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# A Survey on Topology and Position Based Routing Protocols in Vehicular Ad hoc Network (VANET)

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**Abstract**: Vehicular Ad Hoc Networks (VANET) is a subclass of Mobile ad hoc networks. It is a developing new technology in which vehicles interchange the information from one vehicle to another vehicle within a network. VANET is responsible for providing an illustrated approach for Intelligent Transport System (ITS). The main use of VANET is to save life and prevent the accidents. This Paper describes a survey of routing protocols in vehicular ad hoc networks. The survey of routing protocols in VANET is significant and essential for smart ITS. The routing protocols are divided into two categories of topology-based and position-based routing for VANETs. This review discusses the advantages and disadvantages of these routing protocols

***Keywords***: *VANET, Routing Protocol, V2V, V2I, Reactive, Proactive, Hybrid.*

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## 1. INTRODUCTION

Vehicular ad hoc network (VANET) is a network of moving vehicles, in this network moving vehicles can communicate and share information between others moving vehicles. The main purpose behind VANET is to provide safety, in daily life we can see lots of vehicles run on the road, and in some cases, the collision happened due to lack of proper communication to overcome this problem researchers introduce VANET. VANET uses wireless technology for making the network in ad hoc nature; each node is capable of sharing information and considering as packet forwarder in the network. Packet forwards through the nodes which come between source and destination (called intermediate nodes). VANET play crucial role in converting normal transportation system into intelligent transport system (ITS). Now many automobile companies manufacture vehicles with OBUs and other latest technology to allowing intelligent transport system. VANET indorse peerless characteristics compared to mobile ad hoc network (MANET) that provide opportunities to increase performance of the network. In VANET participating nodes are equipped with wireless onboard units (OBUs) to allow communication between vehicles and with road side unit (RSUs). Figure1 show the complete scenario of the vehicular ad hoc network (VANET), each node and infrastructure communicating with each other. VANETs applications are used to aware the drivers for traffic jams, situations of the road to avoid vehicle collision. It is also used to broadcast warning messages to the drivers of rear vehicles to avoid rear end collision on highways. VANET differ from the Mobile Ad hoc Network (MANETs) by some of its characteristics, such as high speed of moving vehicles in VANET, which makes it a challenging of Ad hoc network.

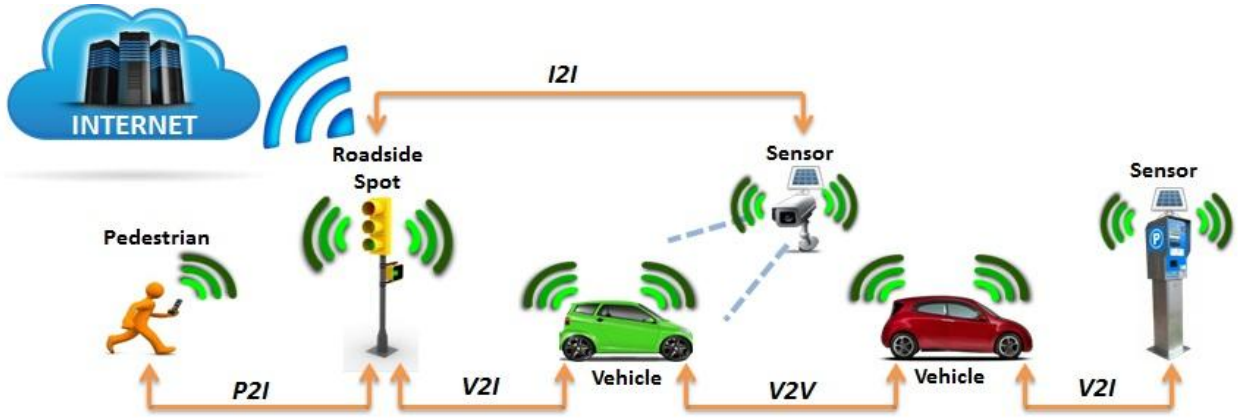


Figure 1: Architecture of VANET

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All nodes in VANET are vehicles that are capable of forming self-organizing networks without knowledge of each other. Continuous communication between the vehicles, routing and security of data are major challenge in VANETs because of dynamic topology of network [5][6] and it makes efficient routing of packet from source to destination vehicle more challenging. Some of the VANET feature such as self-organization, radio transmission conditions and low-bandwidth are the same to MANET technology. Because of this reason, MANET protocols are adopted for VANET scenarios. This paper is organized as follows: Chapter 2 explains the Communication type, challenges and characteristics of VANET. Chapter 3 explains about the various routing protocols in VANETs. Chapter 4 talks about the related works and Chapter 5 conclude this survey paper.

