-finding must start at this point. Always use "Hello" messages to determine and keep track of connectivity with adjacent nodes [125-135]

- **AODV+PG:** AODV+PGB uses Preferred Group Broadcast to reduce communication overhead (PGB). Compared to AODV, it offers more persistent routing. Since this protocol is designed to reduce the significant communication cost caused by the AODV route discovery cycle, PGB receivers can determine whether they are a member of an ideal group and which node in the set wants to talk. The communication's RS (Received Signal) is used to determine the node.

e. **Hybrid Routing:** Hybrid routing, as suggested by its name, combines proactive and reactive routing protocols. The protocols in this category are designed to shorten the time it takes to find a route from one place to another. This category includes protocols like ZRP and ZHLS.

- **ZRP:** ZRP uses both the reactive routing technique and the active routing approach in the vicinity of a node when communication between neighboring nodes is required. IARP (“Intra-zone routing protocol”) is utilized if communication with nearby neighborhoods needs to be established. In another situation, IERP is employed when communication between zones needs to be established[136-143]. Therefore, reactive routing seeks to find routes as per demand when it's necessary to ensure communications to other places, whereas proactive routing is used to give routes within an area or neighborhood.

- **ZHLS:** ZHLS is an additional routing protocol in this group of protocols. ZHLS makes use of node position information to divide the network into non-overlapping zones. Each node in this protocol is aware of the connectedness of its area in the network as well as the nodes that are close by. Information on the connectivity of the zones and the nodes' information is broadcast throughout the network. In light of this, the route can be established using the IDs of the node and the zone[144-158].

II. Position Based Routing Protocols

These protocols use several sources, like maps and the Global Positioning System, to determine the position or location of the vehicles (GPS). As a result, in order to send and receive messages, the source and destination depend on the nodes' status information. This group of protocols does not require the upkeep of topology, route preservation, or discovering information. Therefore, location and packet forwarding are the two main aspects of transferred packets[159-167]. Two typical instances of this family of protocols are GPSR (“Greedy Perimeter Stateless Routing”) and RIPR (“Reliability Improving Position-based Routing”).

a. **GPSR:** The GPSR routing technology works well in wireless and mobile networks. This protocol takes into account geographic routing factors. In order to forward data, GPSR uses two methods: perimeterforwarding and greedy forwarding.

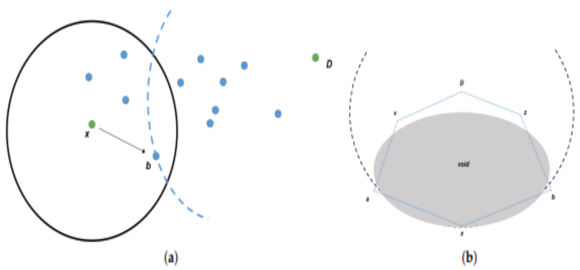

Fig. 8.shows the operation of GPSR (a) A case of greedy forwarding. The nearest neighbor of x to D is b. (b) Node x is void with regard to destination D in perimeter mode.

The second method is used when greedy forwarding is not an option (there is no nearby node other than the present one; see Figure 8b). The first algorithm passes the packet to the nearest neighbor node of the destination and is used by default (see Fig. 8a). The right-hand rule can be used by GPSR to transport packets around holes where there is no nearest neighbour thanks to the perimeter mode. This protocol does not need the development of a complete point-to-point path; instead, it bases decisions on the hop-by-hop principle.[168-174)]

b. RIPR: RIPR was created to offer a fix for several link failures. This protocol establishes the direction and speed of a vehicle's motion. The neighbor's position and speed are then recorded in a routing table that is kept up to date by each node. As a result, according to the data contained in its table, the source node chooses the closest neighbor until it obtains the destination. Because of this, the strategy used to choose the next hop node aids in making better decisions for other midway nodes that are needed in additional hops as positions. This protocol also takes mobility speed into account.

