TOPOLOGY-BASED ROUTING PROTOCOLS IN VEHICULAR AD HOCNETWORKS: A TECHNICAL REVIEW

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Abstract:
A wide variety of different kinds of networks are being developed and implemented in a variety of situations thanks to recent advancements in hardware, software, and communication technologies. The Vehicular Ad-Hoc Network (VANET) is one such network that has drawn a lot of attention in recent years. Because VANET has the potential to significantly increase traffic efficiency, vehicle and road safety, passenger comfort, and driver convenience, it has been a focus of active study, standardization, and development. In this technical review, significant VANETs Protocols which were based on the topologies are compared along with their benefits and drawbacks. In this paper, a literature review is shown on different routing protocols in vehicular ad hoc networks with their limitations. Apart from that discuss the benefits as well as drawbacks related to topologies-based routing protocols.

Keywords:- Mobility, VANET(Vehicular Ad-hoc Netowrks), Topology, Routing Protocols., Proactive, Reactive, Hybrid,

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1. INTRODUCTION

Through the use of dedicated short-range communication (DSRC), VANET allows for wireless communication to be established between moving vehicles. DSRC is just IEEE 802.11a with some modifications to make it compatible with 802.11p's reduced overhead operation[1]. The whole communication stack is standardized by IEEE 802.11p, which is part of the 1609 family of standards that refers to wireless access in vehicle environments (WAVE) [2]. A vehicle can interact either directly with other cars, known as vehicle-to- vehicle communication (V2V), or with stationary equipment adjacent to the road, known as a roadside unit (RSU), known as vehicle-to-infrastructure communication (V2I). These sorts of connections make it possible for cars to exchange a variety of information, such as safety data that may be used to prevent accidents, investigate accidents after they have occurred, or reduce traffic congestion. Other kinds of information, such as those about travelers, which are not deemed to be safety-related types of information, may also be sent. The purpose of disseminating and sharing this information is to deliver a safety message to alert drivers about predicted risks in the interest of reducing the frequency of accidents and so saving people's lives, or providing passengers with enjoyable experiences [3].

Researchers from a wide variety of disciplines flock to this area to work on the development of VANET applications, protocols, and simulation tools. We are concentrating on the routing protocols of VANET and the need they have to improve communication times while reducing the amount of bandwidth that is used [4].

2. VANET ROUTING PROTOCOLS: The routing protocol for VANET may be roughly broken down into five basic categories, each of which has its subtypes.

i. TOPOLOGY-BASED ROUTING PROTOCOL
ii. POSITION BASED/ GEOGRAPHICAL BASED
iii. BROADCAST BASED
iv. MULTICAST BASED
v. INFRASTRUCTURE BASED

In order to forward packets, these routing protocols make use of the knowledge about the connections that already exist in the network.

They are broken down even further into::