## 2. COMMUNICATION IN VANET

There are four types of communication in VANETs which is classified as follows:

2.1 Pure cellular architecture (I2V).

2.2 Pure Ad hoc (V2V).

### 2.1 Pure cellular architecture (I2V)

In pure cellular architecture the direct communication among vehicles cannot be possible (Fig1). The requirement for this communication is road side units (RSUs). The type of this communication is infrastructure to vehicle (I2V) communication. In V2I, the role of infrastructure is very crucial by collecting universal or limited information on traffic and road situations and then proposing or imposing positive performances on a cluster of vehicles.

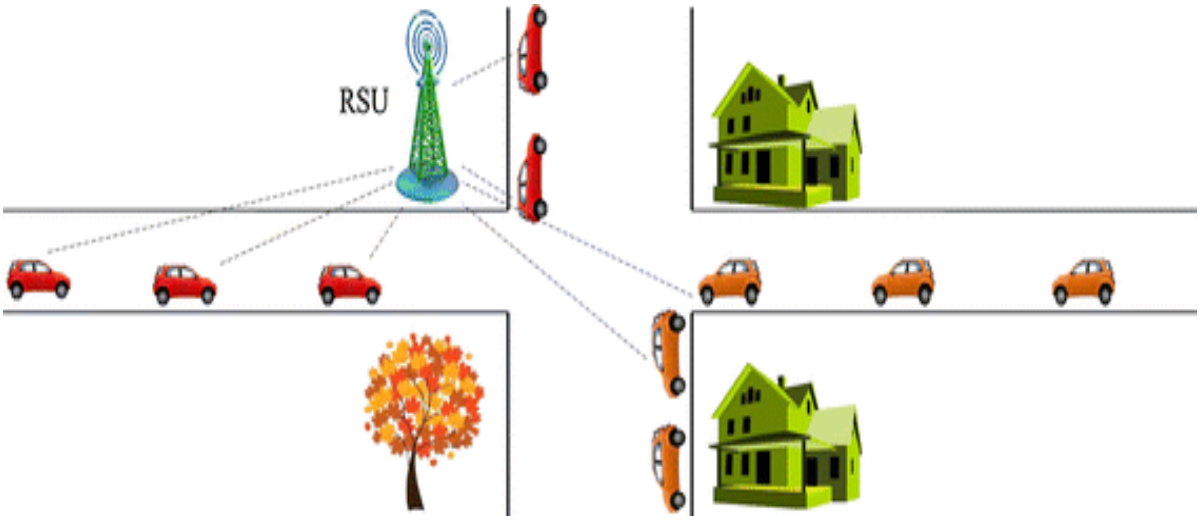


Fig 2: Architecture of I2V communication.

Previously the broad used of this is ramp metering; consuming needs is restricted sensors and actuators (extents of traffic density on a highway and traffic lights on ramps).In a further cultured consequence, the speeds and accelerations of vehicles and inter vehicle distances would be proposed by the infrastructure on the basis of traffic situations, with the goal of adjusting overall radiations, fuel ingestion, and traffic speeds. Recommendations to vehicles might be transmitted to drivers via road displays or straight to vehicles via wireless networks.

### 2.2 Pure Ad hoc (V2V)

In pure Ad hoc architecture, the communication among vehicles doesn't need the comfort of RSUs (Fig2). V2I is an infrastructure less network; with the support of sensors the direct communication among vehicles is possible. The kind of this communication is vehicle to vehicle (V2V).InV2V, because of the decentralized structure it is more problematic to recognize, objectives at establishing the communication among vehicles and probably emerging collaborations among them. At this level, information is exchanged and outcomes through a "local" basis (that is, among a cluster of vehicles in closeness to each other). The introduction of these information exchanges needs a settlement among car industrialists and contractors in terms of communication technology, protocols, and the similar, and exertions are under the technique in this route (the CAR2CAR Consortium).

