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VANET Communication Architecture and Routing Protocols for Intelligent Transportation System: Review

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ABSTRACT: Automotive technology is witnessing a rapid development era. Internet of vehiclesfor the improvement in safety measures and precision in autonomous driving is being actively researched. Vehicle to vehicle communication network can replace the existing complex automotiveembedded systems such as Adaptive cruise control, lane departureand blind spot detection. With active communication between all the nodes involved in any intelligent transport system, vehicles can receive real time surrounding information that can be used to avoid threats and improve the Transportation facilities.This paper reviews the various communication protocolsthat can be used to establish vehicle to vehicle (V2V) and vehicle to infrastructure(V2I) communication.

KEYWORDS: Automotive Technology, Autonomous Driving, Vehicle to vehicle communication., VANET, Routing Protocols.

I. INTRODUCTION

Development of vehicular network has become essential part of intelligent transportation systems. This is mainly being achieved by use of Dedicated short-range communication (DSRC) which allows automobiles to send and receive messages over the dedicated radio frequency spectrum of 5.9 GHz. Vehicular Ad Hoc Network (VANET) is being widely used to build the network between vehicle nodes due to its significant advantages such as network partitioning, intermittent connectivity and ability to adapt variable distance communications. The types of routing techniques used to implement VANET depends on the various factors such as traffic density, environment, Availability of roadside infrastructure, distances to be covered by vehicles and expected vehicle speeds. The communication network can be developed using the automobiles as an individual node which can transmit and receive the necessary information about the surrounding vehicles. Another way is to use road side units as servers to maintain and provide data to the ongoing vehicle which then is used to avoid traffic conjunctions and road accidents. The hybrid network which consists of both the mentioned approaches maps the maximum information about the vehicle and can be proven as the most effective way to build the VANET.

The main requirement of routing protocols is to achieve minimal communication time with minimum consumption of network resources. Many routing protocols have been developed for Mobile Ad Hoc Networks (MANETs), and some of them can be applied directly to VANETs. However, simulation results showed that they suffer from poor performances because of the characteristics of fast vehicles movement, dynamic information exchange and relative high speed of mobile nodes are different from those of MANETs. So finding and maintaining routes is a very challenging task in VANETs. In addition, a realistic mobility model is very important for both design and evaluation of routing protocols in VANETs. In this article, we will survey the most recent research progress of routing protocols.

The vehicular communication system generally contains two types of nodes: vehicular and roadside nodes. The vehicular communication is developed as a part of ITS which enables safety and high efficiency with the aid of integrated embedded computers, sensors, navigation system and the wireless communication. The intelligent transportation seeks to acquire real-time information about the road traffic. Besides the main motivation of an ITS

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which is safety improvements, there are many other merits of ITS: it helps in avoiding congestion and finding better routes by acquiring Realtime information about the conditions.

II. LITERATURE REVIEW

The review paper discusses the classification of VANET Architectures and study of routing protocols. In VANET, vehicles communicate through wireless channels that are mounted on each vehicular node. Each node within VANET acts as both the participant and router of the network, as the nodes communicate through other intermediate nodes that lie within their own transmission range. There is no fixed architecture of VANETs due to their self-organizing nature. The VANET can be distinguished from other ad hoc networks based on following characteristics.

1. VANET Characteristics:

i. Highly Dynamic Topology. As the communication network in VANET has no geographically fix locations for the nodes involved the requirement changes dynamically in the real time. The movement of vehicles in the network is with high speeds and the distance varies accordingly. So, the connection to be stablished between two nodes is only for the confined range of distance, and If two vehicles are crossing each other in opposite direction with high speed the connections will be formed only for few seconds depending on their speed.

ii. Frequent Disconnection in the network is observed due to the same set of reasons. In case of low vehicle density on the highway, vehicle node may get disconnected form the network for longer period of time. This can be tackled using the relay methods in the communication structure.

iii. Hard Delay Constraints need to be followed. The quality and high data transfer rates are not required but time factor plays important role in case of VANET. The message should be transmitted and received within certain time period to avoid the car crash.

iv. Mobility modelling and predication. Due to highly mobile node movement and dynamic topology, mobility model and predication play an important role in network protocol design for VANETs. More-over, vehicular nodes are usually constrained by prebuilt highways, roads and streets, so given the speed and the street map, the future position of the vehicle can be predicated

v. Sufficient energy and storage. A common characteristic of VANETs is that nodes have ample energy and computing power for processing and storage, as nodes are automobiles themselves.

