A comparative Study of VANET Routing Protocols

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ABSTRACT

VANET (Vehicular Ad hoc Network), the network formed by vehicles is an interesting and rapidly growing research area. VANET is an Ad hoc network which is a subset of Mobile Ad hoc Networks (MANET). Now a days it is widely being used for ITS (Intelligent Transport System). For successful ITS the design and implementation of a right VANET routing protocol is an important factor. The way a vehicle behaves and moves is an important characteristic of VANET and makes it different from MANET, such as fast speed of vehicle and due to this the fast change in topology. The vehicles are well equipped with different type of sensors and communication devices that helps in making the ITS useful for human lives. This paper throws a light on the various routing protocols used in VANET communication.

Keywords - VANET, MANET, ITS, Routing protocols, Ad hoc Networks.

1. INTRODUCTION

When we communicate with different devices without having a fixed infrastructure this type of communication forms a network which is known as ad hoc network, and when moving vehicles are involved in this type of communication it is called Vehicular Ad hoc Network (VANET), because of this we don't have any fixed route or link to transfer the data. Routes are dynamically created for the communication with the neighbors. As we can only communicate with the nearest node, direct communication with all the nodes is not possible, as the result the intermediate nodes act as a router to disseminate the information from source to destination nodes (Ramanathan et al., 2002). Vehicles keep on changing their position very fast that results in fast change in network topology, this makes very difficult to take routing decisions and to forward information to the nodes (Ramanathan et al., 2002).

We can categorize Ad hoc Network into: Mobile Ad hoc Network (MANET), Wireless Mesh Network (WMN) and Wireless Sensor Network (WSN). We can further divide MANET into VANET (Vehicular Ad hoc Network) and IVANET (Intelligent Vehicular Ad hoc Network) (Mandale et al., 2014).

MANET was a popular research topic because of the use of laptops and smart mobile. Many research papers are written in this field to study the mobility patterns, end-to-end packet delay and network throughput of the various routing protocols. VANET is a special category of MANET where the speed of the nodes is very high and because of this there is a sudden change in routing topology that makes it a special type of network.

In this study we will be focusing on the various routing protocols those are available for Vehicular Ad hoc Network. Rest of the paper is organized as follows: In section II characters those are specific to VNAET

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are discussed. In section III application of VANET's discussed. In section IV architecture of VANET is discussed, in section V VANET Routing protocols are discussed. Finally, the paper is concluded in section VI.

2. CHARACTERISTICS OF VANET

In spite of having maximum properties of MANET, VANET has some special characteristics that make it different from MANET. In this study we will try to find out the special properties of VANET that makes it different from Mobile ad hoc Network.

A Vehicular Ad hoc Network is a distributed and self configured network which is formed by moving vehicles (Ranjan et al., 2011). The characteristic of VANET are as follows.

2.1 MOBILITY PATTERNS

Nodes in VANET follow a specific mobility patterns that depends on the road layout, Traffic density, vehicle speed, and driving habit of the driver while driving. The mobility patterns generated by a moving vehicle affect the evaluation of VANET routing protocols. There are a number of VANET mobility trace generator softwares are available for the purpose of testing VANET routing protocols performance with the help of simulators. (Jetcheva et al., 2003).

2.2 RAPID CHANGING TOPOLOGY

Due to the fast speed of vehicle there is a rapid change in network topology. A link route established between two vehicles will not be able to sustain if it runs at the speed of 60-70 KM per hours (Ranjan et al., 2011). The routing algorithm developed for VANET must be capable of handling high mobility nodes. The features like connection maintenance, rapid change in neighborhood nodes and high-speed moving nodes are the key factors those need to be addressed by VANET routing protocols.

2.3 FREQUENT NETWORK BREAK

Because of the highly dynamic network topology the link between two nodes (Vehicles) can quickly disappear while they are communicating with each other so we need to have a good VANET routing protocol to overcome the problems caused by frequent change in network topology (Ranjan et al., 2011). The protocol should be capable enough to provide an alternate link to resume the communication.

2.4 PROPAGATION MODEL

It is not just free air communication. There are many obstacles in VANET communication like buildings, trees and other vehicles. The interference of other personal area network also needs to be considered.

2.5 ON BOARD SENSORS

Communicating vehicles are equipped with sensors to provide routing information. Many VANET routing protocols are developed by assuming that we have GPS unit and get a large no of information from on-board unit. We can take better routing decisions based on the large information gathered from the GPS and on-board systems in the case of VANET.