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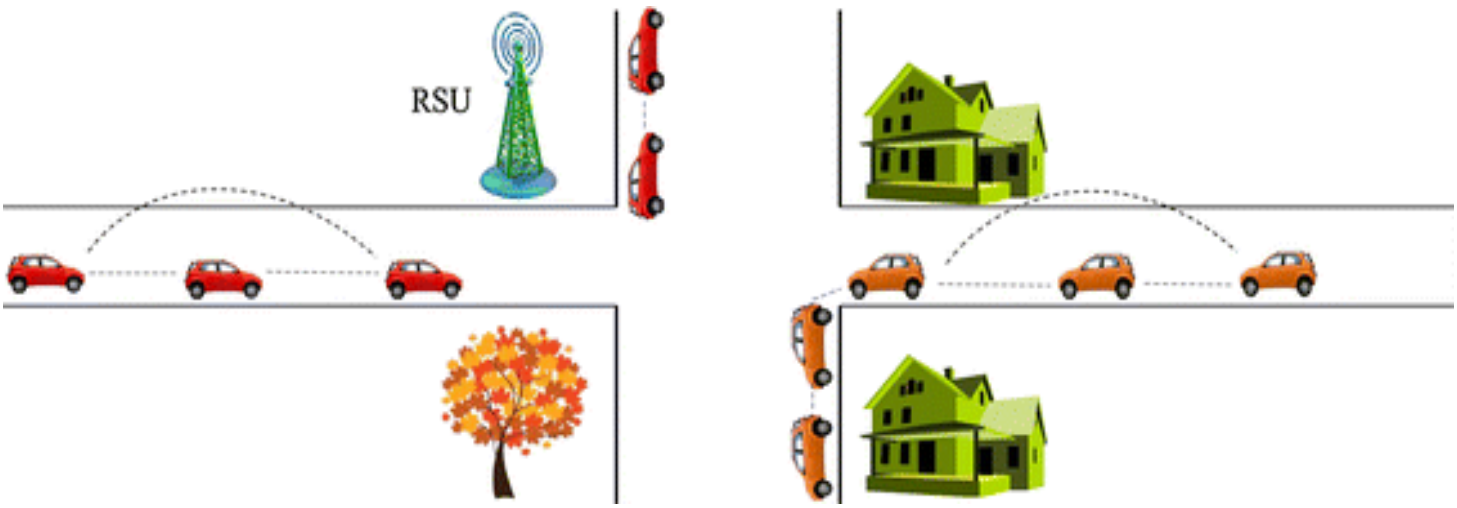


Fig 3: Architecture of V2V communication.

The basis of this communication technology is IEEE 802.11, which is also known as Wireless LAN. The concept of V2V is that, within the radio communication range, two or more vehicles or roadside stations exist then they can connect spontaneously and can create an ad hoc network allowing the sharing of position, speed, and direction data. Each and every vehicle acts as a router and permits transferring packets over multi-hop to additional distant vehicles and roadside stations.

### 3. CHARACTERISTICS OF VANET

Usually VANET is an application of MANET so some characteristics of VANETs are similar to the characteristics of MANETs but it has some own different characteristics which can be explained as follows:

i. **Highly dynamic topology:** Usually in VANETs the nodes are moving at very high speed due to this the network topology of the vehicles is continuously different. So the prediction of node's position is very hard to calculate.

ii. **Frequent exchange of information:** In VANET the ad hoc nature stimulates the nodes to collect information from the other vehicles and road side units. Hence among vehicles the exchange of information becomes frequent.

iii. **Wireless Communication:** The design of VANET is really for the wireless environment. The connection of Vehicles and information exchange is done through wireless. Then certain security size must be measured in communication.

iv. **Unbounded network size:** In VANET the implementation can be done for one city, more than one city or for countries. The meaning of that network size in VANET is unbounded geographically.

v. **Frequent disconnected network:** In VANET the high speed of the vehicles expresses the dynamic topology due to this dynamic topology of networks the link between the two communicating vehicle are disconnected frequently which is termed as intermittent connectivity.