The architecture of VANETs can be categorised into three types: 1) Cellular vehicle Network 2) Pure Ad Hoc Vehicle network and3) Hybrid network.

2. Vehicular Network Architectures:

i. **CellularNetworks**: Fig 2.1 shows the cellular wireless local area network. The vehicular nodes access the internet through cellular gateways and wireless local area network access points. It assists vehicular nodes by giving information about traffic congestion and traffic control. It also provides infotainment services such as downloading data, latest news, parking information and advertising. The deployment of such types of architecture is very hard due to the high cost of cellular towers, wireless access points and geographical limitations.

ii. **Pure Ad-Hoc Vehicle Network**:this establishes the communication between vehicles and among nearby vehicles. It is also called an inter-vehicles ad-hoc network. This type of architecture collects and disseminates road related information without considering any fixed infrastructure. The vehicles are free to move on the road, high mobility of the vehicles induces quick changes in the network topology. The rapid topology changes create fragments in the network. In the pure ad-hoc mode, the frequent partitions of the network due to the high mobility of vehicular nodes make routing the data more challenging. The advantage of the pure ad-hoc mode is that it overcomes the

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deployment cost of base stations. Pure cellular wireless local area network. Pure ad hoc network architecture is shown in Figure. It provides communication between vehicles and among nearby vehicles. It is also called an inter-vehicles ad-hoc network. This type of architecture collects and disseminates road related information without considering any fixed infrastructure. The vehicles are free to move on the road, high mobility of the vehicles induces quick changes in the network topology. The rapid topology changes create fragments in the network. In the pure ad-hoc mode, the frequent partitions of the network due to the high mobility of vehicular nodes make routing the data more challenging. The advantage of the pure ad-hoc mode is that it overcomes the deployment cost of base stations.

iii. **Hybrid Network:** The hybrid architecture, which is shown in Figure 3, is made up of ad-hoc domain and infrastructure domain. It provides communication between vehicles to vehicles (V2V) as well as a vehicle to infrastructure (V2I). This type of architecture is helpful in providing more informative contents and improved flexibility over the time and distance.

3. VANET Routing Protocols:

Internet of vehicles has proved to bechallenging in the networking module as there are uncertainties with respect to the number of nodes that might get involved atany point of time in the network or the unpredictable distance between two nodes of communication. There are number of protocols that can be implemented depending on the research of topology and environment in which the V2V or V2I network is to be build.
The routing protocols for VANET can be classified in two categories which are 1) Topology Based Routing Protocol and 2) Position Based Routing Protocol.

Topology Based Routing Protocol: The protocol uses links of information packets which gets transmitted to next node of communication network. Topology based routing is sub categorised into two mechanisms which are proactive routing protocol and reactive routing protocol.

i. **Proactive Routing Protocol**: The protocol works on the mechanism where every node saves the received data in the tabular form. The data is relatively analysed with respect to its neighbouring nodes. The table gets updated in the pre-defined time intervals. The protocol makes use of algorithm to find the shortest route in the network. Proactive protocol eliminates the need of path discovery and gives low latency to the real-time applications but the disadvantage of this protocol is that a large part of the allocated bandwidth remains occupied with unused data and routes.

ii. **Reactive Routing Protocol**: As the name suggests, this gets initiated only when the communication is required over the network. The transmitting and receiving nodes establish the communication channel between them to send, receive and capture the necessary data. They initiate the requirement based path discovery and reduces the network traffic by significant percents.as the protocol is beaconless this can control the bandwidth efficiently. The disadvantage of the protocol is high latency is required in path finding and setting the communication channel.

Position Based Routing Protocol: The protocol depends upon the routing algorithms which are based on position analysis of nodes. The mechanism uses location mapping applications such as GPS to provide the data for path selection. ta to the destination node, if the destination node is in its transmission range than it directly forwards packet to the destination node. If the destination node is not in the transmission range it will forward the packet to a neighbour node that is the nearest to the destination node. In this way, the packet is relayed to destination. In position-based routing, every node maintains one-hope neighbour information. Existing position-based routing protocols are developed mainly for highway environment Fig.1. shows the number of protocols classified under these categories to accomplish a VANET.