III. Protocols for Cluster-Based Routing

These protocols are intended to group the nodes of the network into clusters. As a result, a cluster of close-by nodes is formed, with one vehicle acting as the cluster leader. The cluster's size varies depending on the techniques employed to create it. To put it another way, the network can be divided into clusters using certain factors such as the quantity of cars, their location concerning other vehicles, or their direction and speed of travel. The cluster's nodes then elect a Cluster Head (CH), who is responsible for overseeing the cluster and enabling inter-cluster communication. As a result, in inter-cluster communication, the data is forwarded to the best neighbor cluster[175-180)].

a. Location-Cluster-based Flooding Routing Algorithm: This protocol separates the network's nodes into clusters. Then, a cluster head will be in charge of coordinating communication between each cluster and its fellow cluster chiefs. Additionally, the cluster heads broadcast beacon signals regularly to update their parameters. Additionally, in order to collect location data for other clusters, cluster headers transmit location request packets. Mentioning the reactive nature of this routing system, which was created to facilitate V2V communication .

IV. Protocols for Broadcast Routing

Traditional approaches for information routing across VANETs are described as relying on broadcast routing techniques that rely on flooding. These protocols are used to exchange information on the condition of the roads and emergency circumstances with vehicles that are outside the source node's communication range. In every condition, every network node receives and transmits packets[181-190)].

a. BROADCOMM: Cells are created in the area using this approach. The cell reflector is then chosen by each member of the cell. The cell reflector consequently gathers messages from adjacent nodes. To put it simply, the cell reflector will serve as the cell's base station for all other nodes. Messages will therefore be transmitted to other vehicular nodes inside the cell by a cell reflector[191-194)].

V. Geo-Cast Routing Protocols

This family of routing protocols relies on forwarding or transmitting data in a location that is suitable for or related to the data that has to be sent. The vehicles that get the geocast message are in the Zone of Relevance (ZOR), and position-based multicast is utilized to transmit the packets to that ZOR. In other words, the Geo-cast Routing Protocol distributes data packets that originate from a single source node to every node that is present in the relevant area. A major flaw in these protocols is network partitioning, which interferes with the timely transmission of messages.

a. Robust Vehicular Routing (ROVER) protocol: Control packets are transmitted using this protocol's flooding technique. Unicast, on the other hand, is used to transmit data messages. The network is divided into important parts by this protocol. After then, a vehicle will only take a message if it is received while it is in that location[196-200)].

5. Literature Review

a. Bio-Inspired Routing Protocol in VANET

Raghu Ramamoorthy et.al (2022)[32)] Proposed Due to rapid mobility and topology changes, VANET communication lines between vehicles are prone to frequent failures. In order to provide dependable communication in this circumstance, this work provides an EBIRA (“Enhanced Bio-Inspired Routing Algorithm”).

In EBIRA, the optimum short-distance routes with the fewest hops are found using improved ant colony optimization (EACO), which is based on distance, received signal intensity metrics, hop count, and evaporation rate. The selected path in EBIRA is short and has a high level of link-level connection with few hops. Simulation results show that EBIRA outperforms road-aware geographic routing protocol and RDACO ("Reliable Route Discovery Using Ant Colony Optimization") in terms of packet delivery ratio, throughput, and latency (RAGR). Along with fluctuations in the received signal strength dependent on vehicle density and speed, the EBIRA route discovery success ratio is also evaluated and shown in relation to vehicle density and speed.

Shubham Soni et. al (2022) **33)**proposed With less time, the developed approach enhanced throughput, packet size, and overhead.The testing results confirmed that, compared to other algorithms in the simulation, the created algorithm offered greater packet size and throughput and lower latency and overhead.

Ali Hashim Abbas et. al. (2021) **34)** Due to the network's extremely high dynamic mobility on the highways, network efficiency must be increased. An efficient routing protocol is necessary to ensure that the vehicles arrive at their destination in the possible time.

A. Gopalakrishnan, et.al (2020)**35)**proposed a Bio-inspired Routing Protocol to look into the best gateway and sink for routing the service request between the service requester and the global server. The gateway choice concentrated on encouraging just the legitimate source to communicate with the sink. The networking nodes were given efficient routing. The VANET sources used SDN (software-defined networking) to stabilize the networking topologies.