vi. **Time Critical:** In VANET there should be the time limit to deliver the information to the vehicles thus a choice can be completed by the Vehicles and execute actions consequently.

vii. **Sufficient Energy:** In VANET vehicles do not have any issue of energy and computation resources. This permits VANET procedure of challenging techniques such as RSA, ECDSA execution and also delivers unlimited transmission power.

viii. **Better Physical Protection:** In VANET the vehicles are physically better protected. Therefore, Vehicles in VANET are more problematic to compromise physically and reduction in the consequence of infrastructure attack.

ix. **Unlimited Battery Power and Storage:** As in sensor networks; the Vehicles in VANETs do not have lack of power and storage limitation thus

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enhancing accountability sequence is not as appropriate as in sensor networks.

x. **Hard delay constraints:** In case of emergency, a critical problem is to deliver the messages on time. Hence, handle such conditions rather talking only about high data rates in not appropriate.

## 4. CHALLENGING ISSUE IN VANET

Although there is some discrimination in the characteristics of VANET with different networks but few characteristics inflicts some challenges to categorize the VANET. These challenges can be characterized into following categories:

**4.1. Technical Challenges :**The technical challenges in VANET deals with the technical problems and those problems must be resolved before the Organization of VANET. The few challenges are following:

i. **Network Management:** The topology of network and channel Condition change rapidly due to high mobility of Vehicles in VANET. Because of this, we can't use communication structures like tree because these structures can't be set up and maintained as rapidly as the topology changed.

ii. **Congestion and collision Control**: In VANET the challenge creates because of unbounded network size. in rural areas the traffic load is low and in night it is even in urban areas. Due to this, the network partitions frequently happens although in rush hours the traffic load is very high and hence network is congested and collision occurs in the network.

iii. **Environmental Impact:** In VANETs the electromagnetic used waves for communication among Vehicles. These waves are distributed by the obstacles like building, tree etc. Hence the environmental impact must be considered to deploy the VANET

iv. **MAC Design:** Usually in VANET the shared medium is used to communicate vehicles therefore the key issue is MAC design. Several approaches have been specified like CSMA, TDMA and SDMA etc. IEEE 802.11 implemented the CSMA based Mac for VANET. In order to communication among the vehicles Protocols have to be design.

v. **Security:** The road safety applications provided in VANET which are life critical Hence security of these messages needs to be satisfied.

**4.2. Security Challenges in VANET:** During the design of VANET architecture, the challenges of security must be considered which are security protocols, cryptographic algorithm etc. The list of some security challenges are as follows:

i. **Real time Constraint**: The safety related message must be delivered with 100ms transmission delay in VANET because it is time critical. So the fast cryptographic algorithm should be used to achieve real time constraint.

ii. **Data Consistency Liability**: The network can disturb or can cause to accidents because even authenticate node can perform malicious activities in VANET. Therefore to avoid this inconsistency a mechanism should be designed. Connection among the received data from different vehicles on specific information may avoid this type of inconsistency.

iii. **Low tolerance for error**: In VANET on the basis of probability certain protocols are designed. VANET uses life critical information on which stroke is completed in very small period. It may cause harm which is small error in probabilistic algorithm.

iv. **Key Distribution:** In VANET all the implemented security mechanisms are depend on keys. To decrypt the encrypted message at receiver end there is a need of different key or either the same key. And different manufacturer can also install keys in different ways.

Hence the major challenge in designing a security protocols is the distribution of keys among vehicles. Section Headings.

## 5. ROUTING PROTOCOLS

Communication and information sharing between two nodes is depending on the routing protocols. Routing Protocols in VANET environment are similar to MANET technology. VANET and MANET environments are not same, there is less mobility in MANET as compared to VANET, due to high mobility in VANET routing is challenging task. Routing protocols mainly classified into two major categories topology based and position based.

