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Analysis of Various Topology Based Routing Protocols in VANET

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***Abstract*—** Vehicular ad-hoc networks (VANETs) offer a vast number of applications without any support from fixed infrastructure. These applications forward messages in a mult-hop fashion. Designing an efficient routing protocol for all VANET applications is very hard. Hence a survey on routing protocols based on various parameters of VANET is a necessary issue in vehicle-to- vehicle (V2V) and infrastructure-to- vehicle (IVC) communication. Vehicular Ad Hoc Networks (VANET) is a subclass of Mobile ad hoc networks which provides a distinguished approach for Intelligent Transport System (ITS). The survey of routing protocols in VANET is important and necessary for smart ITS. In this paper we have studied about VANET, various characteristics and applications of VANET and also have given a brief overview of different topology based routing protocols in VANET along with major classifications. The protocols are also compared based on their essential characteristics and tabulated.

***Index Terms*—** Hybrid, Proactive, Reactive, Routing protocol, VANET

I. INTRODUCTION

VANET is an emerging technology to achieve intelligent inter-vehicle communications, seamless internet connectivity resulting in improved road safety, essential alerts and accessing comforts and entertainments. The technology integrates WLAN/cellular and Ad Hoc networks to achieve the continuous connectivity. A Vehicular Ad-Hoc network is a form of Mobile ad-hoc Networks, to provide communication among nearby vehicles and between vehicles and nearby fixed equipment i.e. roadside equipment. The main goal of VANET is providing safety and comfort for passengers. Each vehicle equipped with VANET device will be a node in the Ad-hoc network and can receive & relay other messages through the wireless network. Collision warning, Road signal arms and in place traffic view will give the driver essential tool to decide the best path along the way.

VANET or Intelligent Vehicular Ad-Hoc Networking provides an intelligent way of using vehicular Networking.[1] The feature of VANET mostly resembles the operation technology of MANET in the sense that the process of self-organization, self-management, low bandwidth and shared radio transmission criteria remain same. But the key hindrance in operation of VANET comes from the high speed and uncertain mobility in contrast to MANET of the mobile nodes (vehicles) along the paths. This suggested that the design of efficient routing protocol demands upgradation of MANET architecture to accommodate the fast mobility of the VANET nodes in an efficient manner. This warranted various research challenges to design appropriate routing protocol. It is therefore important at this stage to reiterate the key characteristics of VANET that may be accounted for the design of various routing protocols.

A. *Specific Characteristics of VANET*

a. ***High Dynamic topology:*** The speed and choice of path defines the dynamic topology of VANET. If we assume two vehicles moving away from each other with a speed of 60 mph (25m/sec) and if the transmission range is about 250m, then the link between these two vehicles will lost for only 5 seconds (250m/ 50ms-1). This defines its highly dynamic topology.[7][3]

b. ***Frequent disconnected Network:*** The above feature necessitates that in about every 5 seconds or so, the nodes needed another link with nearby vehicle to maintain seamless connectivity. But in case of such failure, particularly in case of low vehicle density zone, frequent disruption of network connectivity will occur. Such problems are at times addressed by road-side deployment of relay nodes.[3]

c. ***Mobility Modeling and Prediction:*** The above features for connectivity therefore needed the knowledge of node positions and their movements which as such is very difficult to predict keeping in view the nature and pattern of movement of each vehicle. Nonetheless, a mobility model and node prediction based on study of predefined roadways model and vehicle speed is of paramount importance for effective network design.[3]

d. ***Communication Environment:*** The mobility model highly varies from highways to that of city environment. The node prediction design and routing algorithm also therefore need to adapt for these changes. Highway mobility model, which is essentially a one-dimensional model, is rather simple and easy to predict. But for city mobility model, street structure, variable node density, presence of buildings and trees that behave as obstacles to even small distance communication make the model application that very complex and difficult.[3]

e. ***Hard Delay Constraints:*** The safety aspect (such as accidents, brake event) of VANET application warrants on time delivery of message to relevant nodes. It simply cannot compromise with any hard data delay in this regard. Therefore high data rates are not as important an issue for VANET as overcoming the issues of hard delay constraints.[3]

f. ***Interaction with onboard sensors:*** This sensors helps in providing node location and their movement nature that are used for effective communication link and routing purposes.[4]

