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A Survey on Various VANET Routing Protocols

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ABSTRACT: **In last few years, VANET (Vehicular Ad-hoc Network) has become a remarkable field for research analysis and development. VANET is a subclass of MANET (Mobile Ad-hoc Network). MANET and VANET both are wireless networks which are featured as self-managed and autonomous ad-hoc networks. VANETs distinguish from MANETs in terms of high mobility and dynamic configuration. Because of unstable connectivity, network partitioning and high mobility, information routing in VANETs becomes complicated and challenging, hence generating a requirement for effective VANET routing protocols. This paper offers a summary on VANET and provides its routing protocols which concentrates on vehicle to vehicle such as V2V communication. This paper objectives at categorizes protocols based on routing information and comparing them utilizing following parameters namely methodology utilized, advantages/strengths and restrictions. The paper compares proactive and reactive routing protocols depending on their benefits and drawbacks, also describing the challenges and research related issues for the routing techniques that available in VANETs.**

KEYWORDS: Vehicular Ad-hoc Network (VANET), Routing Protocols, Proactive, Reactive, Issues.

I.INTRODUCTION

VANETs are a particular class of MANETs. VANET has two entities: vehicles and roadside infrastructure. In VANETs, vehicles behave as the mobile nodes. The roadside infrastructure is static, thus behave as distribution points for the vehicles [1]. The two kinds of wireless communications available in VANET,
Vehicle to Vehicle such as V2V and Vehicle to Roadside Infrastructure such as V2I as shown in figure 1. VANET distinguish from MANET in terms of following features that are high mobility, self-organized architecture, dynamic topology, distributed communication, path limitations and variable network size. These features as mentioned before building the VANETs environment complex for developing efficient routing protocols. A huge no. of applications available in VANETs i.e. management applications, traffic efficiency applications, infotainment applications, but the two main applications are: travelers comfort applications and safety applications [5]. VANETs system design and implementation come across following problems i.e.: security, routing, connectivity, privacy and quality of services (QoS).

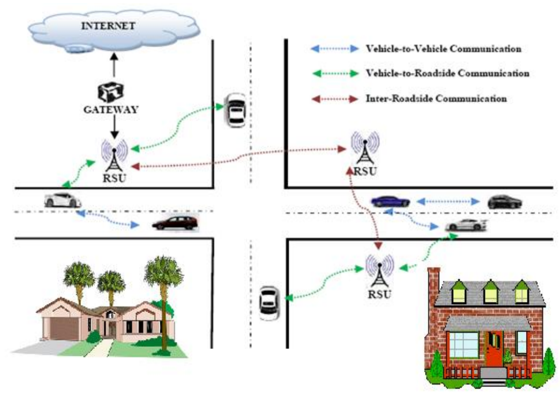

Fig. 1 VANET

II. Network Architectures

Wireless ad hoc networks basically do not depend on static infrastructure for communication and distribution of information. VANETs adopt the same principle and use it to the highly dynamic atmosphere of surface transportation. As depicted in Figure 1, the VANETs architecture primarily falls within three classes: pure cellular/WLAN, pure ad hoc, and hybrid. VANETs may utilize static cellular gateways WiMax/WLAN access points at traffic intersections to link to the Internet, collect traffic information, or for routing aims. The architecture of network under this scenario is a WLAN or pure cellular structure as depicted in Figure 1(a). VANETs can integrate both WLAN and cellular network to build the networks so that a WLAN is utilized where an access point is present and else a 3G link. Fixed or Stationary gateways around the roads sides could offer connectivity to mobile nodes (vehicles), but are finally unviable considering the infrastructure costs included. In this scenario, all vehicles and road-side wireless devices can build a pure mobile ad hoc network (Figure 1(b)) to perform vehicle to vehicle communications and obtain particular objectives, i.e. blind crossing.Hybrid architecture (Figure 1(c)) of integrating ad-hoc networks and infrastructure networks together has also been a possible solution for VANETs. Namboodiri et al. [13] introduced such a hybrid architecture, which utilizes some vehicles with both cellular and WLAN abilities as the mobile network routers and gateways so that vehicles with only WLAN ability can interact with them through multi-hop connection to stay linked to the world. The hybrid architecture can offer better coverage, but also causes new issues i.e. the continuous transition of the communication among various wireless systems.

III. Layered View of Vehicular Networks

Vehicular networks can be categorized based on five different aspects as indicated in table 1. Vehicular Networks has the diverse range of applications that changes safety applications to comfort applications.