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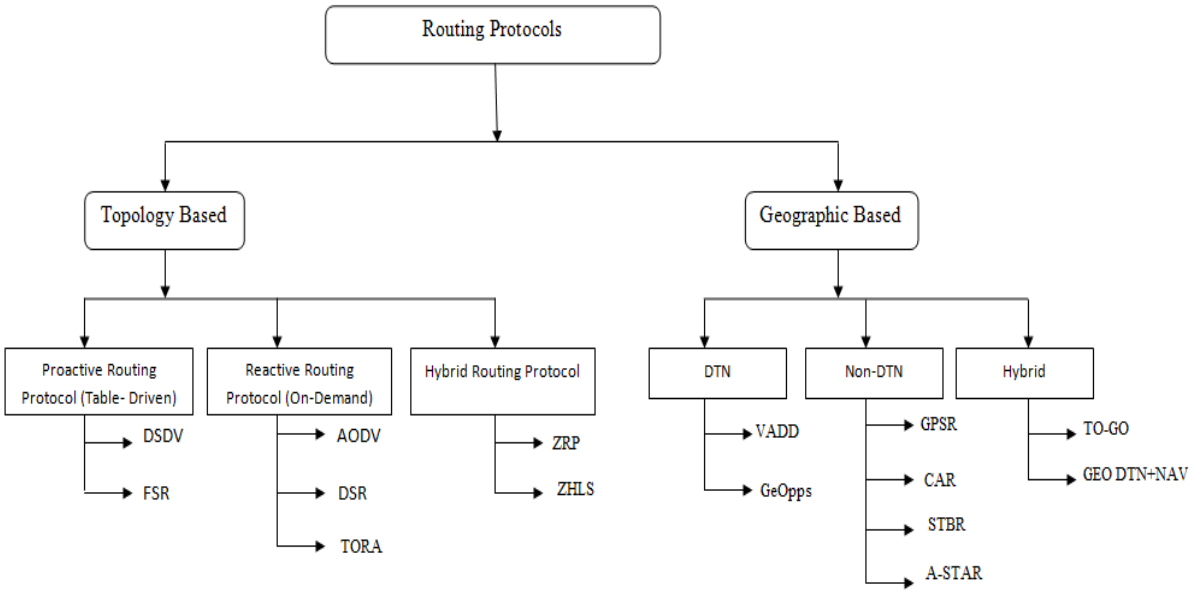


Fig 4: Classification of Routing Protocols

**5.1 Topology based protocol-** In computer networks the topology is an arrangement of a network, containing its nodes and connecting lines or it is defined as "the way by which fundamental parts are interconnected or organized". The routing information is stored in the form of routing table. To transfer the data the routing protocols use the links which are already available in network. In VANET the topology based routing protocols try to find the shortest path from source to destination. Topology based routing Protocols are classified into three categories they are:

**a) Proactive routing protocols**

The Proactive routing has some different features: the routing information such as the next sending hop is maintained in the background irrespective of communication requests. Control packets are continuously transmitted and flooded among nodes to maintain the routes or the connection between any pair of nodes even though some of paths are never used. A table is then created within a node such that each entry in the table specifies the next hop node in the direction of a certain target node. Proactive Routing is also called the Table-driven routing and the main Advantage of table driven routing is for the destination path which is already maintained in background no searching or route discovery is needed but the disadvantage of this it delivers minimal potential for real time applications, most of its bandwidth is disbursed by new paths, which creates overhead mostly in high mobility. Shortest path algorithms are the basis of this protocol. There are two types of proactive routing protocols are: FSR, DSDV.

**i) Fisheye State Routing (FSR):** FSR protocol is considered as proactive protocol and is a link state based routing protocol that has been modified to the wireless ad-hoc network. As a base it communicates on link state protocol, and at each node FSR has the capacity to deliver route information immediately by maintaining a topology map. In the link state table the updated information of the neighboring node will be available. The full topology map is stored and utilized in every node. Fisheye State Routing uses the fish eye technique means that it will diminish the size of information needed to denote graphical data. In routing the fish eye method translate to maintaining exact distance and route excellence information about the immediate neighborhood of a node with gradually less detail as the distance increases.

**Advantages:**

- It reduces the overhead in routing.
- Forward the Path information by maintaining a topology map.

**Disadvantages:**

- If the network size will increase processing overhead will also increase.
- Insufficient knowledge for finding the route.