2.6 BATTERY POWER AND STORAGE

In mobile networks power and storage is a point of concern but in VANET nodes are not having problem of power and storage. Nodes are assumed to have infinite energy and computing power as vehicles are equipped with large battery and no limitations on these points.

3. VANET APPLICATIONS

The VANET applications can be categorized into safety related applications, commercial applications and infotainment applications. With the help of this we can imagine a better human life. There are many other issues those need to be addressed like lack of connectivity, safety message decimation and fast communication.

RSU can be used as access point or as router for faster connectivity and the RSU can store and forward the information as on need basis (Haerri et al., 2006), by some of the VANET applications. The communication between on-board units (OBU) and road side units (RSU) can be implemented by various methods (A. Vinel et al., 2012).

3.1 SAFETY APPLICATIONS

The main aim of ITS is to enhance traffic safety. VANET provides direct V2v communication between moving vehicles on the road. To increase the safety on the road the On-board units communicate with the front and back vehicles about the speed and direction of the vehicles and any other warning message about the accidents that has taken place in the same direction. The information regarding the density of the traffic can be stored on road side units; this information can further be pass on to other vehicles to avoid traffic jams.

Because of the fast movement of vehicles there is a frequent break in connection. And it is very tough to maintain the connection so that the information can be provide on regular basis before the vehicle moves out of the network range (Elboukhari et al., 2018). In case of emergency messages the information needs to be send very fast. For example, information regarding congestion on a road is useless once we are already taken that path; hence timely delivery is very important factor with faster data rates (Kumar et al., 2013). As stated in CAMP, 2005 safety application can take at max 100 ms mean delay and 99.9% probability of successful transfer to be effective.

3.2 INFOTAINMENT AND COMMERCIAL APPLICATIONS

These applications are considered to be less priority applications as these applications are used to help and entertain the driver and passengers of vehicles. It also provides Route information, music services and other personalized services. This type of applications is used to maximize the Driver's comfort by automatically planning the routes, tolls and parking availability.

4. VANET NETWORK ARCHITECTURE

It VANET architecture tries to provide the way it interacts between vehicles to vehicles (V2V) and vehicle to the road side equipments (V2I). Figure 1 shows the VANET architecture that falls in three categories namely pure cellular/WLAN, Hybrid and pure Ad-hoc (Mohamed W. , 2010). In the first category cellular or WLAN can also understood as vehicle to Infrastructure Communication (V2I),

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where VANET is using cellular access point to exchange the information or to establish a network.

It is difficult to install the cellular or access point infrastructure due to cost factor or geographic limitations, nodes can communication with each other. Information gathered by one vehicle from sensor can be useful for other vehicle as about traffic condition and other services (Lee et al., 2006). This infrastructure-less network architecture said to be in pure ad hoc network category where nodes perform vehicle-to-vehicle (V2V) communication with each other. Finally, the third category is known as Hybrid because it combines the concept and capabilities of V2I and V2V technique discussed above. The hybrid architecture of cellular/WLAN and Ad-hoc approaches provide great deal of flexibility in information sharing.

To explain it further in Vehicle to Infrastructure (V2I) vehicles use RSU to connect to the network and provide real time information. So RSUs are used to gather information from vehicles. The delay is very less in this type of communication as Vehicles communicates with RSU using single hop. One major drawback of this category is to deploy the fixed infrastructure on road side which is time consuming and costly.

In V2V communication the fixed infrastructure is not used so it uses multi hop multi cast communication, it is cheaper than V2I infrastructure but delay may be higher in V2V communications.