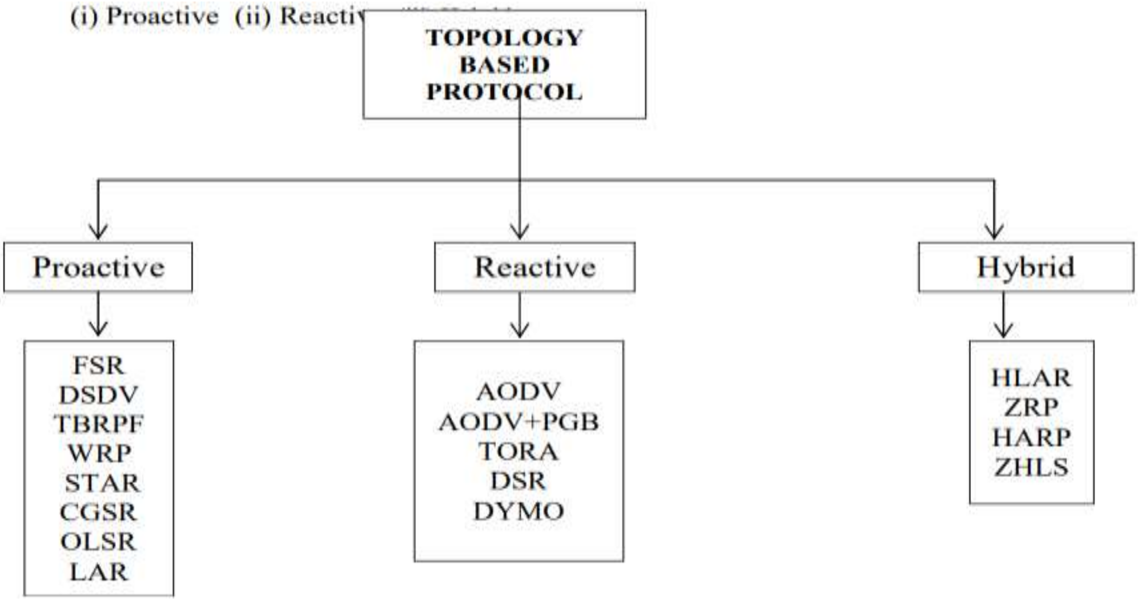

Figure 2.1: Routing Protocol Classification

2.1 PROACTIVE TOPOLOGY-BASED PROTOCOL

Table-driven routing protocol is another name for the proactive protocol. These protocols operate by routinely communicating topological information among all network nodes. In proactive routing, the routing details, such as the next forwarding hop, are kept up to date in the background regardless of communication requirements. Within a node, a table is built and maintained. As a result, each item in the table denotes the subsequent hop node leading to a certain destination. Additionally, it results in the maintenance of abandoned data channels, which lowers the bandwidth that is readily accessible [5].

Advantage:-The proactive routing protocol has the benefit that it eliminates the need forroute discovery. This is because the path to the destination is kept in the background and is always accessible upon search.

Disadvantage:-The fact that this protocol offers low latency for real-time applications is,however, one of its drawbacks. -There is a substantial amount of bandwidth that is being taken up by pathways that are not being utilized [6].

- **Fisheye State Routing (FSR)**

This is an effective method of link-state routing that keeps a topology map at each node and propagates link-state modifications solely with the nodes that are immediately next to it rather than with the complete network. In addition, the information about the condition of the connection is sent using frequencies that vary from one entry to another according to the hops that separate that entry from the current node. Entries that are located in closer proximity are disseminated at a higher frequency than the nodes that are farther away. Because of the decrease in broadcast overhead, the imprecision in the routing is adjusted as the packets come closer and closer to their final destination[7].

Advantages: Because it only communicates partial routing update information with neighbors, FSR results in a considerable reduction in the amount of bandwidth that is used.
- Bring down the overhead of the route.
- Even if there is a connection failure of any kind, there will be no change in the routing table since it does not trigger any control message for link failure.

Disadvantages: Extremely low performance in somewhat unstructured ad hoc networks.
-A lack of information on more distant nodes.
-As the size of the network grows, the complexity of the storage space required for the routing table as well as the processing load will also rise.
- The information provided is insufficient for route creation.

- **Destination-sequenced Distance-vector Routing (DSDV)**

This approach DSDV [25] is a table-driven routing protocol for ad hoc mobile networks that was developed based on the Bellman-Ford algorithm. C. Perkins and P. Bhagwat came up with the idea for it in 1994. Every node in a DSDV network maintains its copy of a next-hop table, which it then distributes to its neighboring nodes. There are two distinct varieties of next-hop table exchanges: event-driven incremental updating and periodic full-table broadcasting[8]. The mobility of the nodes influences how often the full-table broadcast and incremental updates take place. A sequence number is added by the source node at the end of each data packet that is sent during a next-hop table broadcast or an incremental update. This sequence number is then added to the item in the next-hop table for each node that has received the related distance-vector updates by all nodes that have received those updates. After receiving a new next-hop table from its neighbor, a node will only modify its route to a destination if either the new sequence number is bigger than the one that was previously recorded, or if the new sequence number is the same as the one that was previously recorded, but the new route is shorter. Each route's settling time is estimated in order to cut down on the control message overhead even more. After the settling time for the route has ended and ithas been determined that the route is still the best option, a node will update its neighbors with the new route. The practice of route looping has been done away with, convergence speed has been sped up, and control message overhead has been reduced[9].