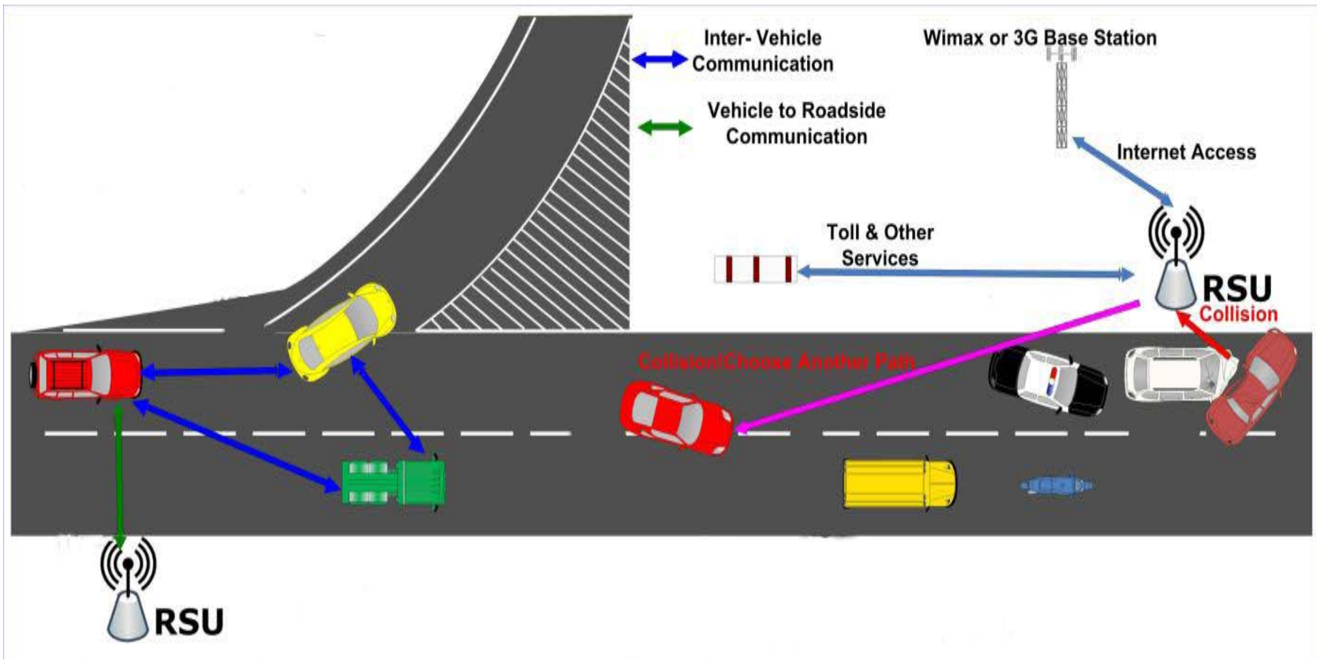

Figure 1: Vehicular adhoc networks and some possible applications

B. *Applications of VANET:*

VANET application can be divided into following categories:[5]

a. VANET provides ubiquitous connectivity on the road to mobile users.
b. Intelligent Transport System (ITS) provides efficient vehicle to vehicle communications in VANET.
c. ITS have variety of applications like cooperative traffic monitoring, control of Traffic flows, blind crossing and collision prevention.
d. Comfort application is the application to allow the passenger to communicate with other vehicles and with internet hosts, which improves passengers comfort.
e. VANET provides internet connectivity to vehicular nodes while on the movement so that passenger can download music, send emails, watch online movies and can online chatting etc.

