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Review on classification of different VANET Protocols based on routing information

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Abstract: Vehicular Ad-hoc Networks (VANETs) are the special class of Mobile Ad-hoc Networks (MANETs) with high mobility and frequent changes of topology. It is a type of highly dynamic wireless network that can be formed without the need for any pre-existing infrastructure which aims to improve the transportation system by integrating sensors, wireless networks, GPS, 2G and 3G technologies with the Ad-hoc networks. Due to higher mobility of nodes (vehicles), routing becomes the most challenging task in VANETs. A variety of research has been done on routing and several protocols have been proposed with their implementation. As VANET (Vehicular Ad-hoc Network) research field is growing very fast. It has to serve a wide range of applications under different scenarios (City, Highway). It has various challenges to adopt the protocols that can serve in different topology and scenario. The main objective of Vehicular Ad-hoc Networks is to build a robust network between mobile vehicles so that vehicles can talk to each other for the safety of human beings. This paper deals with the study of classification of different Ad Hoc routing protocols and their different routing techniques.

Keywords: VANET (Vehicular Ad-hoc Network), MANET (Mobile Ad-hoc Network), routing protocols, AODV, AOMDV.

I. INTRODUCTION

Driving means changing location constantly. This means a constant demand for information on the current location and specifically for data on the surrounding traffic, routes and much more. This information can be grouped together in several categories. A very important category is driver assistance and car safety. This includes many different things mostly based on sensor data from other cars. We could think of brake warning sent from preceding car and collision warning, information about road condition and maintenance, detailed regional weather forecast, premonition of traffic jams, caution to an accident behind the next bend, detailed information about an accident for the rescue team and many other things. We could also think of local updates of the cars navigation systems or an assistant that helps to follow a friend's car.

Another category is infotainment for passengers. For example internet access, chatting and interactive games between cars close to each other. The kids will love it.

Next category is local information as next free parking space (perhaps with a reservation system), detailed information about fuel prices and services offered by the next service station or just tourist information about sights. A possible other category is car maintenance. For example online help from your car mechanic when your car breaks down or just simply service information. So far no inter-vehicle communication system for data exchange between vehicles and between roadside and vehicles has been put into operation. But there are several different research projects going on [1] [2]. VANET is one of those.

In 1999, the Federal Communications Commission of the United States allocated 75 MHz of bandwidth in the 5.9-GHz band for the new generation of a nationwide VANET. This wireless spectrum is commonly known as the dedicated short-range communication (DSRC) spectrum, which has been used for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications [3]. In August 2006, the European Telecommunications Standards Institute has also allocated 30 MHz of spectrum in the 5.8-GHz band for ITS [4].

IEEE 802.11p is a new upcoming standard using the DSRC spectrum. It extends the IEEE 802.11 standard for a high-speed vehicular environment, which covers the data link layer and the physical layer of the wireless access in vehicular environments (WAVE) protocol stack. Meanwhile, IEEE 1609, which is a family of standards, has been developed to define the five upper layers of the WAVE. The latest version of IEEE 802.11p has been approved and published in July 2010 [5].

IEEE 802.11p supports data communication between vehicles, in turn supports Intelligent Transportation Systems (ITS) applications. The channel capacity is 10 MHz, and there are two safety channel, one control channel and six service channel. Radio communication range is about 300 to 1000 meters and data rate is 6 to 27 Mbps [6 and 7]. This paper deals with study of different types of routing protocols for VANET.

II. VANET ARCHITECTURE

An VANET system architecture consists of different domains and many individual components as depicted in Figure1 [8].