Advantages:
- It is an excellent choice for developing ad hoc networks with a limited number of nodes due to its suitability.
- The issue with the Routing Loop has been resolved, and the count-to-infinity problem has been mitigated.
- Instead of keeping track of many routes to each destination, DSDV will just keep track ofthe most efficient route.

Disadvantages:-DSDV needs a frequent update of its routing tables, which reduces battery power and a small amount of bandwidth even while the network is inactive. Apart from that, a new sequence number is required anytime the topology of the network changes. The DSDV is one of the protocols that should not be used in highly dynamic networks.

- **Optimized Link State Routing Protocol (OLSR)**

It is a proactive link-state routing protocol that is used for r mobile ad hoc networks called OLSR, the performance of OLSR is high mobility with low bandwidth. An example of a traditional link-state routing protocol is OLSR, which uses specialized nodes that serve as multipoint relays (MPRs) to efficiently flood control information regularly. The quantity of necessary transmissions is decreased when MPRs are used [10]. To preserve the topology information of the whole network in the face of mobility and failures, OLSR daemons frequently exchange various messages. Three primary message types—HELLO, TC (topology control), and MID (multiple interface declaration) messages—are mostly used to carry out the fundamental functionality.

Neighboring nodes exchange HELLO messages across a one-hop distance. Link sensing, neighborhood identification, and MPR selection signaling are all supported by their use. These messages are issued regularly and include details on the nearby nodes and the connections between their network interfaces. ii. MPRs send out TC messages regularly to let other nodes know which ones have chosen them as their MPRs. Each network node's topological information base, which is used to calculate routing tables, contains this information. Such messages are sent via the network to the other nodes. A sequence number is used to differentiate between new and old TC messages since they are broadcast frequently. iii. The nodes transmit MID messages to report information about the network interfaces they use to connect to the network. Such information is required since the nodes may participate in communications via numerous interfaces with separate addresses[11].

Advantages:- Capable of providing loop-free pathways that are the best possible.
- May be used to bolster the Quality of Service.

Disadvantages: The link-state routing protocols still have the vast majority of their flaws. Maintaining dependability at the link layer is still necessary.
- If changes are performed often, there is a significant cost; otherwise, outdated routing information.
- The major disadvantages are scalability is level of low.

- **Topology Dissemination Based on Reverse-Path Forwarding (TBRPF)**

It is an ad-hoc network-specific link-state routing protocol. By employing a topology table, each node builds a source tree that has links to every other node that is accessible. Using HELLO messages, nodes are frequently updated with the changes between the prior and current network state. Because routing messages are smaller as a result, they may be forwarded to neighbors more often[13].

- **Wireless Routing Protocol (WRP)**

The WRP stands for Wireless Routing Protocol which was based on the distance-vector routing system that is table-based [14]. Each node in the network is responsible for maintaining an up-to-date version of several tables: the Distance table, the Routing table, the Link-Cost table, and the Message Retransmission list. The WRP protocol, which is an upgraded form of the distance-vector routing protocol, determines paths with the use of the Bellman-Ford technique. The distance table (DT) takes into account, among other things, the network viewpoint of a node's neighbors. It consists of a matrix that has the distance and the penultimate node given by a neighbor for each destination that is included inside an element of the matrix. The RT provides access to the most up-to-date network view for every destination that is currently known. In the connection Cost Table (LCT), the cost of carrying messages over each connection is given. For instance, the number of hops necessary to reachthe destination is one of the factors that contribute to this cost. With the help of the Message Retransmission List (MRL), maintains a counter for each entry, so that the update message will be resent to all for designated as an entry. In this feature, the update message will be decreased with each subsequent retransmission. The updated information will be delivered to all related contains lists in networks. Nodes RT has the responsibility of each node to deliver and update the message it provides to acknowledge the updated message. If the counter hits "0" that means the update message has not been acknowledged or not received message thatis why it is to be resent again update message itself is to be deleted once it has been processed. A node can determine whether or not there has been a break in the connection by counting the number of update periods that have passed since the last successful transfer. After receiving an update message, a node not only modifies the distance between transmission neighbors but also checks the distances of the other neighbors. As a result,convergence happens considerably more rapidly than it does with DSDV[15].