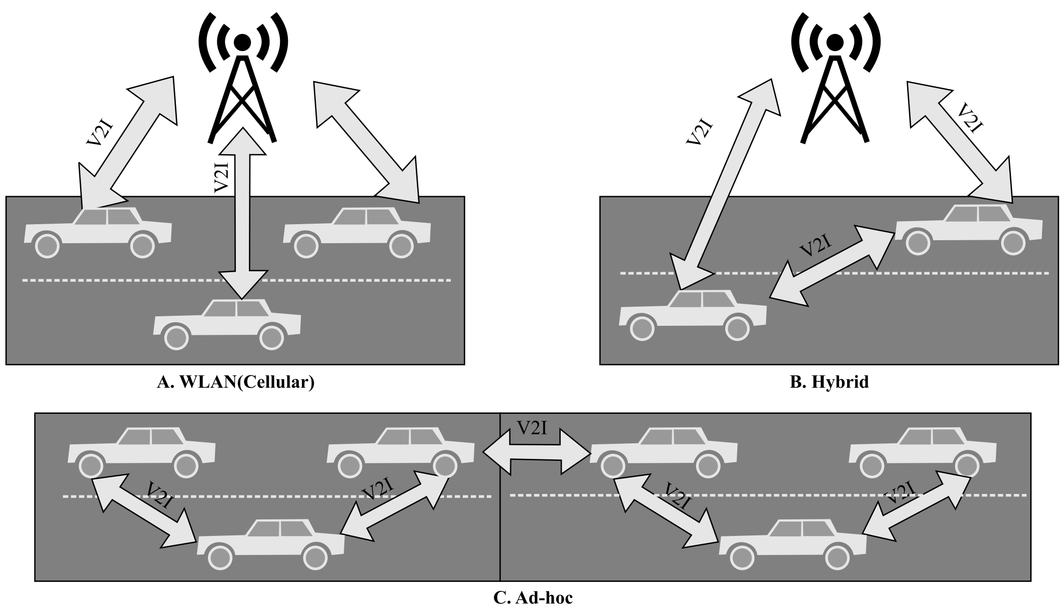

Figure 1: Modes of VANET communications

5. OVERVIEW OF VANET ROUTING PROTOCOL

VANET governs the communication between two devices, it is responsible for route establishment, route management, packet forwarding and route recovery. There are a number of protocols those are developed for VANET and can be classified based on network architecture, protocol characteristics, routing technique and quality of service (Anas Abu Taleb, 2018).

As per the information received for routing, the routing protocols can be divided into two categories Routing Information and Transmission Strategies. When we classify the VANET routing protocols according to the route discovery these can be divided into proactive, reactive, hybrid and predictive. Finally on the basis of Quality of Service (QoS) routing protocols can be categorized as flat, position and hierarchical aware routing (Anas Abu Taleb, 2018).

There may be many methods to classify the routing protocols by looking at the various points. In this study we divide the VANET routing protocols based on the characteristics and routing techniques used by them. As a result the VANET routing protocols can be divided into the following categories; Position based, Topology based, Geo-cast based, broadcast and cluster based (Anas Abu Taleb, 2018). Figure 2 shows the VANET routing protocols that falls under each category.

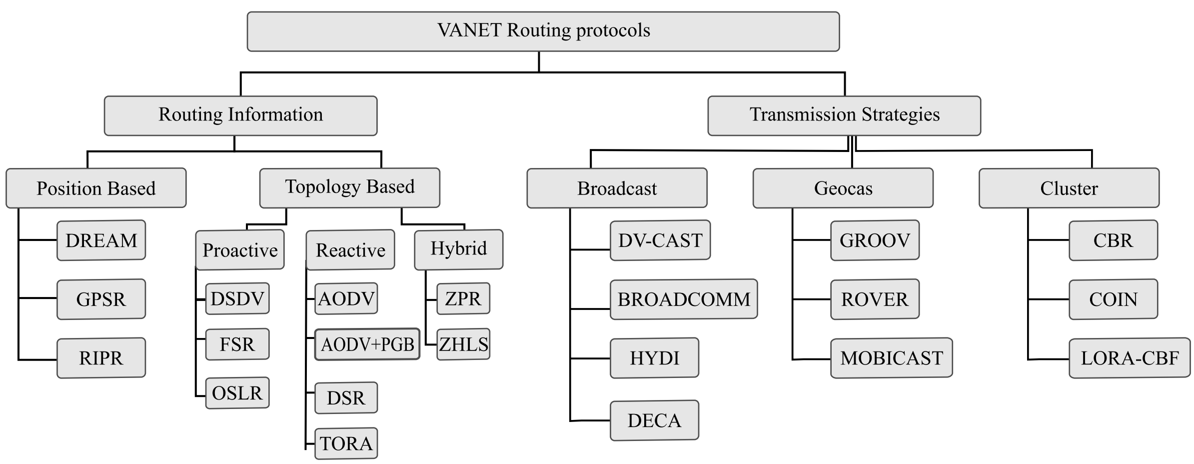

Figure 2: Classification of VANET routing protocols

5.1 TOPOLOGY BASED PROTOCOLS

The way in which the nodes are arranged in a network is known as topology. This category of VANET routing protocol uses the link information that is there in the network to transfer data from source node to destination node. The topology based protocols can be further subdivided into three categories namely Proactive or on-demand protocol, proactive or table driven protocol and Hybrid protocols (Elboukhari et al., 2018).