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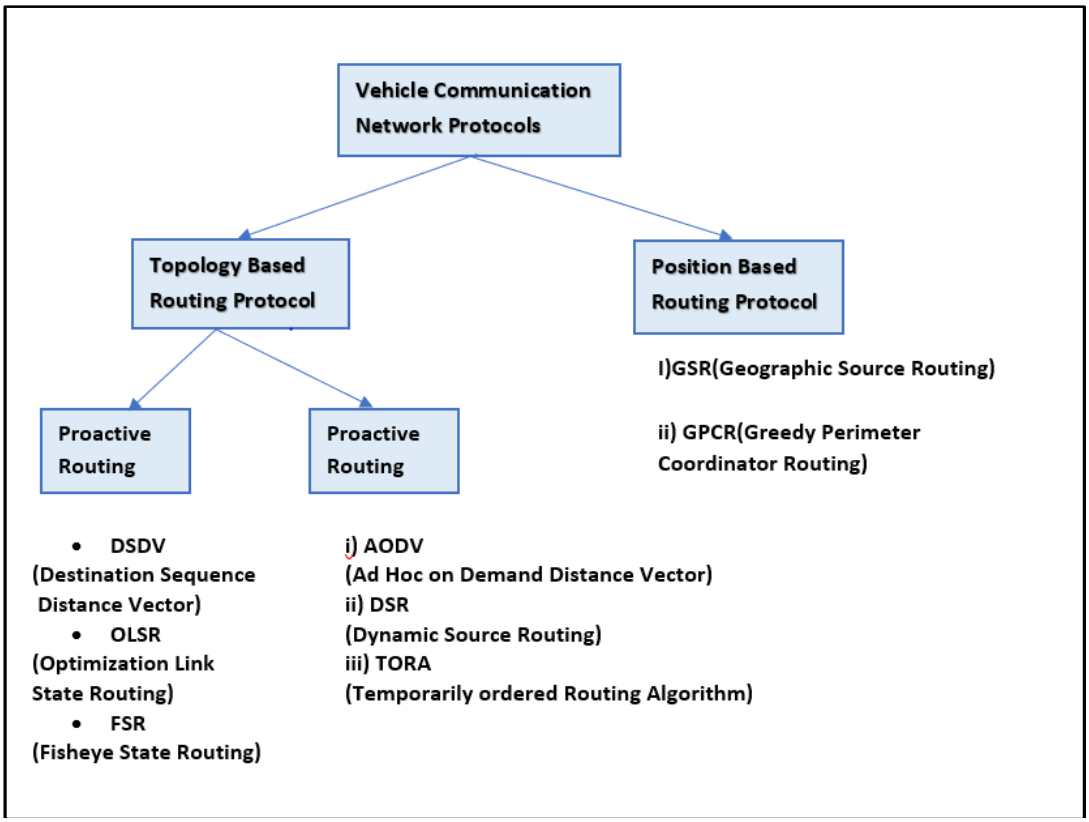

Fig. 1

The figure illustrates the classification of routing protocols used depending upon the various scenarios. DSDV, OLSR, FSR, AODV, DSR and TORA these are few protocols which follow topological based routing. Whereas, Position based routing is done by GSR and GPCR routing.

III. CONCLUSION AND FUTURE SCOPE

The Paper discussed the top view of VANET Model development with its architecture and different types of protocols in brief. VANET stands out from other Ad Hoc networks and that was discussed with description of characteristics.

In general, position-based routing and geocasting are more promising than other routing protocols for VANETs because of the geographical constrains. However, the performance of a routing protocol in VANETs depends heavily on the mobility model, the driving environment, the vehicular density, and many other facts. Hence selecting AODV Routing protocol has been proven more efficient than any other due to the fact that it has significant advantages over its disadvantages. Due to the challenges faced by the VANETs, having a universal routing solution for all VANETs application scenarios or a standard evaluation criterion for routing protocols in VANETs is Difficult. In other words, for certain VANETs application, we need to design specific routing protocol and mobility model to fulfil its requirements.

However, while the routing mechanism for efficient vehicular communication in VANETs has gained much attention from the wireless network research community, there is still a lack of careful exploration of some of the challenges related to routing. One of them is secure routing in VANETs. Security is vital for message dissemination routing protocols because illegal message tempering will result in overwhelming penalties. Without secure

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communication, many applications will have an impact on life or death decisions. Due to these features of VANETs, secure routing is more challenging that should be tackled effectively in the near future.

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