Table 1: Layered View of vehicular networks

Vehicular Network	Application Type	• Safety application • Intelligent transport application • Comfort application
	Quality of Service	• Non-real-time • Soft-real-time • Hard-real-time
	Scope	• Wide area • Local
	Network Type	• Ad hoc • Infrastructure-based
	Communication Type	• V2I • V2V

Safety Applications improves the driving conditions and decreases the possibility of accidents by offering enough time to the driver and using the brakes automatically. These can be further classify into the following: -

• Cooperative collision warning
• Incident management
• Emergency video streaming

Intelligent transport applications aim at offering faster delivery of traffic information, and enhancing the accuracy and efficiency of traffic detection by permitting collaborative processing of information among vehicles. These applications concentrate on observing the traffic pattern and maintaining traffic accordingly. It can be further classified into the following:

• Traffic Management
• Traffic Monitoring
• Platooning
• Vehicle tracking
• Notification services

Comfort applications are the VANET applications related to comfort level of the passenger travelling in the vehicle. It can be further classified into the following:

• Parking place management.
• Distributed games and/or talks.
• Peer to Peer applications

Accordingly, the Quality of Service (QoS) needed for the network changes from *non-real-time*, to *soft real-time* where a timing failure might compromise service quality, up to *hard real-time* where a timing failure might yield to a catastrophe. These applications can also be represented by their scope, such as whether they offer communication across a *wide area*, or are *local* only. Eventually, such applications can vary in their networking technique: *ad hoc*, where vehicles interact randomly, or *infrastructure-based*, where communication is controlled by static base stations. VANET has the communication type: Vehicle to Vehicle (*V2V)* and Vehicle to Infrastructure (*V2I).*

IV. DISCUSSIONS ON ROUTING PROTOCOLS IN VANETS

Depending on routing information, routing protocols are widely classified as position-based and topology-based routing protocols. In topology-based routing technique, we covers the network layout/architecture of the nodes such that packet sending is possible utilizing the information that is existed about the nodes and connections within the network while, nodes location should be known in position based routing mechanism for packet sending.

A. Topology-based Routing Protocols

Topology-based routing protocols build usage of routing tables for saving the connection information as a basis of packet sending from source to destination node. These protocols are further classified into two types depending on the network architecture [1]: Reactive and Proactive routing protocols.

i. Proactive Routing Protocols: Proactive routing protocols, also called as table-driven protocols, permit each network node to manage a routing table for recording the route information to all other nodes, each next hop node is managed in the table entry that comes in the path towards the destination node from the source node. The routing table of each node gets updated whenever a modification in network configuration takes place as a result of which more overhead cost is incurred. These protocols offer real data to the network existence [1]. The shortest path algorithms are utilized by these protocols to determine which route has to be selected. Fisheye State Routing (FSR) and Destination Sequenced Distance Vector (DSDV) protocols are proactive routing protocols.

1. Destination Sequenced Distance Vector (DSDV) Routing Protocol: depending on the distance vector technique utilizing shortest path algorithm, DSDV [1] routing protocol implements a single route from source node to destination node which has been managed in the routing table. A routing table is managed for every node having information of each accessible node in the network and total no. of hops required to succeed those nodes. The destination node starts a sequence no. to each entry in the table. Every node manages the route reliability by flooding their routing table to the neighboring nodes. DSDV protocol does not permit cyclic routes, decreases control message overhead and eliminates additional traffic caused by frequent update. The total size of routing table is decreased as DSDV holds solely the best possible path to every node rather than multi paths. DSDV is not capable to control the networks congestion that reduces the routing efficiency.

2. Fisheye State Routing (FSR) Protocol: FSR [1] is a table-driven routing protocol that manages a configuration map for every node and manages its routing table by gathering the latest information from its neighboring nodes. The updated data is flooded with different frequencies with higher frequencies instead of the farther ones to several different destination nodes depending on the hop distance from the sending node. However FSR supports each network node to interchange the updated routing information with its immediate neighboring nodes partially, it decreases the consume bandwidth and offers decrement of routing overhead. The limitations with the FSR are the increasing network size the no. of routing tables that results to storage complexity and process overhead of routing table. Route establishment becomes complicated if destination node goes outside the source node range. Even if there is any connection failure, changes in routing table do not take place because FSR does not trigger any message for connection failure. FSR works on the basis of Global state routing and Link State routing. Hence the proactive routing protocol benefits can be abbreviated as follows, i.e.