II. OVERVIEW OF ROUTING PROTOCOLS

Routing is the act of moving information across an internetwork from a source to a destination. Along the way, at least one intermediate node typically is encountered. Routing occurs at Layer 3 (network layer) of the OSI model. In VANET, the routing protocols are classified into five categories: Topology based, Position based, Cluster based, Geocast, Broadcast [1].This paper gives brief overview of different topology based routing protocols.

A. *Topology Based Routing Protocols:*

These routing protocols use link information that exit in the network to perform packet forwarding. They discover the route and maintain it in a table before the sender starts transmitting data.[2] They are further divided into reactive, proactive and hybrid protocols.[4]

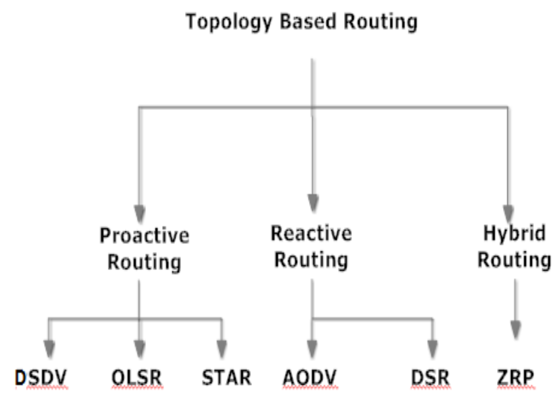

Figure.2 Topology Based Routing Protocols

a. *Proactive routing protocols:*

The proactive routing means that the routing information, like next forwarding hop is maintained in the background irrespective of communication requests. The advantage of proactive routing protocol is that there is no route discovery since the destination route is stored in the background, but the disadvantage of this protocol is that it provides low latency for real time application. A table is constructed and maintained within a node. So that, each entry in the table indicates the next hop node towards a certain destination. It also leads to the maintenance of unused data paths, which causes the reduction in the available bandwidth.[4][1] The various types of proactive routing protocols are:

a) *Destination Sequenced Distance Vector Routing (DSDV):*

Each DSDV node maintains two routing tables: one for forwarding packets and one for advertising incremental routing packets.[8] Advantages of DSDV It is quite suitable for creating ad-hoc networks with small number of nodes Solve the Routing Loop problem Count to infinity problem is reduced DSDV maintains only the best path instead of maintaining multiple paths to every destination .

Disadvantages of DSDV, DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle whenever the topology of the network changes, a new sequence number is necessary DSDV is not suitable for highly dynamic networks.[2]

b) Optimized Link State Routing (OLSR):

OLSR is a table driven and proactive routing protocol. Basically OLSR is an optimization of the classical link state algorithm adapted for the use in wireless ad hoc networks. First, few nodes are selected as Multipoint Relays (MPRs) to broadcast the messages during the flooding process. Second level of optimization is achieved by using only MPRs to generate link state information. This results in minimizing the "number" of control messages flooded in the network. As a final level of optimization, an MPR can chose to report only links between itself and those nodes which have selected it as their MPR. MPRs play a major role in the functionality of the protocol.[8] OLSR is designed to support large and dense wireless networks. It is also suitable for scenarios, where the communicating pairs change over time. Once the communicating pair changes, a route to new pair is readily available, and no control traffic or route discovery process is needed as in the case of reactive protocols. This can be beneficial for situations where time critical or safety related data needs to be delivered with minimum possible delay. [6]

c) Source-Tree Adaptive Routing (STAR):

Source-Tree Adaptive Routing (STAR) is another link State protocol.[2] It reduces overhead on the network by eliminating periodic updates. This protocol can be suitable for large scale networks but it needs large memory and processing because it has to maintain large trees for whole network. The Each node maintains a source tree. Each node builds a partial topology graph using aggregates of neighbor information learnt using an underlying neighbor. [4]

b. Reactive routing protocols:

Reactive routing opens a route only when it is necessary for a node to communicate with another node. It maintains only the routes that are currently in use, thereby reducing the burden on the network. Reactive routing consists of route discovery phase in which the query packets are flooded into the network for the path search and this phase completes when route is found. These protocols are called as on-demand routing protocols as they periodically update the routing table, when some data is there to send. The various types of reactive routing protocols are AODV, DYMO, DSR and TORA .[1][4]

a) Ad Hoc on Demand Distance Vector routing (AODV):

AODV is a source initiated routing protocol and uses HELLO messages to identify its neighbors. Source node broadcasts a route request to its neighbors which fill forward to the destination. Then the destination unicast a route reply packet to the sender. Every node maintains broadcast-id which increments for new RREQ. When a RREQ arrives at a node, it checks the broadcast id if it is less than or equal to previous message then it will discard the packet.[10]

b) Dynamic Source Routing (DSR):

This protocol consists of two operations "Route Discovery" and "Route Maintenance" that makes it self-configuring and self-organizing. Another important property of DSR routing protocol is network type flexibility. It uses source routing instead of depending on intermediate node routing table. So routing overhead is always dependent on the path length. The limitation of this protocol is that the route maintenance process does not locally repair a broken link. The performance of the protocol briskly decreases with increasing mobility.[10] The connection setup delay is higher than in table-driven protocols, this routing overhead is directly proportional to the path length.[2]

c. Hybrid routing protocols:

Hybrid routing protocols is combination of reactive routing protocols and proactive routing protocols which reduce the control overhead of proactive routing protocols and decrease the initial Route discovery delay in reactive routing protocols.[12] E.g. Zone Routing protocol (ZRP), Hybrid Routing Protocol (HARP) etc.[10][4]

a) Zone routing protocol (ZRP):

In this the network is divided into overlapping zones. The zone is defined as a collection of nodes which are in a zone radius. The size of a zone is determined by a radius of length α ,where α is the number of hops to the perimeter of the zone. In ZRP, a proactive routing protocol (IARP) is used in intra-zone communication and an inner-zone reactive routing protocol (IARP) is used in intra-zone communication. Source sends data directly to the destination if both are in same routing zone otherwise IERP reactively initiate a route discovery. ZRP aims to find free routes to the destination. It uses border casting method to construct multicast trees to flood the query packet instead of standard flooding to discover the destination route.[10]

III. COMPARISON

Table 1. Comparison of various topology based routing protocol

Protocols	**Proactive routing (DSDV, OLSR, STAR)**	**Reactive routing (AODV,DSR)**	**Hybrid routing (ZRP)**
Prior Forwarding Method	Wireless multi hop Forwarding	Wireless multi hop Forwarding	Wireless multi hop Forwarding
Digital Map Requireme nt	No	No	No
Virtual Infrastructu re Requireme nt	No	No	No
Realistic Traffic Flow	Yes	Yes	Yes
Recovery Strategy	Multi Hop Forwarding	Carry & Forward	Multi Hop Forwarding
Scenario	Urban	Urban	Urban

Network Organization	Flat/ Hierarchical	Flat	Flat
Topology Dissemination	Periodical	On-Demand	Combination of both
Route Latency	Always Available	Available when needed	Always Available
Mobility Handling	Periodical Updates	Route maintenance	Route Maintenance
Commutation Overhead	High	Low	Moderate

IV. CONCLUSION

In this paper, it has been mentioned the introduction of Vehicular ad-hoc networks (VANET), and various characteristics and application of VANET and also about the three types of topology based routing protocols. The major requirement in VANET is the security. VANETs are more vulnerable to security attacks as they are infrastructure less and autonomous. Main objective of this paper is to address the different VANET topology based routing protocols. In order to provide secure communication and transmission, researcher worked specifically on the security issues in VANETs, and many secure routing protocols and security measures within the networks were proposed. This paper will give the brief idea regarding VANET to the people who are conducting researches in VANE and also analyzes the comparison between the different topology based routing protocols in VANET.

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