**ii) Destination-Sequenced Distance-Vector Routing (DSDV):** DSDV is a table-driven routing scheme for ad-hoc mobile networks based on the Bellman- Ford algorithm. It removes route looping, increases convergence speed, and decreases control message overhead. In DSDV, each node maintains a next-hop table of all other nodes, which it exchanges with its neighbors. In packet header it carries destination sequence number. Full dump and Incremental packets are used to carry this protocol. Full dump packets hold routing information of all nodes which are broadcasted

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to neighbors and incremental packet deliver updates. Bandwidth is affected in full dump packets and the incremental packets affect overhead in networks. Both types make DSDV unsuitable for highly Dynamic VANETs.

**Advantages:**

- It carries the destination sequence number so the Path is loop free.
- Reduces the latency for finding the Routes.

**Disadvantages:**

- The sleeping nodes are not available.
- The major issue is Scalability.

**b) Reactive routing protocols:**

Reactive routing opens the route only when it needs to forward packets to its target node to communicate with each other. It keeps only the routes that are currently in use till the target node becomes unreachable beside each path from the source as an outcome it diminishes the load of the network. Reactive routing contains the path finding part in which the request packets are flooded into the network for the path search and this part end when route is found. The types of reactive routing protocols are AODV, DSR and TORA.

**i) Ad hoc On Demand Distance Vector (AODV):**

In Ad hoc On Demand Distance Vector (AODV) routing, upon receiving of a transmission request (RREQ), nodes record the address of the node sending the query in their routing table. This process of recording its earlier hop is called backward learning. Upon arriving at the target node, a reply packet (RREP) is then sent over the complete route found from backward learning to the source. At every end of the path, the node would record its earlier hop, therefore creating the forward path from the source. The flooding of request and sending of reply create a full duplex path. After the path has been established, it is maintained as long as the source uses it. A link disappointment will be conveyed recursively to the source and will in turn trigger another query-response process to find a new path.

**Advantages:**

- For the large scale Ad-Hoc networks it may be useful.
- This protocol provide loop free path.

**Disadvantages:**

- The demand for processing is very high.
- To create the routing table it takes more time.

**ii) Dynamic Source Routing DSR:**

Dynamic Source Routing (DSR) is a reactive routing protocol. In case of forwarding a data packet from one node to another node in the network first it will search route when required and then forward the data from source to destination. The node will go for route searching by broadcasting RREQ (Route Request) with a unique ID from source. When the packet is received by the nodes in the network it will find where the data packet required to be sending in the network and broadcasting till it is received at exact target node. The packet will back to source with unique ID when the target node receives the data packet and broadcast a RREP (Route Reply). The main task of this protocol is to maintaining the route information. If any broken link or unused route found then the information will be handled by route maintenance, and in case finding any route error then the nodes will forward a RERR (Route Error) message to the network.

**Advantages:**

- It does not interchange updates in routing periodically due to which it is on-demand.
- In case of the failure it can refers to cache for new route.

**Disadvantages:**

- There will be high route latency for finding the path in case of the large network.
- The more Traffic overhead is there.

**c) Hybrid routing protocols**

Hybrid routing protocols uses the advantages of both proactive and reactive routing. In hybrid protocols, there is the division of network is in two levels. The division levels are the inner layer and the outer layer. The inner layer is proactive, which is used to maintain and updates information on routing among all the nodes at all times in a network. The outer layer is reactive which is used to maintain and updates the information on routing between currently used nodes on the basis of need. Finally the hybrid protocols are used to reduce the control overhead of proactive routing protocols and decrease the initial route discovery delay in reactive routing protocols. The hybrid protocol discussed here are ZRP and ZHLS.

**i) Zone Routing Protocol ZRP:**

In ZRP there is a division of network into two overlapping zones. The zone is a collection of nodes and the nodes should be in a zone radius. In intra-zone routing the data packets are forwarded within the routing zone of the source node to reach the outlying node. In inter-zone routing the data packet is forwarded from the outlying node to the target node. There is restriction to a small neighborhood of a node in the proactive part of the protocol and for the reactive part is that it is used for routing across the network. This reduces the latency in path finding and reduces the number of control messages.

**Advantages:**

- Minimizes control overhead for longer routes.
- Eliminating the delays within zone.

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**Disadvantages:**

- It's not suitable for high density and rapidly changing topology of VANETs.