- However route from source node to destination node is managed through routing table, there is no requirement of route discovery procedure.
- Proactive routing protocols performance is good in low mobility networks while reactive routing protocols have high density and mobility as compared to the proactive routing protocols.
- In proactive protocols, increase in network overhead takes place when unutilized routes consume existed bandwidth.

ii. Reactive Routing Protocols: Reactive routing protocols, also called on-demand routing protocols. They are known as so because on need of a route that does not available from source node to destination node, the route discovery initiates. This decreases the network traffic and saves bandwidth. Broadcasting of the network supports in route discovery process by forwarding a route request message. Any node available on the route towards the destination node on receiving the request message, forwards back a route reply message to the source node utilizing unicast communication. These routing protocols have high route discovering latency and are appropriate for large sized mobile ad-hoc networks which are highly mobile and have frequently changing configuration. The following sections show few available reactive routing protocols.

1. Ad-hoc On-demand Distance Vector (AODV) Protocol: AODV [1, 3, 11] protocol decreases broadcasting in the network and provides low network overhead in comparison of the proactive protocols. This routing protocol decreases the routing table by generating a route when a node wants to forward information data packets to network other nodes, thus decreasing the memory size needed. The routing table keeps the entries of the current active nodes and the next hop node of the route rather than keeping the entire route. AODV utilizes destination sequence no. (DesSeqNum) for route discovery which removes looping in routes and offers dynamic updates for following the route conditions. AODV is more appropriate for huge networks and network having high dynamic configuration. This protocol causes delay in route discovery mechanism. When route failures take place, new route discovery is needed causing extra delays hence reducing the data transmission rate and increasing the network traffic. This causes more bandwidth consumption that is increased because of increasing no. of network nodes which causes collision resulting to packet loss issue.

2. **Dynamic Source Routing (DSR) Protocol:** DSR [1, 3, 4, 12] routing protocol is a reactive protocol which implements routing procedure utilizing low overhead and frequent reaction to frequently changing configuration to assure successful packet delivery even if change in network occurs. DSR is a multi-hop routing protocol reduces the network traffic by reducing periodic messages. DSR offers two processes that are the route discovery procedure

and route maintenance procedure. During the discovery technique, when the source node needs to search a non-available route, a route request message is forwarded by it to all its neighboring nodes. All nodes in- between that obtain the request message broadcast it again except to the destination node or if there is a direct route from the sending node towards the destination node. After which the source node obtains back route response message and that route is recorded in the routing table of the source node for future usage. If any failure in route takes place, the source is reported by forwarding a route error message back to the source node. In this protocol routing, every information packet contains a list of nodes that available in the path so that source node removes the nodes on the route which have failed from its cache and records another successful route to that destination node and interchanges it with a right route. If no such route available, DSR again initiates a new route discovery mechanism. The advantages/benefits offered by DSR routing are best visible in networks with less mobility as it makes usage of alternate routes before a new route discovery process is started. Although multi- route discovery could cause further routing overhead/traffic because of addition of entire route information to every information packet of routing table, besides, as the network finds large routes as well as extra nodes, the routing overhead increases frequently resulting in reduction of network performance.

3. **Temporally Ordered Routing Algorithm (TORA) Protocol:** TORA [1] is a distributed routing protocol. TORA utilizes multi-hop routes during routing process. This protocol decreases the communication overhead to follow with quick network changes and does not involve implementation of shortest path algorithm and thus, routing doesn't represent a distance. This protocol generates a directed graph which has the source node as its tree root node. This protocol contains tree structure in which packets should run from higher nodes to lower nodes. As a node floods data packets to its destination node, its neighboring node forward back a route response message if its packets run from higher levels to lower level to the destination node, else it only rejects the data. The protocol adapts multi path routing and loop free routing as the information moves down to the destination node and does not move back upward to the sending node. TORA offers a route towards every node of the network configuration, also decreasing control message broadcast which are the main benefits of TORA. In this routing technique, routing traffic/overhead is caused during route maintenance between network nodes in high dynamic VANETs.

IV. DISCUSSIONS ON ISSUES IN VANETS

Depending on our review on VANET routing protocols, we determined that few challenges and open research issues available in VANETs routing which is the most significant region for research today. These open issues and challenges in VANET routing i.e. loss of signal, driver's behavior, interferences caused by tunnels and high buildings [5, 6] have been explained in this section.

A. Fault Tolerance: however a VANET has fast changing configuration; various vehicles could enter or exit the network periodically. If during the communication, a node leaves the network, a novel route should be generated by the routing protocols to maintain the network. This issue can be solved if the route failure is aware in advance, this needs lot of updated information exchange resulting to un-scalable communication.

B. Security Enhancement: Security [2] stands the most significant and challenging issue in safety applications of VANETs. If no security is offered in routing protocols, a malicious node can enter the network and cause spoilage. This could lead in information misleading which can be utilized by terrorists to trap innocent people as dead end tunnel. So in turn to secure the information; integrity, authentication and non-repudiation must be get such that there is no entry of any unauthenticated vehicle into the network and no changes of the data packets is permitted during the communication. Thus, security is a significant issue as future research field.