Hao Liu, et al. (2020)**36)** proposed a PASRP for emergency data in urban VANET. A computerized map and geographic information system were used to create a parking lot-based spider-web transmission system. The emergency information was then broadcast on the chosen channel using a multi-mode greedy algorithm. The data were prioritized using a dynamic multi-priority scheduling approach. Finally, the simulation outcomes showed that the recommended methodology outperformed more established techniques.

Bhushan Yelure et al. (2020)**37)**developed a PSOR routing method based on PSO for the VANET, which enhanced QoS (Quality of Service). Using the particle's velocity and position, the best overall solution based on fitness value was validated.Using this technique, the next vehicle that would be accessible close to the Destination vehicle was selected. The message was transmitted using the carry and forward mechanism. The testing results confirmed that, compared to other algorithms in the simulation, the created algorithm offered greater packet size and throughput and lower latency and overhead.

Daxin Tian, et al. (2018)**38)** proposed cellular attractor selection was used to select the following hops in a bio-inspired URAS for VANET. The importance of adapting to its complex and dynamic environment was stressed by this algorithm. Additionally, when choosing the nexthop utilizing a multi-attribute decision-making process, the number of duplicate candidates decreased. The simulation results demonstrated that in terms of PDR (Packet Delivery Ratio), E2E (End-to-End Latency), and congestion, the suggested solution performed better than the current strategy.

b. Clustering-based Routing Protocol in VANET

Mohammad Sadegh Azhdari et.al (2022)**39)** proposed Due to its characteristics, such as a high degree of node mobility and erratic wireless communication links, vehicular ad hoc networks present a challenge for routing. As a result, it makes for an intriguing research topic. Additionally, because of the above-mentioned characteristics of these networks, it is crucial to create an authentication method between the source node and the destination node. In this paper, we describe an authentication-capable fuzzy logic-based routing approach for automotive ad hoc networks. Three parts make up the suggested routing technique: clustering, routing between cluster head nodes, and authentication.Vehicles are clustered in the first stage utilizing an effective method. We distinguish between immediate and regular data packets in the suggested technique.

Viswanathan Ramasamy et. al (2021) devised a "Position Particle Swarm Optimization with Fuzzy Logic (PPSO-FL)" technique for VANETs, relying on collectively coordinated measures rather than instantaneous velocity

Wenxiao Dong et al. (2017)**41)** proposed a CRB ("cluster-based recursive broadcast") routing system as a remedy for the issues with delay time and delivery ratio. Only the selected vehicles were capable of transmitting the received emergency event to other vehicles nearby. The recommended approach helped enhance the message's efficacy of transmission and delivering the directed broadcast based on the traffic light situation. Tests conducted on NS2 revealed that the proposed technique outperformed previous algorithms.

Khalid Kandali et al. (2020)42) presented an RPKHM to lengthen the links between automobiles and boost the stability of the vehicular network ("Routing protocol employing an adaptive K-Harmonic Means"). A mathematical model was put into practice to determine the number and initial placements of the centroids while taking into account the network's topology and the overall number of cars. On the other hand, a similarity value based on Euclidean distance was used to group the data. The clusters were ultimately preserved, and new cluster heads were selected using a cost function that considered the total amount of free buffer and ETX ("Expected transmission count"). The simulation's findings demonstrated the proposed protocol's effectiveness in terms of throughput, average E2E time, and PDR.

Parisa Saraj Hamedani, et al. (2018)[43)] suggested a dependable cluster-based two-layer approach to address the connection failure issues in VANETs. Whilethe second level used a greedy algorithm to choose the shortest path, the first level chose the reliable link. Instead of using more traditional approaches, the NS-2.35 was used to stimulate the ideal algorithm based on network characteristics such E2E latency and PDR. PDR and E2E latency were both improved by using this technique.

Waqar Farooq et al. (2017)[44)] developed a AAGVs routing algorithm that made use of aerial vehicles to address the communication issues with AGVs and spread MDMs (Mines Detection Messages). Additionally, a cluster-based system was created to allow for the real-time adaption of the established algorithm without affecting its performance. In order to accomplish this, reliable IVC ("Inter-Vehicular Communication") linkages were kept up. The established method was stimulated using the Network Simulator. The findings showed that the established algorithm helped reduce latency and overhead while increasing PDR and throughput using a multicast communication approach.