5.1.1 PROACTIVE ROUTING PROTOCOLS

Proactive routing protocols maintains a routing table for every node, the nodes are highly mobile in VANET, so it maintains the routing entry for the newly joined nodes and the nodes those are gone out of the network. Each route consists of routing table which gets updated whenever a vehicle enters or leaves the network or whenever a communication link is created or broken so that it is ready to use all the times. This protocol results in reduced throughput because of the increased overhead due to frequent update in routing tables. There are many protocols in this category such as Destination Sequence Distance Vector (DSDV), Optimized Link State Routing (OLSR), Fisheye State Routing (FSR) (Gayathri N. and S.R. Kumar, 2015).

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5.1.1.1 DSDV

This protocol uses the shortest path algorithm, where a routing table is maintained for each node which stores path for every other node in the network. Shortest and best path are stored in routing tables for each node. On any update in the network the routing tables are updated by exchanging it's table with the neighboring nodes. Cyclic routes are not allowed in DSDV routing protocol.

5.1.1.2 OLSR

OSLR uses Multi-Point Relay algorithm to reduce and minimize the number of active relays required to reach 2-hop neighbors. Neighbors that can be reached in 1 or 2 hops is maintained periodically by each node. Routing tables in OSLR is maintained using Link State Protocol. Once the algorithm stabilizes, we can get the active links (Haerri J et al.,2006).

5.1.1.3 FSR

FSR protocol maintains table based on the information collected from its neighbors using a topology map at every node. All nodes broadcast information to every node in the network. Routing overhead is reduced in FSR as it exchanges updated information. With the increase in size of the network FSR suffers from high overhead to store and process the routing table.

5.1.2 REACTIVE ROUTING PROTOCOLS

In Reactive Routing Protocol a route is formed when it is required. When a vehicle needs to send information to another vehicle, a route between these two vehicles is formed using discovery and maintenance technique. There are many protocols in this category such as Ad hoc On Demand Distance Vector (AODV), AODV Preferred Group Broadcasting (AODV + PGB), Dynamic Source Routing (DSR) and Temporally-Ordered Routing Algorithm (TORA).

5.1.2.1 AODV

In AODV every node stores recent active routes and the next hop node in a routing table. The routing table has reduced size as it only stores information of next node. To initiate route discovery it uses destination sequence number and determines the up to date path.

5.1.2.2 AODV+PGB

This new protocol improves path availability by reducing the time required for path updates and overhead due to control messages. This protocol is intended to achieve better performance than AODV protocol.

5.1.2.3 DSR

The next protocol that falls in this category is DSR. DSR mainly focuses on route discovery and route maintenance. When a new non existing route to the destination is required the route discovery process is started by the source node to find the path to the destination. On getting a route reply message the new route will be stored in the routing table.

5.1.2.4 TORA

TORA uses the core concept of control message localization. This is done by maintaining routing information in a node about its adjacent nodes. The main functions of this protocol are: Route creation, Route Maintenance and Route erasure.

5.1.3 HYBRID ROUTING PROTOCOLS

Hybrid Routing Protocol has a capability to decrease the time required to find a route between source and destination by combining the features of the above mentioned categories. The protocols falls in this category are Zone Routing Protocol (ZRP) and Zone-based Hierarchical Link State (ZHLS) routing protocol (Theofaniz T.K., 2007).

5.1.3.1 ZRP

ZRP is designed to speed up the delivery and reduce the processing overhead by selecting the most efficient protocol through the route. This VANET routing protocol uses both proactive and reactive routing protocols. Proactive routing protocol Intra-zone Routing Protocol (IARP) is used when there is a need to send information inside routing zones and when the information needs to sent between routing zones, reactive routing protocol Inter-zone Routing Protocol (IERP) is used.

5.1.3.2 ZHLS

ZHLS is a hierarchical routing protocol for VANET in which a network is divided into non-overlapping zones. It is a hybrid protocol based on node ID and zone ID. In this category of protocol each node knows only the node connectivity within its zone and the zone connectivity of the whole network. Finally in ZHLS the route can be established based on node ID and zoneID (T. Hamma et al., 2006).