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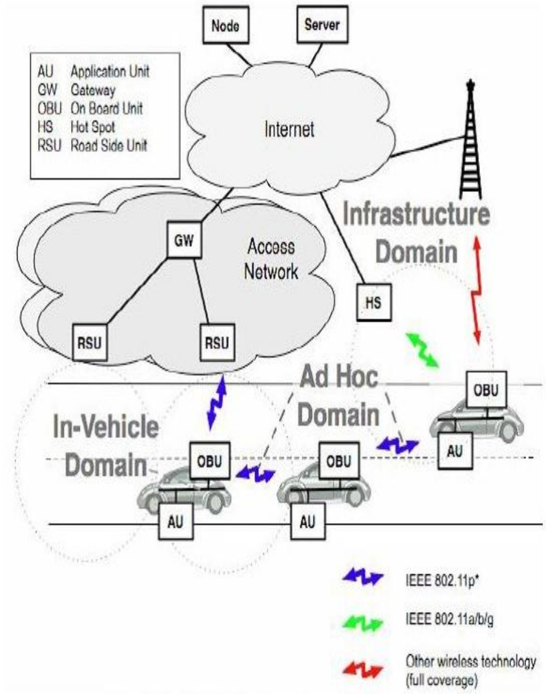

Fig 1: VANET System Architecture [8]

In-vehicle domain
This consists of an on-board unit (OBU) and one or more application units (AU) inside a vehicle. AU executes a set of applications utilizing the communication capability of the OBU. An OBU is at least equipped with a (short range) wireless communication device dedicated for road safety, and potentially with other optional communication devices (for safety and non safety communications). The distinction between AU and OBU is logical; they can also reside in a single physical unit [9].

Ad hoc domain
An ad hoc domain is composed of vehicles equipped with OBUs and road-side units (RSUs), forming the VANET. OBUs form a mobile ad hoc network which allows communications among nodes without the need for a centralized coordination instance. OBUs directly communicate if wireless connectivity exists among them; else multi-hop communications are used to forward data [9].

Infrastructure domain
The infrastructure consists of RSUs and wireless hotspots (HT) that the vehicles access for safety and non-safety applications. While RSUs for internet access are typically set up by road administrators or other public authorities, public or privately owned hot spots are usually set up in a less controlled environment [9]. Easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

III. AD HOC ROUTING PROTOCOLS

VANET has some special characteristics that distinguish it from other mobile ad hoc networks; the most important characteristics that differentiate VANETs from MANETs are: high mobility, self-organization, distributed communication, road pattern restrictions, and no restrictions of network size. All these characteristics made VANETs environment a very challenging task for developing efficient routing protocols. We have a number of ad hoc routing protocols for MANETs but when we are dealing with a VANET then we require ad hoc routing protocols which must adapt continuously according to the unreliable conditions. MANET routing protocols are not suited for VANET because it is difficult for MANET routing protocols to find stable routing paths in VANET environments. Many routing protocols have been developed for VANET environments, which can be classified in many ways, according to different aspects; such as: protocols characteristics, techniques used, routing information, quality of services, network structures, routing algorithms, and so on.

VANET routing protocols can be classified into five classes based on the routing protocols characteristics and techniques used: topology-based, position-based, multicast-based, broadcast, and cluster-based protocols [10], [11], [12]. Also these routing protocols can be classified according to the network structures, into three classes: hierarchical routing, flat routing, and position-based routing. Moreover, according to routing strategies these protocols can be categorized into two classes: proactive and reactive [14]. On the other hand geographic-based and topology-based are the two categories according to the routing information used in packet forwarding [13]. Based on the quality of services, there are three types of protocols that are dealing with network topology (hierarchical, flat, and position aware), that concerning with route discovery (reactive, proactive, hybrid and predictive), or based on the MAC layer interaction [15]. We are hereby considering the classification based on routing information used in packet forwarding.