Salim Bitam et.al. (2015)[45)]Their Model has increased traffic safety and facilitated passenger comfort. Security and privacy concerns have not been given any thought in their model.

c. Traffic Aware Routing Protocol in VANET

Maryam Gillani et.al (2022)[46)]proposed the study of VANETs is a tough but active field. It offers a wide range of applications, such as Intelligent Transport System (ITS), efficient traffic flow, effective road traffic monitoring, and applications for road safety. The fixed silence segments interfere with effective communication while real-time data is being gathered for emergency circumstances. Furthermore, this issue can cause crucial ITS operations to be delayed. In order to address communication constraints, the Real-Time Traffic-Aware Data Gathering Protocol (TDG) proposed in this study uses dynamic segmentation switching.To gather and send data packets based on the present and rapidly changing traffic conditions, TDG is a lightweight, dynamic system. To accommodate real-time data collecting time limits, the main goal is to reduce network and data transfer overhead.

Yida He et. al (2021) [47)]It is a particularly difficult task to design an effective routing protocol for urban VANETs due to their unique characteristics. The Q-learning algorithm, which consists of various strategies for forwarding data packets within roads and intersections.

Satheshkumar Kandasamy et. al (2021)[48)]VANET has drawn a lot of attention due to its distinct abilities to manage a high level of vehicle mobility, major topological changes, and experiencing frequent route failures or breaks.

Forough Goudarzi, etal.[49)] created a vehicular ad hoc network (VANET) routing method for urban regions that takes traffic into account (2018). An ant-based technique was utilized to locate a path that had network connectivity. By comparing the route on a street map with the least amount of weight for the entire journey when utilizing a source vehicle, the best path between a source and a destination was found. The simulated environment was taken into account to determine the precise functionality of the proposed protocol. The simulation findings demonstrate that at speeds up to 70 km/h, the proposed technique was able to decrease overhead and E2E (end-to-end) time while enhancing PDR (packet delivery ratio) by 10%.

Rui Wu et al. (2019)[50))] proposed In a GeoTAR, a map-based and traffic-aware routing algorithm, traffic data was gathered and the optimum route was determined using a digital map and a Geohash coding method. In addition, packets for which buildings were regarded as radio barriers were sent using the restricted forwarding technique known as IFRF (intersection-first restricted forwarding). The routing path was determined by taking into consideration the wired channel present in the RSUs (Roadside Units). The simulation results demonstrated that the recommended method was successful in enhancing VANET performance in terms of PDR and E2E delay when compared to other protocols.

Jinqiao Wu etal. (2020)[51)] looked into a new routing algorithm dubbed QTAR ("Q-learning-based Traffic-Aware Routing") based on RSU for urban VANETs. A routing path was used to choose the trustworthy connection road segments so that the packets could be sent effectively. In order to reduce latency and the impact of swift vehicle movements on path sensitivity, the packet was broadcast in a road section using distributed V2V Q-learning combined with QGGF. In order to broadcast the packet at each intermediate intersection, distributed R2R Q-learning was introduced. The testing results demonstrated that the analyzed method outperformed the standard processes in terms of average and least average E2E (end-to-end) delays.

Sadia Din et al. (2020)[52] developed the BTA-GRP (Geographical Routing Protocol with Beaconless Traffic-Aware), which chose the next forwarder node and the route taking into account traffic density, distance, and direction . Given that the topology was dynamic, a novel routing method was intended to address a variety of problems, including the disconnectivity in metropolitan regions. This approach could be used to shorten the wait time and increase throughput. The simulation's findingsverified that the proposed protocol worked well in VANETs.

d. Geographic Routing Based Protocol for Routing in VANET

O. Alzamzami, et.al (2021)[53] presented a cross-layer frameworkof LDB (link dynamic behavior) . Considering LDB, an extended version of geographic routing known as Geo-CAP algorithm was developed for urban VANETs (Vehicular ad hoc Network). More truthful links were selected, and varying nodes and network conditions were considered to provide higher gains for which packet loss and delay was mitigated. NS-3 was applied for quantifying the developed algorithm in the experimentation. The results indicated that the developed algorithm was effective with regard toPDR (packet delivery rate), throughput and E2E (end-to-end) delay.