C. Flexibility and Scalability: Area decides the no. of vehicles, for example no. of vehicles in rural region is low without road side units, it becomes complicated to manage the network connectivity. For the road side units development, large investments are needed, thus less power restraints can be utilized by increasing communication ranges with higher transmission power to make each node arrive its destination without support of the roadside units. On the opposite, urban area is very huge and crowded having a large range of vehicles running. The routing protocols require to decrease the overhead and control of data packets as a larger no. of vehicles require to interact. It should offer safety communication instead of control overhead.

D. Dynamic Topology and High Mobility: Vehicles are the mobile nodes in VANETs and move according to the road pathways which limits the nodes mobility. This causes the interruptions in communications and changing configuration. For routing protocol growth, we should traumatize dynamic configuration. A solution to provide efficient information distribution not withstanding fast changing configuration may be broadcast based communication.

V. RESULTS

Figure 2 provides division of the routing protocols as explained above in the paper depending on which the results have been obtained in the comparisons form. The study results of routing protocols have been provided as a comparison of the routing protocols in the form of tables explaining their benefits and drawbacks. Table I provides comparison between the proactive and reactive routing protocols stating their benefits and drawbacks [7] and Table II provides the difference between the position-based and topology-based routing protocols.

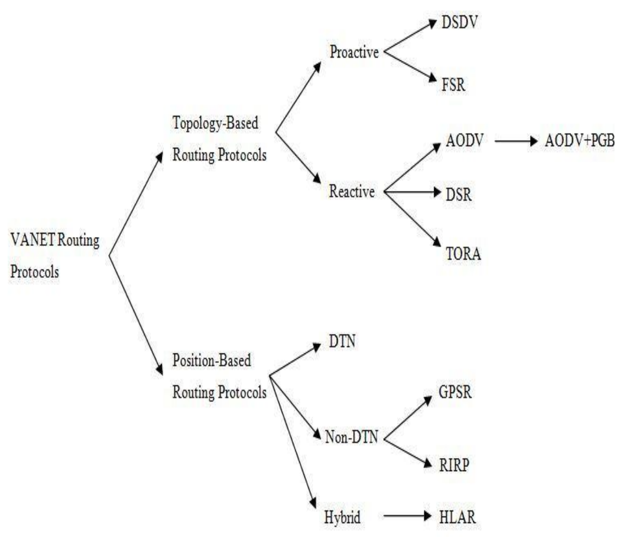

Fig. 2 VANET Routing Protocols

TABLE I: Advantages and Disadvantages of Reactive and Proactive Routing Protocols

Topology-based Routing Protocols	Reactive Routing Protocols (On-Demand)	Proactive Routing Protocols (Table-Driven)
Advantages	1. On-demand broadcasting of the network takes place to update the routing table. 2. Saves bandwidth as these protocols are beaconless.	1. Route discovery is not needed. 2. Real-time application latency is low.
Disadvantages	1. Have high route determining latency. 2. High broadcasting in the network causes disruption in node.	Needed part of the existed bandwidth is occupied by unutilized paths

TABLE II: Difference between Topology-based and Position-based Routing Protocols

VANET Routing Protocols	Topology-Based Routing Protocols	Position-based Routing Protocols
Methodology	1. Employ shortest path algorithms. 2. Packet forwarding is performed based on connection information stored in routing table.	1. Position determining service is utilized. 2. Vehicle position is needed to send data packets.
Benefits/Strength	1. Route discovery is needed to search best possible shortest route between source node and destination node. 2. Beaconless. 3. appropriate for unicast, multicast and broadcast routing.	1. Route discovery and maintaining protocol routes is not needed. 2. Beaconing 3. Support high mobile environment.
Limitations	1. Utilize more overhead. 2. Route discovery and delay restraint maintenance. 3. Failure in discovering complete path Because of frequent network changes.	1. provide least overhead. 2. Position finding services. 3. Deadlock may happen in location server.
Remarks	1. Basically introduced for MANETs. 2. provide less overhead and appropriate for small networks.	1. Appropriate for large networks i.e. VANETs. 2. Research is in progress for control congestion and small networks.

VI. CONCLUSIONS

This paper has offered a summary of VANETs such as vehicular ad hoc networks discussing their features and motivations with a study of VANET routing protocols that target vehicle to vehicle communication. This paper offers two classes of VANET routing protocols that available since previous couple of decades, providing a brief discussion of the protocol working and their significant advantages/benefits and drawbacks along with limitations. This review paper has provided differences among major classifications of routing protocols. In this brief study on several VANET routing protocols; various related research issues and challenges/difficulties are shown that need more effort and research to approach them.

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