TOPOLOGY BASED ROUTING
Several MANET routing protocols have used topology based routing approach. Topology based routing protocols use link's information within the network to send the data packets from source to destination [17]. Topology based routing approach can be further categorized into three groups:

1. Proactive routing
2. Reactive routing
3. Hybrid routing

1. Proactive Routing
Proactive routing protocols are mostly based on shortest path algorithms. They keep information of all connected nodes in form of tables because these protocols are table based [16]. Furthermore, these tables are also shared with their neighbors. Whenever any change occurs in network topology, every node updates its routing table. Strategies implemented in proactive algorithms are Link-state routing (e.g. OLSR) and distance-vector routing (e.g. DSDV). The working details for proactive routing protocols are as follows: Destination Sequence Distance

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Vector Routing (DSDV) [16] use Distance Vector shortest path routing algorithm, it provides loop free single path to the destination. DSDV sends two types of packets "full dump" and "incremental". In full dump packets, all the routing information is send while in incremental only updates are send. It decreases bandwidth utilization by sending only updates instead of complete routing information. The incremental still increases the overhead in the network, because these incremental packets are so frequent that makes it unsuitable for large scale networks. Optimized link state routing (OLSR) [16] maintains routing information by sending link state information. After each change in the topology every node sends updates to selective nodes. By doing so, every node in the network receive updates only once. Unselected packets cannot retransmit updates; they can only read updated information. Source-Tree Adaptive Routing (STAR) [16] is another link State protocol. In STAR, preferred routes to every destination are saved in each router. It reduces overhead on the network by eliminating periodic updates. There is no need of sending updates unless any event occurs. 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. Proactive based routing protocols may not be suitable for high mobility nodes because distance vector routing takes much bandwidth to share routing information with neighbors. Furthermore, size of the table is also quite big while discussing about large networks and in case of link state routing a lot of memory and processing may also be required. As in VANET, nodes (vehicles) have high mobility and moves with high speed. Proactive based routing is not suitable for it. Proactive based routing protocols may fail in VANET due to consumption of more bandwidth and large table information.

1.1 Destination Sequence Distance Vector Routing (DSDV)

This protocol is based on classical Bellman-Ford routing algorithm designed for MANETS. Each node maintains a list of all destinations and number of hops to each destination. Each entry is marked with a sequence number. It uses full dump or incremental update to reduce network traffic generated by rout updates. The broadcast of route updates is delayed by settling time. The only improvement made here is avoidance of routing loops in a mobile network of routers. With this improvement, routing information can always be readily available, regardless of whether the source node requires the information or not. DSDV solve the problem of routing loops and count to infinity by associating each route entry with a sequence number indicating its freshness. In DSDV, a sequence number is linked to a destination node, and usually is originated by that node (the owner). The only case that a non-owner node updates a sequence number of a route is when it detects a link break on that route. An owner node always uses even-numbers as sequence numbers, and a non-owner node always uses odd-numbers. With the addition of sequence numbers, routes for the same destination are selected based on the following rules: 1) a route with a newer sequence number is preferred; 2) in the case that two routes have a same sequence number, the one with a better cost metric is preferred.

2. Reactive Routing

On demand or reactive routing protocols were designed in such a manner to overcome the overhead that was created by proactive routing protocols. This is overcome by maintaining only those routes that are currently active [16]. Routes are discovered and maintained for only those nodes that are currently being used to send data packets from source to destination. Route discovery in reactive routing can be done by sending RREQ (Route Request) from a node when it requires a route to send the data to a particular destination. After sending RREQ, node then waits for the RREP (Route Reply) and if it does not receive any RREP within a given time period, source node assumes that either route is not available or route expired [18]. When RREQ reaches the particular destination and if source node receives RREP then by using unicasting, information is forwarded to the source node in order to ensure that route is available for communication. Reactive routing can be classified either as source routing or hop-by-hop routing. In source routing complete route information from source to destination is included in data packets. When these data packets are forwarded to other intermediate nodes in the network, each node takes route information from the data packet and stores it in the header of data packet.