P. Singh, et.al (2022[54]***)*** projected aW-GeoR (Weighted Geographical Routing) algorithm for applications of health monitoring in VANET (Vehicular ad hoc Network) to select next-hop node so that the crucial signs were disseminated to monitor post-disaster health in urban traffic environments . The next-hop node was selected using the traffic aware information related to traffic mobility, inter-vehicle distances, speed differences, communicating link expiration time, channel quality, and proximity factors. SUMO-0.32 and NS-3.23 platforms executed to test the projected algorithm on apost-disaster scenario. The simulated results exhibited the supremacy of the projected algorithm concerning the number of path breaks, lost packets, throughput, PDR (packet delivery ratio), delay, and mean hop count.

S. Jiang, et.al (2021) [55] suggested an adaptive UAV (unmanned aerial vehicle) based GRQL (geographic routing with Q-Learning). There were 2components:aerial andground. The initial component deployed a FL (Fuzzy Logic) and DFS (Depth First Search) algorithm based onUAV-collected information like the global road traffic for computing theglobal routing path, and transmitting this information to theground requesting vehicle. The latter one utilized a vehicle for maintaining a fix-sized Q-table converged with a reward function and forwarding the routing request to the optimal node. For this,Q-table filtered was considered in accordance with the global routing path. The simulation outcomes confirmed that the suggested algorithm was applicable to enhance PDR (packet delivery ratio) andE2E (end-to-end) delay.

S. A. Rashid, et.al (2022)[56] intended an innovativemodel called RAMO (Reliability Aware Multi-Objective Optimization)to perform routing in VANETs . Besides, an optimization block adopted for controlling the metrics of every block. Moreover, an EGMHS (Enhanced Gaussian Mutation Harmony Searching) algorithm was put forward on the basis ofGaussian mutation, objective decomposition and a harmony memory extraction algorithm.The mathematical functions and network simulator were executed to compute both the algorithms. The experimental results demonstrated that the intended model was more robust in comparison with other methods with regard todelta metric, hyper-volume, PDR (packet delivery ratio) andE2E (end-to-end) delay.

e. General Protocols for Routing in VANET

M. K. Diaa, et.al (2022) [57] suggested an OPBRP (Obstacle Prediction Based Routing Protocol) in order to detect vehicles, transmit the packets to RSU (Roadside Units) and select an optimal route reliably . For this, Kinematics and Mobility of vehicle was predicted in VANET (Vehicular ad hoc Network). The major objective of this work was to upgrade the predictive routing algorithm for transmitting the packets through a reliable route, and to introduce a novel logic so that the intermediate nodes were selected to the destination for enhancing PDR (Packet Delivery Ratio). The suggested protocol was applicable to increase PDR up to18.46%, lessen the E2E (end-to-end) delay up to10.51% and energy utilization up to 23.80% while transmitting the data.

G. D. Singh, et.al (2022) [58] projected an HGFA (Hybrid Genetic Firefly Algorithm)-based routing algorithmto establish a communication in VANET (Vehicular ad hoc Network) quickly . This algorithm focused on integrating the attributes of GA (Genetic Algorithm) with attributes of FA (Firefly algorithm), and utilizing them in routing forsparse and dense network scenarios. The behavior of fireflies was considered for accomplishing the task and coordinating with other nodes. A novel OF (Objective Function) was constructed using the attributes of GA. The experimental results indicated that the projected algorithm offered an accuracy of 0.77% and 0.74% against FF algorithm and 0.55% and 0.42% against PSO (Particle Swarm Optimization) technique in both scenarios respectively.

S. Zhou, et.al (2021) [59] investigated a MIS (multiple intersection selection) routing algorithm planned on the basis of road section connectivity probability to establishV2V (vehicle–vehicle) communication in urban VANETs (Vehicular ad hoc Network) .The traffic lights considered to distribute the vehicle. Primarily, a technique was put forward for computing the road section connectivity probability of a two-way lane with regard to traffic lights. Subsequently, an optimization technique was implemented for choosing the optimal road routeamid source and destination node. Eventually, an analysis was performed on selecting the relay node on the road section after verifying the optimal road path. The simulation results reported that the investigated algorithm was performed well with regard toPDR (packet delivery rate) and E2E (end-to-end) delay.

