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Vehicular Ad Hoc Network (VANET): A Survey

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***Abstract* – Vehicular ad hoc network (VANET) is a component of the intelligent transport system. It is the need of today's world for providing safety and other applications to the drivers as well as passengers of the vehicles. The road safety is the major reason behind the emergence of this technology. It allows vehicle-to-vehicle and vehicle-to-infrastructure communication for sharing the critical information to avoid road accidents. VANET establishes a mobile network between moving vehicles by treating each vehicle as a node in the network. Each participating vehicle is turned into a wireless router or node. VANET provides connectivity between vehicles from 100 to 300 meters range. This paper highlights the characteristics, significances and the routing strategy of VANET.**

***Index Terms*– OBU, RSU, V2V, V2I and VANET.**

I. INTRODUCTION

VANET is an extension of mobile ad hoc network in which communication takes place between vehicles and roadside equipments. As the number of vehicles is increasing day by day, accidents frequency is also going high. So VANET is established for collision avoidance and its target is to send safety messages to the vehicles with minimum delay [1].

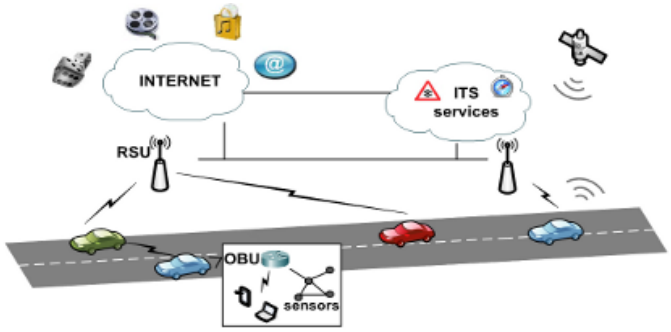

Fig. 1 VANET Architecture

Fig. 1 shows the architecture of VANET. Communication takes place between vehicle-to-vehicle as well as vehicle to roadside unit. An On Board Unit (OBU) is setup on every vehicle for signal transmission. Using VANET, vehicles can share music and video files.

Communication in VANET is of two types as in the fig. below.

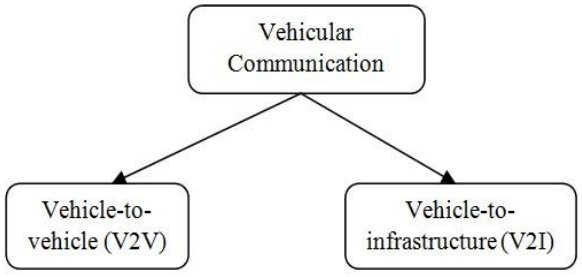

Fig. 2 Types of communication in VANET

1) V2V communication allows sharing information about the traffic environment among moving vehicles. Internet connectivity is required in this type.
2) V2I communication allows vehicles to communicate with fixed units (i.e. roadside unit) deployed on the sides of road at a fixed distance. This type of communication is beneficial for the vehicles that are offline hence no internet connection is required.

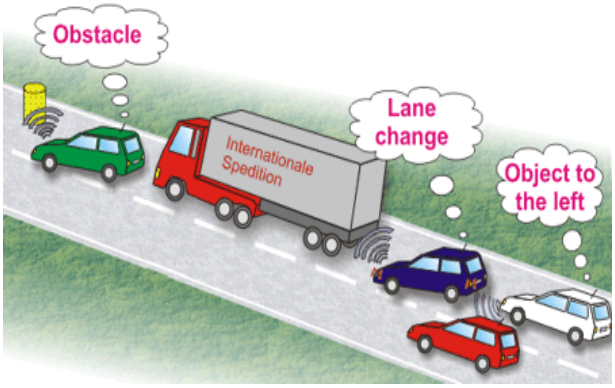

Fig. 3 Collision avoidance using VANET

Fig. 3 shows that the collision is avoided by sending the message to the other vehicles on the road to change the lane. The vehicle that senses the obstacle on the road sends the alert message to the trailing vehicles, so that the vehicles could take necessary action for avoiding collision.