As a result, each intermediate node does not need to update all route information in order to send packet to the particular destination [16]. The main drawback of source routing is that it may not be suitable for large scale networks, where numbers of nodes are quite high and their behavior is highly dynamic such as VANET. The first reason is that as numbers of nodes are larger in large scale ad hoc networks hence it may result in route failure. The second reason is that as numbers of intermediate nodes are increasing, thus network overhead may occur and route information in the header of each node may also increase. Hop-by-hop reactive routing is better than on demand source routing as each data packet in it contains next hop and destination addresses. Thus intermediate nodes from source to destination contain the routing table information in order to send data packet to a particular destination. This can be quite helpful for accommodating sudden changes in network topology. Thus when topology changes nodes receives fresh routing table information and selects new routes accordingly. As a result these selected routes are now used to send data packets to destination. These types of routing protocols continuously update their routing information and carried knowledge of each neighboring node Therefore this type of reactive routing can be adopted in highly mobile ad hoc networks such as VANET [16]. Many reactive routing protocols have been proposed so far but in this section we briefly described about Ad Hoc On Demand Distance Vector Routing (AODV) and Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV). Moreover we check the suitability of these protocols for VANET.

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2.1 Ad Hoc On Demand Distance Vector Routing- AODV

Ad Hoc On Demand Distance Vector Routing (AODV) is an example of pure reactive routing protocol. AODV belongs to multihop type of reactive routing. AODV routing protocol works purely on demand basis when it is required by network, which is fulfilled by nodes within the network. Route discovery and route maintenance is also carried out on demand basis even if only two nodes need to communicate with each other. AODV cuts down the need of nodes in order to always remain active and to continuously update routing information at each node. In other words, AODV maintains and discovers routes only when there is a need of communication among different nodes. AODV uses an efficient method of routing that reduces network load by broadcasting route discovery mechanism and by dynamically updating routing information at each intermediate node. Change in topology and loop free routing is maintained by using most recent routing information lying among the intermediate node by utilizing Destination Sequence Numbers of DSDV.

2.2 Ad Hoc On Demand Multipath Distance Vector Routing- AOMDV

The AOMDV [19] [20] [21] routing protocol is an extension of AODV. It is a reactive (on-demand) routing protocol as compared to proactive OLSR protocol. Thus the route is calculated only when needed not in advance as in OLSR protocol. Like AODV it also involves two methods: route discovery and route maintenance. But it is multi-path routing protocol as compared to single path based AODV protocol. Therefore, it is suitable for highly dynamic ad-hoc networks like vehicular ad-hoc networks where network partitioning and route breakdown occur very frequently. For dealing with such network scenario AOMDV protocol determines multiple paths during the procedure of route discovery. As a result in case of link failure in the network there is no need to find the new route every time due to availability of other routes while the AODV protocol require an additional burden related with the route discovery procedure to be invoked every time to find the new route whenever route breaks causing a delay in data transfer. So AOMDV is said to be an improved form of AODV routing protocol.

3. Hybrid Routing

Hybrid routing combines characteristics of both reactive and proactive routing protocols to make routing more scalable and efficient [16]. Mostly hybrid routing protocols are zone based; it means the number of nodes is divided into different zones to make route discovery and maintenance more reliable for MANET. Haas and Pearlman [19] proposed a hybrid routing protocol and named it as ZRP (Zone routing protocol). The need of these protocols arises with the deficiencies of proactive and reactive routing and there is demand of such protocol that can resolve on demand route discovery with a limited number of route searches. ZRP limits the range of proactive routing methods to neighboring nodes locally, however ZRP uses reactive routing to search the desired nodes by querying the selective network nodes globally instead of sending the query to all the nodes in network. ZRP uses “Intrazone” and “Interzone” routing to provide flexible route discovery and route maintenance in the multiple ad hoc environments. Interzone routing performs route discovery through reactive routing protocol globally while intrazone routing based on proactive routing in order to maintain up-to-date route information locally within its own routing range [19]. The overall characteristic of ZRP is that it reduces the network overhead that is caused by proactive routing and it also handles the network delay that is caused by reactive routing protocols and perform route discovery more efficiently. The drawback of ZRP is that it is not designed for such environments in which the nodes behavior is highly dynamic and rapid changes in topology such as VANET. In other words we can say this routing protocol is specifically designed for such networks where nodes are not highly mobile and network size is depend on limited number of nodes. Pure proactive or reactive routing protocols can be suitable to some extent in a highly dynamic environment like VANET as compared to Hybrid routing.