Table 1

AUTHOR NAME	**YEAR**	**TECHNIQUE**	**DATA-SET**	**FINDINGS**
BIO-INSPIRED ROUTING PROTOCOL VANET				
Raghu Ramamoorthy et. al[32]	2022	“Enhanced Bio-Inspired Routing Algorithm (EBIRA)”	NS2	“According to the simulation results, EBIRA performs better than RDACO and RAGR in terms of throughput, latency, and packet delivery ratio”.
Shubham Soni et. Al[33]	2022	“Routing protocol PSOR”	NS3	With less time, the developed approach enhanced throughput, packet size, and overhead.
Ali Hashim Abbas et. al.[34]	2021	“A Cross-Layer Approach MAC/NET with Updated-GA (MNUG-CLA)”	NS2	Due to the network's extremely high dynamic mobility on the highways, network efficiency must be increased. An efficient routing protocol is necessary to ensure that the vehicles arrive at their destination in the possible time.
A. Gopalakrishnan, et. al.[35]	2020	“Protocol for Bio inspired Routing”	NS2	The networking topologies in the VANET are stabilized by the SDN.
Hao Liu, et al. [36]	2020	“Protocol for spider-web routing facilitated by parking areas”	NS2	The recommended protocol outperformed more established methods in terms of performance.
“Bhushan Yelure, et al.”[37]	2020	“Routing protocol PSOR”	NS2	The created algorithm offered improved throughput, packet size, and overhead with less time.
“Daxin Tian, et al.”[38]	2018	“Protocol for unicast routing based on attractor selection (URAS)”	MATLAB	Regarding PDR, E2E latency, and congestion, the projected strategy was reliable and effective.
CLUSTERING BASED ROUTING PROTOCOL IN VANET				
“Mohammad Sadegh Azhdari et.al”[39]	2022	“Fuzzy Logic”	NS2	We evaluated the performance of our proposed technique using E2E delay, packet collision, packet delivery rate (PDR), routing overhead, throughput, and packet loss rate (PLR).
“Viswanathan Ramasamy et. al”[40]	**2021**	“Fuzzy Logic”	VNODA, LLA	Devised a “Position Particle Swarm Optimization with Fuzzy Logic (PPSO-FL)” technique for VANETs, relying on collectively coordinated measures rather than instantaneous velocity

"Khalid Kandali, et al."[42]	2020	"Routing protocol using an adaptive K-Harmonic Means (RPKHM)"	NS2	Regarding PDR, average E2E time, and throughput, the proposed protocol was efficient.
"ParisaSaraj Hamedani, et al."[43]	2018	"Algorithm for two-layer cluster-based routing"	NS-2.35	By using this technique, the PDR was increased and the E2E delay was decreased.
"Wenxiao Dong, et al."[41]	2017	"Cluster-based recursive broadcast (CRB)"	NS2	With regard to delivery ratio and delay time, this algorithm worked well.
"Waqar Farooq, et al."[44]	2017	"Autonomous Aerial and Ground Vehicles (AAGVs) routing protocol"	NS2,NS3	The established algorithm helped to increase the PDR and throughput while reducing the latency and overhead.
"Salim Bitam et.al."[45]	**2015**	"Generic Cloud Computing Model"	NS2	Their Model has increased traffic safety and facilitated passenger comfort. Security and privacy concerns have not been given any thought in their model.
TRAFFIC AWARE ROUTING PROTOCOL VANET				
"Maryam Gillani et.al."[46]	2022	"Real-time CH election (R-CHE) algorithm"	NS-2.35	Using NS-2.35 on Ubuntu, we ran extensive simulations to verify our findings. In this instance, the network deployment and message initiation are done using TCL.
"Yida He et. al"[47]	**2021**	"Intersection-based Traffic-Aware Routing with Fuzzy Q-learning for Urban VANETs"	ITAR-FQ	"It is a particularly difficult task to design an effective routing protocol for urban VANETs due to their unique characteristics. The Q-learning algorithm, which consists of various strategies for forwarding data packets within roads and intersections".
"Satheshkumar Kandasamy et. al"[48]	**2021**	"A smart transportation system in VANET based on vehicle geographical tracking and balanced routing protocol"	NS 2.34	VANET has drawn a lot of attention due to its distinct abilities to manage a high level of vehicle mobility, major topological changes, and experiencing frequent route failures or breaks.
"Jinqiao Wu, et al."[51]	2020	"Traffic-Aware Routing based on Q-Learning with RSU assistance (QTAR)"	QualNet	With relation to the average and least average E2E delay, the researched method performed better.
"Sadia Din, et al."[52]	2020	"Geographical Routing Protocol With Beaconless Traffic-Aware (BTA-GRP)"	NS2.34 simulator	This approach could be used to shorten the wait time and increase throughput.
"Rui Wu, et al."[50]	2019	"GeoTAR"	NS3	PDR and E2E delay performance on the VANET were effectively improved by the suggested strategy.
"Forough Goudarzi, et	2018	"Position-based routing protocol with traffic	OMNeT++, SUMO, and	At speeds up to 70 km/h, the developed method was able to reduce the overhead and E2E time while