- **Cluster-head Gateway Switch Routing (CGSR)**

A clustered, multi-hop wireless network using heuristic routing is called CGSR. The Cluster Head Gateway Switch Routing protocol may operate on several channels. It makes code separation possible between clusters. The clusters are created via a labor-intensive process called cluster head election. For this reason, the protocol utilizes an election method known as the Least Cluster Change (LCC) algorithm. Cluster heads can only be changed via LCC if two cluster heads come into touch with one another or if a node moves away from all othercluster heads. The CGSR protocol is not self-contained. The underlying routing method is DSDV. Utilizing a hierarchical cluster head-to-gateway routing, the DSDV protocol isupdated. A packet sent by a node is first sent to its cluster head, after which it is forwardedfrom the cluster head to a gateway, and so forth until it reaches the cluster head of the target node. The packet is subsequently sent to the target node by that destination cluster head[16].

Advantages:- A more efficient use of bandwidth; A smaller size of the distance vectordatabase as a result of the routing being carried out exclusively over the cluster head.

Disadvantages: - An increase in the amount of time devoted to the selection of cluster headsand gateways If the mobile node is using CDMA or TDMA, then the process of obtaining authorization to transmit packets may take some time. Alterations to the cluster head might cause many branches of the route to break.

- **Location Aided Routing (LAR)**

Maintaining a topology database for nodes and updating the network information on additional nodes that are in the network is what Location-Aided Routing (LAR) is all about. By making use of location information, Location-Aided Routing (LAR) intends to bring about a decrease in the amount of overhead involved in the routing process. The LAR will make use of the information provided about the position to limit flooding to a certain region known as the request zone. As a direct result of this, the quantity of route request messages has been cut down. This protocol sends signals to a selection of nodes from which the likelihood of discovering a route is extremely high. Rather than sending route discovery messages to the whole network, it sends them just to a subset of nodes. An expected zone is an area that is anticipated to include the present position of the target node in LAR. This region is described as an expected zone. The route request flooding that takes place throughout the operation for discovering routes is restricted to a request zone. This zone includes the anticipated zone as well as the location of the sender node[17].

Advantages: It reduces the amount of overhead caused by routing. It is not too difficult to choose the best path.

Disadvantages: The request zone serves to limit the effects of flooding requests.

2.2REACTIVE TOPOLOGY BASED

Reactive routing protocol working is based on demand routing because it starts route discovery when a node needs to communicate with another node thus it reduces network traffic[18].

Advantages: -The benefit of this protocol is updated routing table does not require periodic flooding of the network. Flooding requires when it is demanded. -Beaconless so it saves bandwidth.

Disadvantages:- For route finding latency is high.
- Excessive flooding of the network disrupts the node's communication.

- **Ad Hoc On-Demand Distance Vector (*AODV)***

AODV enables mobile nodes to get routes rapidly for new destinations, and it does not need nodes to retain routes to destinations that are not in active communication. AODV also reduces the amount of routing maintenance that mobile nodes are required to do. It is capable of both unicast and multicast routing at the same time. It is distinct from other on-demand routing protocols because it employs a destination sequence number, also known as a DestSeqNum. The AODV protocol requires that the route discovery process be started anytime a source node has to interact with a destination node and does not already have that destination node's routing information in its table. The node sends out an RREQ packet, which is known as a route request, to all of its neighbors. The source address, the source sequence number, the broadcast ID, the destination address, the destination sequence number, and the hop count are all included in the route request packets. An RREQ may be identified in a way that is unique by its source address and broadcast ID. The purpose of the source sequence number is to ensure that information on the path back to the origin is kept as up-to- date as possible. The destination sequence number indicates the minimum amount of time that must have passed since a route was last used before it may be acknowledged by the source. If a neighbor understands how to get to the destination, it will respond to the route query with a route reply control message known as RREP, which will then be sent down the reserve path. If this is not the case, the neighbor will continue to rebroadcast the RREQ until either an active route is discovered or the maximum number of hops is achieved[19].