II. VANET CHARACTERISTICS

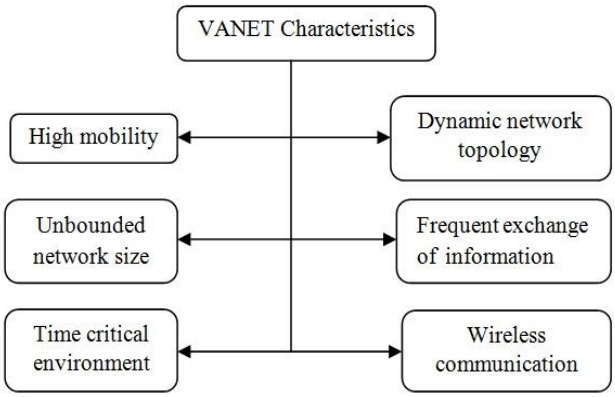

Fig. 4 Characteristics of VANET

A. *High Mobility*

In the VANET, vehicles moves at high speed. So it becomes difficult to predict the position of a vehicle and to provide security to the vehicle.

B. *Unbounded Network Size*

VANET size is not fixed, as it can be deployed for single or several cities. Hence the network size is unbounded.

C. Time Critical Environment

The safety information in the VANET must be reached to the nodes in a short span of time so that the receiving node can make a decision and action can be performed accordingly.

D. Dynamic Network Topology

As the nodes in the VANET are moving at very high speed, network topology changes very frequently.

E. Frequent exchange of Information

The information exchange among nodes is very frequent in VANET. As the purpose of VANET is road traffic safety, the information is frequently broadcasted in the VANET to alert the vehicles of any danger.

F. Wireless Communication

As the communication in VANET takes place among mobile vehicles, wired connection is not possible. Nodes exchange information by establishing wireless network [4], [5].

III. SIGNIFICANCES OF VANET

The main significance of VANET lies in its road safety application, Electronic Toll Collection (ETC), parking availability application and many others. Only some of the important applications of VANET are discussed here.

A. Road Safety Application

Road Safety application of VANET monitors the surface of the road, approaching vehicles, road curves and surrounding road.

Some of the road safety applications are as follows:

1) Hazard Control Notification

Vehicles notify other vehicles about road conditions e.g. land sliding, sudden downhill or any road curve.

2) Traffic Vigilance

The road side unit can be equipped with the cameras for traffic vigilance and would capture all the traffic offenses for a particular area.

3) Collision Notification

Warning is sent to the drivers that are driving on the crash route so that they can change their directions.

4) Post Crash Notification

The vehicle which is involved in an accident would notify the trailing vehicles about its position by broadcasting warning messages so that the other vehicles could move to the clear roads. Also a signal to the highway security could be sent for providing help at the site of collision [4], [5], [9].

B. Electronic Toll Collection (ETC) Application

Toll payment can be collected electronically rather manually through a Toll collection point. Toll collection point reads the OBU of the vehicle and collects the necessary information about the vehicle. OBU works through GPS. This application is beneficial for both the drivers and the toll operators.

C. Parking Availability Application

VANET can help finding parking slots to the vehicle drivers in the metropolitan cities.

Inspite of these applications, route and trip planning can also be done in case of road traffic jams.

IV. ROUTING PROTOCOLS USED IN VANET

According to routing strategy VANET routing protocols are classified as in the figure below.

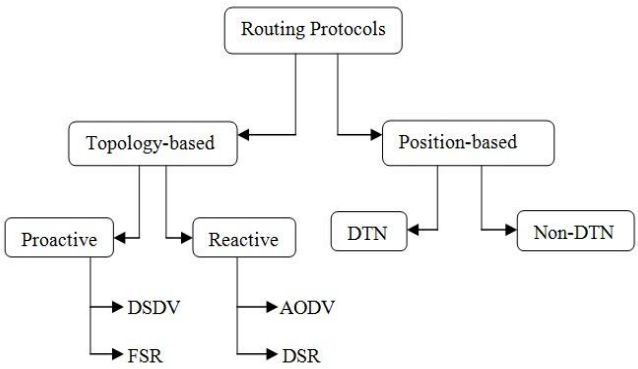

Fig. 5 Routing protocols classification diagram

A. Topology-Based Routing Protocols

Protocols under topology-based routing are broadly categorized into two types: Proactive routing protocols and Reactive routing protocols.

1) Proactive Routing Protocols

The Proactive routing protocols are also known as table-driven routing protocols because each router has its own routing table. In this category routes are discovered in advance for each destination node in the network. So in this approach most of the efforts are wasted because it is not necessary that communication will take place between each source-destination pair and all routes are not utilized.