5.2 **POSITION BASED ROUTING PROTOCOLS**

These protocols routing is based on geographic positions of the vehicles to achieve efficient routing in VANET. Position based routing protocols are more promising as it supports geographic position information of the vehicles to achieve efficient routing in VANET. In this kind of protocol there is no need to maintain information about topology and route. In order to obtain correct routing information, we need to determine speed and direction of the intermediate nodes. Protocols falls in this category are Distance Routing Effect Algorithm for Mobility (DREAM), Greedy Perimeter Stateless Routing (GPSR) and Reliability Improving Position-based Routing (RIPR).

5.2.1 DREAM

DREAM protocol uses GPS in every node to get its position and it is stored in a location table. This protocol uses two algorithms one used to send data packets and other is based on flooding and used to distribute location packets.

5.2.2 GPSR

GPSR uses greedy forwarding approach to send data packets to send data packets to nodes that are always closer to the destination. The use of greedy forwarding approach makes this protocol responsive and efficient for VANET.

5.2.3 RIPR

RIPR is developed to solve multiple link failure. It is the last protocol that is discussed in this category. Each node maintains a routing table that contains neighbor's speed and position, in this way direction and speed of vehicle is determined in this protocol. Based on this a nearby neighbor is selected by the source until it reaches to destination.

5.3 CLUSTER BASED ROUTING PROTOCOL

The protocols that falls in this category are Location-Based Routing Algorithm with Cluster-Based Flooding (LORA-CBF). Cluster Based Routing Protocol (CBR), Clustering for Open IVC Network Routing Protocol (COIN) and Cluster-Based Directional Routing Protocol (CBDRP). In CBRP routing technique we divide the network into interconnected substructures known as clusters. In each cluster we have a cluster head (CH) that works as coordinator within that cluster. It acts as a temporary base station within the cluster and communicates with other CHs. Also, the number of vehicles, movement direction and velocity of vehicles can be used as metrics to divide the network into clusters. Hence the next nearby cluster is used to forward data for inter-cluster communication.

5.3.1 LORA-CBF

The main objective of this type of protocol is to divide the network into clusters. In this, cluster will have a cluster head that will be responsible for communication with other clusters and cluster heads. In Location based Routing Algorithm with Cluster Based Flooding (LORA-CBF) periodic beacon messages are sent by cluster heads to update its parameter. The cluster head also send location request messages to collect location information (Anas Abu Taleb, 2018).

5.4 BROADCAST ROUTING PROTOCOL

Broadcast Routing Protocol is one of the traditional techniques that use flooding to send information in VANET. In all cases the packets are flooded to all the nodes in the network. However, it can consume the network bandwidth by sending duplicate packets, so each node to identify which packet is duplicate so that it can be discarded. The other main role of this protocol is in route discovery process. The protocols those lie in this category are BROADCOMM, Density Aware Reliable Broadcasting Protocol (DECA), Distributed Vehicular Broadcast Protocol (DV-CAST) and Hybrid Data Dissemination Protocol (HYDI).

5.4.1 BROADCOMM

This works on the principle of division of network region into cells. A cell reflector is selected by the members of the cell. Finally, it cell reflector will act as a base station for other nodes in the cell. The messages will be forwarded to all the vehicles available in the cell (Rehman et al., 2013).

5.5 GEOCAST ROUTING PROTOCOL

In VANET the Geocast routing protocol uses a multicast service that enables a single vehicle to send data packets to all other vehicles present in specific geographical area with labeled zone of relevance (ZOR)

(Gayathri N. and S.R. Kumar, 2015). Routing protocol in this category forward and disseminate information to a specific geographic area that is related to the information being transmitted. There are many protocols available in this category and some of them are Robust Vehicular Routing Protocol (ROVER), MOBISAST, The Distributed Robust Geocast (DRG), A Geographic Routing Over VANAT (GROOV) (Elboukhari et al., 2018) etc. One of the main drawbacks of Geocast routing protocol is packet transmission delay.

6. CONCLUSION

This paper gives an overview of VANET routing protocols those are used in vehicular communications. By reviewing many studies on routing protocols, it is found that the existing routing protocols for VANET are not sufficient to meet all traffic requirement as every protocol has its own pros and cons. This paper does not cover all the VANET routing protocols as there are so many of them. The future work is to analyze the performance of different VANET Routing protocols using tools like SUMO, MOVE and Ns3.

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