Advantages: - A route that leads to the destination that has been brought up to date as a result of employing the destination sequence number. It decreases the need for an excessive amount of memory and eliminates route redundancy. AODV replies to the breakdown of the connection in the network.
- It applies to ad hoc networks that are of a vast size.

Disadvantages:-When compared to other methods, establishing a route requires much more time due to the longer time required for connection setup and first communication.
-Inconsistency in the path may result if intermediary nodes still have outdated items in theirdatabases.
-There will be a significant increase in the amount of control overhead if there are many routereply packets for a single route reply packet.
- Because it periodically sends beacons, it uses up more bandwidth.

- **Preferred Group Broadcasting (AODV+PGB)**

This is a broadcasting protocol, and its goal is to reduce the broadcast cost associated with AODV's route discovery. As a result, it improves route stability, which is particularly crucial in VANETs. Based on the signal that they have received, the receivers will next decide whether or not they are part of the chosen group and which member of the desired group to transmit. Because only one node is permitted to broadcast at a time and the favored group is not always the one that makes the greatest headway toward the destination, the process of discovering a route may take more time than it does when using AODV. Another disadvantage is that broadcasting may be terminated if it is discovered that the group isdevoid of members owing to the existence of sparse networks. Since two nodes in the preferred group might broadcast at the same time, packet duplication is another possibility.

According to Naumov, the best solution to eliminate the problem of broadcast duplication is to include the packet's predecessors within the packet itself[20].

- **Dynamic Source Routing (DSR)**

Dynamic Source Routing protocol (DSR) [21] is made up of two primary processes that, when combined, make it possible for source routes to be discovered and maintained in an ad hoc network. These methods are as follows:

Route Discovery: It is the method that allows a node S that wants to transmit a packet to another node D to get a source route to D. In this mechanism when sender S wants to send the packet without previous route history in the memory of destination D then it perform the route discovery to the D.

Route Maintenance: In route maintenance, the enabled sender S has utilized the source route then it detects any discriminations in the route to the destination D or any fault related to the change in the topology to the D whenever it no longer utilizes the route. It checks the links between the S to D. Whenever found any fault from the source route to the destination route then the source has the option to change the different routes with proper permissions and execute the utilization of the route for further uses. So route discovery performs the new route from source S to destination D for future packet transmission. Also, route maintenance willbe notified to others for source route broken information with broadcasting messages. Only if S is actively transmitting packets to D is Route Maintenance for this route utilized. Both Route Discovery and Route Maintenance may be considered to be "on-demand" operations in DSR.

Advantages:-Beacon less.-To get routes between nodes, it causes a minimal amount of strain on the network. It takes advantage of caching, which lowers the burden on the network and enables more efficient route finding in the future. In DSR, there is no obligation to do monthly updates.

Disadvantages:-There will be byte overhead as a result of the route information included inside the header if there are an excessive number of nodes in the network. Flooding that is not essential puts pressure on the network.
-It has worse performance in the high mobility pattern.
- We are unable to fix broken connections on the local level.