al.”[49]		awareness”	VACO	increasing the PDR by 10% above.
GEOGRAPHIC ROUTING BASED PROTOCOL FOR ROUTING IN VANET				
P. Singh, et.al[54]	2022	W-GeoR (Weighted Geographical Routing)	NETSIM,NS2	The simulated results exhibited the supremacy of the projected algorithm concerning the number of path breaks, lost packets, throughput, PDR (packet delivery ratio), delay, and mean hop count.
S. A. Rashid, et.al[56]	2022	RAMO (Reliability Aware Multi-Objective Optimization)	OMNeT++, NS3	The experimental results demonstrated that the intended model was more robust in comparison with other methods with regard to delta metric, hyper-volume, PDR (packet delivery ratio) and E2E (end-to-end) delay.
O. Alzamzami, et.al[53]	2021	Geo-CAP algorithm	V2X Simulation Runtime Infrastructure (VSimRTI), OMNeT++	The results indicated that the developed algorithm was effective with regard to PDR (packet delivery rate), throughput and E2E (end-to-end) delay.
S. Jiang, et.al[55]	2021	An adaptive UAV (unmanned aerial vehicle) based GRQL (geographic routing with Q-Learning)	SUMO	The simulation outcomes confirmed that the suggested algorithm was applicable to enhance PDR (packet delivery ratio) and E2E (end-to-end) delay.
GENERAL PROTOCOLS FOR ROUTING IN VANET				
M. K. Diaa, et.al[57]	2022	OPBRP (Obstacle Prediction Based Routing Protocol)	NS3	The suggested protocol was applicable to increase PDR up to18.46%, lessen the E2E (end-to-end) delay up to10.51% and energy utilization up to 23.80% while transmitting the data.
G. D. Singh, et.al[58]	2022	HGFA (Hybrid Genetic Firefly Algorithm)-based routing algorithm	NS3,SUMO	The experimental results indicated that the projected algorithm offered accuracy of 0.77% and 0.74% against FF algorithm and 0.55% and 0.42% against PSO (Particle Swarm Optimization) technique in both scenarios respectively.
S. Zhou, et.al[59]	2021	A multiple intersection selection routing algorithm	NS2	The simulation results reported that the investigated algorithm was performed well with regard toPDR (packet delivery rate) and E2E (end-to-end) delay.