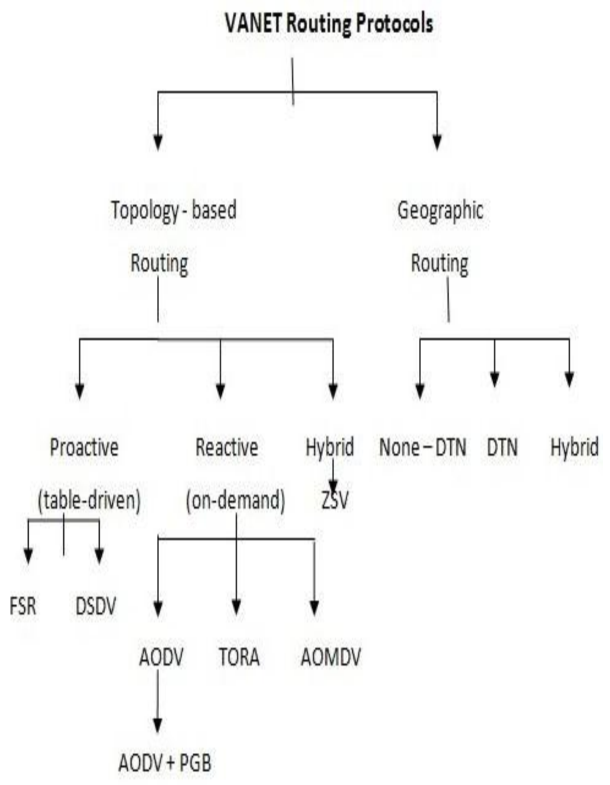

Fig 2: VANET routing protocols classification

IV. GEOGRAPHIC (POSITION) BASED ROUTING

In geographic (position-based) routing, the forwarding decision by a node is primarily made based on the position of a packet’s destination and the position of the node’s one-hop neighbors. The position of the destination is stored in the header of the packet by the source. The position of the node’s one-hop neighbors is obtained by the beacons sent periodically with random jitter (to

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prevent collision). Nodes that are within a node's radio range will become neighbors of the node. Geographic routing assumes each node knows its location, and the sending node knows the receiving node's location by the increasing popularity of Global Position System (GPS) unit from an onboard Navigation System and the recent research on location services (Flury, 2006; Li, 2000; Yu, 2004), respectively. Since geographic routing protocols do not exchange link state information and do not maintain established routes like proactive and reactive topology-based routings do, they are more robust and promising to the highly dynamic environments like VANETs. In other words, route is determined based on the geographic location of neighboring Figure 2 sub-classifies Geographic routing into three categories of non-Delay Tolerant Network (non-DTN), Delay Tolerant Network (DTN), and hybrid. The non-DTN types of geographic routing protocols do not consider intermittent connectivity and are only practical in densely populated VANETs whereas DTN types of geographic routing protocols do consider disconnectivity. However, they are designed from the perspective that networks are disconnected by default. Hybrid types of geographic routing protocols combine the non-DTN and DTN routing protocols to exploit partial network connectivity.

IV. CONCLUSION

In this review paper we can conclude that MANET routing protocols are not suited for VANET environment because of their high mobility, distributed communication, road pattern restrictions and self-organization and no restrictions of network size. Also we have reviewed the criteria on which different VANET protocols are categorized. The classification based on routing information used in packet forwarding is Topology based routing and Geographic routing and this has been discussed here.

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