- **Temporally Ordered Routing Algorithm (TORA)**

This routing belongs to a family of link reversal routing methods. In this family of algorithms, the height of the tree rooted at the source is utilized to create a directed acyclic graph (DAG) toward the destination. This DAG guides the flow of packets and guarantees that they may be reached by all of the nodes in the network. When a node has a packet to deliver, it will broadcast that packet using the broadcast command. The packet is then broadcast by that node's neighbor if the DAG determines that the neighbor is the transmitting node's downward link[22]. By broadcasting a query packet, a node contributes to the construction of the directed graph. When it receives a query packet, if it has a downward connection to the destination, it will broadcast a reply packet. If it does not have a downward link, however, it will simply dump the packet. When a node receives a reply packet, it will only update its height if the height that was provided by the reply packet provides the minimum of all the heights that it has previously received from other reply packets. After then, it sends out another transmission of the reply packet. The execution of the TORA algorithm provides a route to all of the nodes in the network, and it lowers control messages that reach far afield to a group of nodes that are nearby to those nodes. These are both benefits of the TORA protocol. Nevertheless, because it establishes a connection to every node in the network, the process of maintaining these connections is a laborious one, and this is particularly true in highly active VANETs.

Advantages: -When it is required to do so, it generates a DAG (direct acyclic graph).
-Decrease the burden on the network by eliminating the need for all intermediate nodes to rebroadcast the message.
-Perform well in congested networks.

Disadvantages:-It is not utilized since DSR and AODV perform better than TORA, which is why they are used instead.
-It is not possible to scale it up.

- **Dynamic MANET On-demand (DYMO):**

Another reactive routing protocol that is compatible with multi-hop wireless networks is called DYMO. DYMO is straightforward to use and has a simple structure[23].

2.3HYBRID TOPOLOGY-BASED PROTOCOL

The introduction of hybrid protocols was done in order to cut down on the control overhead of proactive routing protocols while also cutting down on the initial route discovery latency that reactive routing techniques experience[24].

- **Zone Routing Protocol (ZRP):-** ZRP is a hybrid wireless networking routing protocol that sends data across the network using both proactive and reactive routing algorithms. This protocol creates overlapping zones on the network. A group of nodes that are contained inside a zone radius is referred to as the zone. A radius of length, where is the number of hops to the zone's perimeter, determines the size of a zone. In ZRP [9], intra-zone communication uses the proactive IARP routing protocol while inter-zone communication uses the reactive IERP routing system. If both parties are in the same routing zone, the source delivers data immediately to the destination; otherwise, the IERP receptively starts a route discovery process. When a packet's destination is in the same zone as its origin in the ZRP protocol, the proactive protocol, which uses a routing table that has already been saved, is utilized to transport the packet right away. A reactive protocol takes over and checks each subsequent zone in the route to verify whether the destination is within it or if the destination is outside the packet's originating zone. The processing overhead for certain routes is decreased as a result. The proactive protocol, also known as the saved route-listing table, is used to transport the packet after it has been determined that a zone has the target node[25].

Advantage:-ZRP looks for loop-free routes to the target. By picking the most effective kind of protocol to employ along the path, ZRP was created to hasten delivery and lower processing overhead.

- **Hybrid Ad hoc Routing Protocol (*HARP*):** separates the whole network into distinct zones that do not overlap. Its goal is to reduce the amount of time that passes between a source and a destination by establishing a reliable path between the two. It uses route discovery across zones to prevent flooding in the network and selects the optimal path based on the requirements for network stability. In HARP, the process of routing is carried out on two different levels, depending on the location of the destination: intra-zone and inter-zone. It utilizes proactive protocols for intra-zone routing and reactive protocols for inter-zone routing, respectively[26].

Disadvantage: It cannot be used in ad hoc networks with a high degree of mobility.

- **Hybrid Location Based Ad hoc Routing Protocol (HLAR)**

To achieve the highest possible level of scalability performance, a protocol known as hybrid location-based ad hoc routing (HLAR) [27] was developed specifically. It combines a modified version of the AODV protocol with another geographic routing technology known as greedy forwarding. HLAR combines aspects of reactive routing and location-based spatial routing in its design. The goal of our proposed protocol is to make effective use of all of the available location information, to keep the routing overhead to a minimum, and to transition smoothly to reactive routing if the quality of the location information deteriorates. Within the framework of the proposed system, every node would be equipped with two distinct tables, each of which was locally built based on the beacon packets:

(i) A table of neighbors, which will be used in the process of carrying out geographic routing.
(ii) An ETX_table, which will be utilized to generate the AODV route (the AODV routing table) upon request to achieve optimum performance concerning scalability.