Some of the proactive routing protocols are discussed below.

a) DSDV (Destination Sequenced Distance Vector) Routing Protocol

DSDV routing protocol was developed by P. Bhagwat and C. Perkins in 1994. The main purpose behind its development was to solve the routing loop problem. The routing table contains a sequence number with each entry. If a link is present then the sequence number is even else the number is odd. The sequence number is generated by the destination node.

The routing table entry with the latest sequence number is used for the selection of route. The entries that have not been updated for a while are deleted. These entries are called stale entries.

DSDV requires a frequent updating of its routing tables. Also it is not suitable for large scale networks.

b) FSR (Fisheye State Routing)

This protocol is based on link state routing. A topology map is maintained at each node so that it could provide route information instantly. In FSR, routing information is updated from the neighbor node through link state table.

FSR uses “Fisheye” technique in which the size of information required to represent graphical data is reduced and only relevant information is stored. The fisheye captures the pixels near the focal point with high details but as the distance from the focal point increases the amount of capturing details decreases.

So in this routing, accurate distance and path quality information about the immediate neighborhood of node is maintained with less detail as the distance increases.

2) Reactive Routing Protocols

The Reactive protocols are also known as on-demand routing protocols because routes are not discovered in advance. Routing is done on the demand basis which specifies that routes are created only when a node require to send packets to the other nodes.

An overview of DSR and AODV routing protocols is given below.

a) Dynamic State Routing (DSR)

Each packet in DSR protocol carry the full address i.e. every hop in the route from source to the destination. In large networks, this protocol is not effective due to increase in overhead of carrying full information of route in the packet. Therefore, in highly dynamic and big networks, most of network bandwidth is consumed due to this overhead. The other disadvantage of DSR is that broken links are not locally repaired by the route maintenance mechanism. But a major advantage of this protocol is that, there is no need to periodically flood the table update messages in the network. Therefore nodes can enter in sleep mode for power saving. In small to moderately size networks, DSR protocol performs better. Also, in this protocol nodes can use route cache to store multiple routes, so that before initiating route discovery, source node can check its route cache for a valid route and if a route is found there is no need for route discovery [6].

b) Ad hoc On-demand Distance Vector Routing (AODV)

The AODV routing protocol is the combination of DSR and DSDV algorithm. It uses the sequence numbering and periodic beaconing of DSDV and a route discovery procedure similar to DSR. However, AODV differs from DSR in two aspects. The major one is that in DSR, each packet carries full routing information, whereas in AODV, only the destination address is carried by the packets. It means there is less routing overhead in AODV than in DSR. The other difference is that the route replies in DSR carry the address of every node along the route, whereas in AODV only the destination IP address and the sequence number is carried by the route replies. The major advantage of AODV is that it performs better in highly dynamic networks. However, during route construction node may experience large delays and link breakage may initiate another route discovery, which further increases delay and as the size of the network increases nodes consumes more bandwidth [3], [6].

B. Position-Based Routing Protocols

The routing mechanism in position-based routing depends on the position of destination node. Instead of using network address, packets are forwarded on the basis of location data. Every node in the network finds its location as well as of their neighboring nodes using Geographical Positioning System (GPS). When a node requires sending a packet, it saves the location of destination node in the header of the packet that does not require any route discovery and any awareness of topology. Hence, position based routing protocols are considered to be suitable for highly mobile VANET. Position based protocols are further classified as DTN and Non-DTN protocols [7], [8].

1) Delay Tolerant Network (DTN) Routing Protocols

Delay tolerant network is the network where there is lack of connectivity and no instantaneous end-to-end paths. Hence protocols take "store and forward" approach for packet delivery. The packet of information is incrementally moved and stored throughout the network until the destination node is encountered.

2) Non Delay Tolerant Network (Non-DTN) Routing Protocols

Non-DTN routing protocols use a greedy approach for packet forwarding. A node forwards the data packet to its neighbor that is closest to the destination node. Communication may fail if no such neighbor exists except itself. The routing protocols in this category have their own recovery mechanism to deal with such a failure [2].

V. CONCLUSION

Vehicular ad hoc network from the perspective of its significance has been discussed in this paper. The VANET characteristics discussed in section 2 of the paper specifies that the routing in VANET is a challenging task. Different types of routing protocols are discussed in the last section. From the study of topology based routing and position based routing, it is concluded that the position based routing is more appropriate for VANET.

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