**5.2) Geographic Based protocol**

Geographic Based protocols are known as position based protocol or geo-protocols, nodes are decided where packet will travel based on geographical coordinates of neighbor nodes. Topology Based protocols fails in the dynamically change in node connectivity, position based protocols resolved this problem. Beacon messages are sends periodically for informing neighbor nodes. If node gives response of beacon messages that mean node is neighbor node and fall under in the same coverage area. The main advantages of position based protocol are there is need of route discovery, scalability, Efficient in rapidly changing mobility pattern, low overhead. And disadvantages are obtaining exact location; obstacle on highways, there is no guarantee of connectivity in indoors and underground locations.

**a) Delay tolerant network (DTN) protocol**

These protocols enable communication where connectivity issues there like high routing, more latency, error rates and no end to end connectivity. These protocols based on store and forward method. Main motive of these protocols are to reduce the latency of messages and increase the message delivery rates.

**i) Vehicle-assisted data delivery (VADD)**

It uses the concept of carry and forward concept for forwarding the data packets to a moving vehicle node. In VADD protocol node doesn't send the data until get confirm response from neighbor node that is in the coverage area, after getting the confirmation it send the quickly.

**Advantages of VADD**

- It good in multi hop data delivery.
- Low data transmission and it perform better compare to GPSR and DSR.

**Disadvantages are of VADD**

- In selecting neighbor node with less packet delivery rate.
- Big delay due to dynamic topology and large traffic.

**ii) Geographical Opportunistic Routing (GeOpps)-**

GeOpps use navigation system which gives advice in selecting the next neighbor node. The packet sends only that node which has the very less arrival time [13]. Packet delivery system totally depends on the mobility pattern and on the road topology.

**Advantage of GeOpps –**

- High delivery ratio
- Ratio of delivery is depending on the mobility of pattern.

**Disadvantage of GeOpps-**

- Privacy is big issue due to navigation system.

**b) Non-Delay Tolerant Network (Non-DTN) protocols-**

Main motive of Non-DTN protocols is to reduce the packet delivery communication time between source and destination node. It is also known as Min-Delay protocols. Non-DTN protocols are dividing into beacon based, non-beacon based and hybrid protocols. To reduce the packet delivery ratio uses the shortest path in the network. In beacon routing protocols "“HELLO”" message plays an important role for discovering the neighbor node in the network. ““HELLO”” messages periodically send for maintaining information of the neighbor node.

**i)Greedy Perimeter Stateless Routing (GPSR)-**

Beacon messages use for selecting neighbor node, it use greedy techniques for forwarding the packets to the nodes [14]. If this techniques is not work than GPSR use perimeter forwarding mechanism to select the next forwarding node. GPSR also give the recovery mechanism through nearest vehicles. GPSR is best for the wireless datagram networks. Planarization is used to remove cross links in the network.

**Advantages of GPSR-**

- Forwarding of packets is simple and easy because node has to be remembering only one hop neighbor information.
- Planarization is used to remove cross links in the network.

**Disadvantages of GPSR-**

- 1. Maintenance is difficult if length of route is increase in the network because of mobility environment.

**ii) Geographic Source Routing (GSR) –**

GSR Protocols use of route maps and discover shortest path from source to destination. Instead of RLS (Reactive Location Service) beacon messages is used to find the path between source and destination node. In GSR route maps are available and vehicles have the navigation system. GSR also uses greedy forwarding approach to send the packet from source to destination.

**Advantages of GSR-**

- GSR gives good packet delivery ratio compare to other position based protocols.

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- Scalability is good compare to AODV and DSR.

**Disadvantages of GSR-**

- Performance is not better in sparse network.
- Higher routing overhead because of beacon messages.

**iii) Connectivity Aware Routing (CAR) –**

CAR is mainly focus on the inter vehicle communication it better work on highway scenario. CAR is different from other position based protocol because it finds both position of the destination node and connected path between source and destination also. It also works in city area environment.

**Advantages of the CAR-**

- CAR finds the path which exists in real, not prediction based.
- It gives algorithm based on inter vehicle communication which work in city and highway scenario.

**Disadvantages of CAR-**

- If changes done in traffic environment then CAR is not work properly.
- CAR considers unnecessary nodes also.

**c) Hybrid Protocols-**

The hybrid protocols use considers both beacon based mechanism and non-beacon based mechanism.