Discovery of the Route:[28] If the origin vehicle does not know how to go to the destination vehicle, it is the responsibility of the origin vehicle to begin the on-demand process of route discovery. Following the generation of RREQ, the node consults its neighbor table to determine whether or not it has any vehicle neighbors that are closer to the target vehicle. If there is a car that is a closer neighbor that is available, the RREQ package will be sent to that vehicle. If there isn't a car that is a closer neighbor, the RREQ packet will be broadcast to all of the other vehicles in the area. There are only three circumstances in which a destination vehicle will send a route reply (RREP) packet in response to an RREQ packet that it has received:

(i) If this RREQ packet is the very first one to be obtained from the source vehicle.
(ii) If the RREQ packet has a higher source sequence number than the RREQ packet that the destination vehicle has already replied to with its response, then the condition is met.

(iii) If the RREQ packet has the same source sequence number as the RREQ packet to which the destination vehicle has already replied, but the new packet indicates that a higher quality route is available.

- **Zone-based hierarchical link state (ZHLS)**

The ZHLS protocol segments the network into non-overlapping zones; each node in the network has its ID in addition to a zone ID that is determined by a GPS[29]. In this ZHLS routing protocol, the roads are divided into two different geographical segments called zones. These zones are mainly used to distribute road information to the different geographical segments. The GPS location is widely used by different segments for improving routing performance as well as road information databases. ZHLS routing protocol provides a threefold environment to be aware of the location of diffident zones and also it is useful for creating a dynamic zone with geographical location maps. It is also useful to improve the density of different zone to size. The second most useful advantage of the ZHLS routing protocol is it constructs a path between sources to destination with respect to their zones' topology. The third major reason for using ZHLS in VANET is its support for high mobility.

Table 1.1 Comparisons of Topology-based Routing Protocol in VANET

PARAMETER → PROTOCOL ↓	TYPE	FORWARDINGSTRATEGY	SUB TYPE	SCENARIO
FSR	Topology based	Multihop	Proactive	Urban
DSDV	Topology based	Multihop	Proactive	Urban
TBRPF	Topology based	Multihop	Proactive	Urban
STAR	Topology based	Greedy Forwarding	Proactive	Urban
CGSR	Topology based	Multihop	Proactive	Urban
OLSR	Topology based	Multihop	Proactive	Urban
LAR	Topology based	Multihop	Proactive	Urban
AODV	Topology based	Multihop	Reactive	Urban
AODV+PGB	Topology based	Multihop	Reactive	Urban
TORA	Topology based	Multihop	Reactive	Urban
DSR	Topology based	Multihop	Reactive	Urban
DYMO	Topology based	Multihop	Reactive	Urban
ZRP	Topology based	Multihop	Hybrid	Urban
HARP	Topology based	Multihop	Hybrid	Urban
ZHLS	Topology based	Multihop	Hybrid	Urban
HLAR	Topology based	Multihop	Hybrid	Urban

3. Conclusion

VANETs utilize the principles of mobile ad hoc networks (MANETs) and enable moving vehicles to communicate with each other in an ad hoc manner. Several VANETs application exists such as electronic brake lights, platooning, traffic information systems, road transportation emergency services, and on-the-road services, whose ultimate goal is to provide driver safety and passenger comfort. With recent advancements in wireless technologies and the rapid development of smart cities across the globe, the scope of VANET has been increasing. This paper explores the routing protocol which is based on the topology structure for vehicular ad hoc network (VANET). Furthermore, this paper gives the advantages and disadvantages of such routing protocols apart from that several protocols are used for telecommunication or ITS system. These existing studies show how to use the protocol in future networks and how to identify the challenges and open issues for VANET implementation have been mentioned

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