Comparison Table 1

Routing Protocol	**Network Type**	**Network Architecture**	**Routing Approach**	**Mobility Model**	**Key Feature**	**Advantages**	**Disadvantage**
General Routing Protocol	Infrastructure Based or Infrastructure Less	Ad-hoc or Hybrid	Traditional	Random Waypoint	Uses traditional routing algorithm such as AODV,DSR or DSDV	Can support both ad-hoc and infrastructure-based communication	Can Suffer from high overhead due to frequent broadcast
Bio-Inspired Routing Protocol	Infrastructure Less	Ad-hoc	Swarm Intelligence	Random Waypoint or Manhattan Grid	Uses Swarm Intelligence to optimize routing decision	Can adapt to dynamic changes in network topology	May require more time to converge
Traffic Aware Routing Protocol	Infrastructure Less	Ad-hoc or Hybrid	Traffic Aware	Random Waypoint or Urban Grid	Consider traffic patterns and congestion levels when making routing decision	Improves network throughput and reduces delays	May require additional information to be exchanged
Geographic Routing Protocol	Infrastructure Less	Ad-hoc	Geographic	Random Waypoint or Manhattan Grid	Uses geographic location of vehicle to determine routing paths	Can improve network scalability and performance	Can be affected by mobility patterns oof vehicles
Clustering Based Routing Protocol	Infrastructure Less	Ad-hoc	Clustering	Random Waypoint or Manhattan Grid	Divides network into cluster to reduce overhead and also increase stability	Can provide efficient routing and resource management	May require additional overhead for cluster formation and maintenance

Comparison Table 2

Routing Protocol	Security	Data Aggregation	Energy Efficiency	Routing Stability	QOS Support	Scalability
General Routing Protocol	Vulnerable To Security Attacks	No	Yes	Low	Limited	Good
Bio-Inspired Routing Protocol	Susceptible To Security Attacks	Yes	Yes	High	Limited	Limited
Traffic Aware Routing Protocol	May be Susceptible to Security Attacks	Yes	No	Medium	Good	Limited
Geographic Routing Protocol	Vulnerable To Security Attacks	No	Yes	High	Limited	Good
Clustering Based Routing Protocol	Susceptible To Attacks Targeting Cluster Heads	Yes	Yes	Medium	Limited	Good

6. Findings discovered from reviewing existing literature sources

This paper includes a methodical literature evaluation to ensure future replication of this survey. The findings discovered from reviewing existing literature sources are as follows:

a. The goal of this effort is to condense the knowledge of routing protocols based on various criteria for VANET to make optimal routing decisions.
b. By categorizing, ranking, and making the research on a particular study question, field, topic, or phenomenon of interest available.
c. This survey is beneficial for VANET researchers who are creating new emergency and data-interchange-specific amenities and require a robust routing mechanism to generate reliable results.
d. The goal of this work is to improve hop-to-hop decisions made by multi-parameter routing systems in vehicular communications (that typically use a single metric for routing decisions).

This review's findings support the claim that using different metrics in routing protocols improves the ability of vehicular communication to make decisions.

7. Conclusion

VANETs are an integral part of ITS (Intelligent Transportation System) based communication infrastructure. Therefore, over the past twenty years, they have been broadly analyzed from both industrial and academic perspectives. New generation vehicles are expected to be deployed with cutting-edge OBUs (onboard units), diverse communication technologies as well as fresh sensor paradigms. VANETs use vehicle-to-vehicle communication to deliver important information to drivers. VANETs make a substantial contribution to assuring their minimal dependence on static infrastructure routing because of their dispersed and self-configuring nature.This article highlights some of the earlier suggested routing protocols specifically for VANETs and examines the significance of establishing routing protocols for them. This article emphasizes the significance of these measurements in predicting the behavior of vehicular networks and focuses in particular on ideas that employ several indications to determine the most appropriate course of action. The characteristics of reactive and proactive routing protocols are presented in this study, together with the method used to evaluate them, such as the year of publication, the area under consideration, and the metrics used (i.e., simulators and mobility generators). This paper concludes that link stability, location, density, and speed are particularly advantageous properties in routing protocols for VANETs due to geographic limits.However, the mobility model has a significant impact on how well routing protocols perform in a network of vehicles. This work additionally takes into account additional measurements like direction, trajectory, and acceleration. These measurements are effective and appropriate for network dynamics. In order to meet the demands of VANETs, creating explicit routing protocols and taking into account the mobility model are required. Although the wireless network industry has shown a lot of interest in routing in VANETs, several difficulties have not yet been thoroughly investigated.Artificial intelligence and communicative trust are two new guidelines for the VANET routing protocol. In order to conduct a thorough examination of VANET performance, future work will involve gathering information on VANET routing protocols mentioned in the literature.

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