**i) TO-GO (Topology-assist Geo-Opportunistic) routing-**

TO-GO protocol enhances the packet delivery ratio by including the opportunistic forwarding technique. In TO-GO packet is marked for an anchor node, determined by the Next-hop Prediction Algorithm (NPA), and broadcasted.

## 6. RELATED WORKS

In VANETs, vehicles communicate with each other or with the road side units (RSU) to provide safety by avoiding accident and traffic. In VANET routing is one of a major challenge due to high mobility and dynamic topology. Routing protocols of VANET is classified into two categories topology based and position based.

Topology based protocol are categorized into three category proactive, reactive and hybrid. Proactive protocol also known as Table-Driven, all information of available routes are maintain in tables and based on these tables protocol make decision for selecting the route for forwarding the packets between the nodes. Main feature of table driven routing is that ,there is no searching or route discovery as destination path is already maintained in background. Position based routing protocols used geo coordinates for forwarding the packets one node to another node. Mostly position based protocol used beacon message in order to select next neighbor node for routing and selecting the path.

Yong Xiang [13] present geographic stateless VANET unicast routing – Geo SVR. Geo SVR solved the problem of local maximum and sparse connectivity by estimate vehicle density on given road type. GeoSVR protocol is able to provide high packet delivery ratio with low latency. Geo SVR used multi-path to avoid selecting an improper path when the routing encounters multiple paths with identical sum of type and deviation.

Omar Sami Oubbati[11] in this paper UVAR protocol is proposed, UVAR protocols are consider for urban vehicular environments, main objective of this protocol is to enhance the performance of routing based on the UAVs awareness of the road traffic in the ground. In this paper two protocol is proposed UVAR-G for ground-to-air communication and UVAR-S for air-to-air communication.

Parminder Singh et al [1] did the comparison between Unicast routing and Multicast routing using varied data rates in VANET. Using the parameters like packet delivery ratio, delay metrics and routing overhead they evaluate performance of both the protocols.

Bara T. Sharef et al [7] conversed about several VANET protocols and proposed taxonomy of these protocols by classifying them in two categories. i.e. V2V routing protocols and V2I routing protocols. According to him these protocols cannot address the dynamic network and frequently discontinuation in network. Finally the distinctive issues among VANET protocols is unifying and identifying paths between the source node and destination node.

In VANET several issues are there but the Handoff is major concern because the vehicles are continuously moving so it will become tougher to transfer the data packets when the vehicles are out of the communication range. But here Yibo Yang et al [5] discussed that for the applications of VANET VMIPv6 schemes and MIP diminishes the handoff latency and recovers the performance of MIP.

According to Osama M. Hussain Rahman et al [3] a new sender-oriented broadcasting scheme i.e. bi-directional stable communication (BDSC) protocols is proposed. Over densely populated vehicular network; it shows that how BDCS protocols accomplishes lower end-to-end delays and increases reachability of alert messages.

Many proposed position based protocols are available in

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VANET but the requirement of these protocols for selecting the vehicles are vehicle position coordinates. Mohamed SaadaBoba and Suleiman MohdNor [7] compared the various greedy algorithm in urban scenarios and gives details about various problems concerning routing and design strategy.

Sanjay Batish et al [12] discusses comparison among the AODV, DSR and DSDV routing protocols. According to him when the RSU are not used then DSR protocols performs better than AODV protocols and the throughput is always higher than AODV which make it well-organized in real city scenario.

According to James Bernsen, D.Manivannan [10] there is various unicast based routing protocols and the included design factors in that routing protocols, and the potential application for the technology for VANET environment.

## 7. CONCLUSION

In this paper we discussed introduction of VANET, types of communications, characteristics, challenges and different routing protocols in VANET. In this paper routing protocols are categorized into two major category topology based and position based protocols. Topology based protocol also categorized into three categories proactive, reactive and hybrid protocols. Protocols are discussed with advantages and disadvantages. Position based protocols also categorized into three categories Delay tolerant network protocols (DTN), Non-DTN (Non-Delay Tolerant Network) and Hybrid protocols. Also discuss some research work proposed by researchers. This literature survey mainly focused on different type challenges in VANET and routing protocols. VANET is play major role in converting traditional transportation system into intelligent transportation system (ITS).

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