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A Literature Survey on VANET Protocols

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Abstract*— *In the past few years, Vehicular Adhoc Networks (VANETs) has become an important area for the researchers. VANET make use of vehicles that are designed using wireless communication devices, digital maps and positioning systems. The communication in VANET takes place in two different ways Vehicle-To-Vehicle (V2V) communication and Vehicle-To-Infrastructure (V2I) communication. In V2V communication, the data propagation is between two vehicles to improve safety in transportation, whereas in V2I communication, the data is sent from vehicles to Road Side Units to gather commercial and entertainment services. In this paper, we made a detailed survey on the importance of using infrastructure Road Side Units (RSUs) and the various protocols used for communication between V2V and V2I in one solid document for the developers and researchers to understand the advantages of different Protocols.

Keywords*— *VANET, Road Side Unit (RSU), Intervehicular communication (IVC)

1, INTRODUCTION

The Vehicular Adhoc Network (VANET) consists of vehicles that are designed using wireless communication technology. In recent trends, VANET mainly focuses on the application development which can be grouped as improving road safety, traffic efficiency, and maximizing the benefits of road users [26]. In VANET, research on routing is limited to vehicles of short distance. But in some applications, it is necessary to send data to far vehicles. This is carried out by connecting vehicle with Road Side Units (RSUs) [2]that are interconnected with each other through a high-capacity mesh network. When Vehicles and RSUs are equipped with onboard processing and wireless communication modules, the communications between vehicle-to-vehicle and vehicle-to-infrastructure are directly possible when it is in range or also across multiple hops.

With the help of Internet, the users of RSUs are allowed to download maps, traffic data, multimedia files and also to check emails and news update. We refer these types of VANETs as Service-Oriented VANET [1] that provides data to drivers and passengers virtually. The basic communication architecture of VANET is shown in Figure 1.1.

Here we classify our paper into five sections. In Section 1, a brief introduction about the importance of RSU is given. Section 2 tells about the related works. Section 3 is about the different routing protocols based on V2V communications. Section 4 is about the different routing protocols based on V2I communications. Finally, Section 5 ends with conclusion of the paper and the future works that can be done.

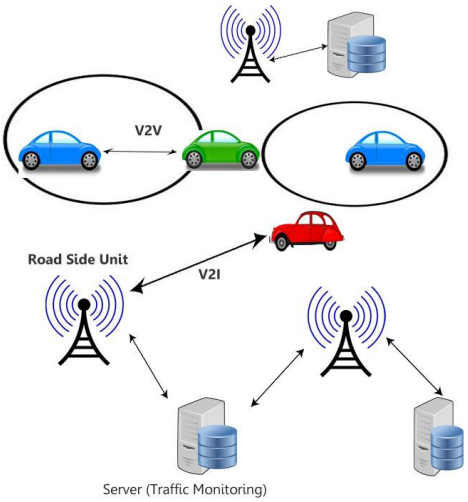

Figure 1.1 VANET Architecture

2, Related Works

To improve the communication in VANETs, several measures has been taken by implementing mobile network, developing of sensors in wireless Sensor Network (WSNs) and misbehavior detection problem in VANETs. The vehicles which are involved in VANETs will be responsible for their nearby nodes resulting in less traffic accidents. All the signals are received by sensors through nodes. Taking a survey in a global database is very expensive and it is not practical. It does not provide any privacy. It improves safety in the road by sending critical alerts to vehicles. The vehicles by receiving alerts can be precautious and can avoid accident, collision, merge, etc. VANETs pose challenges on technology, security, and protocols that make the need for research in this field.

Further in [3], the performance of a VANET can be used in small distance communication between vehicle to vehicle and also in long-distance communication by using vehicle to Road Side Unit. Sourav [4] states that in VANET the major issue is data communication between vehicles and security to vehicles. If VANET is attacked then the entire network will shut down by degrading the network performance. Urmila Shrawankar [5] states that the most important challenge in the VANET system is security and privacy. In this system the vehicles can communicate together and it gives comfort to Driver. Jamalul-lail Ab Manan[6] describes that daily there is a threat for human lives and we can also use R&D Eco system to avoid accident and traffic jams.

3, Routing Protocols based on V2V communications

In V2V communication, each vehicle is designed by using sensors, network devices, Global positioning System (GPS), computing devices and digital map which has the road segment information. Vehicles sense its traffic messages and exchange with its neighboring vehicles to avoid any critical situation such as road side accidents, traffic jams, speed control, free passage of emergency vehicles and unseen obstacles by periodically broadcasting beacon or HELLO messages. The communication between V2V can be either unicast or multicast packet forwarding techniques from source vehicle to destination vehicles. Since the VANET is highly dynamic topology, designing an efficient routing protocol is very much challenging.

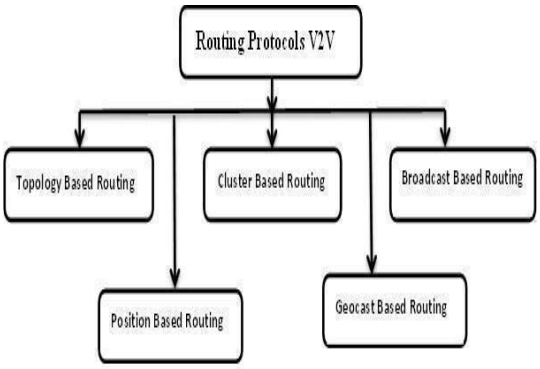

Figure 1.2 Routing Protocols in V2V

The routing protocols of VANET can be classified into five categories as shown in figure 1.2 such as Topology based Routing Protocol, Position based Routing Protocol, Cluster based Routing Protocol, Geocast based Routing Protocol, and Broadcast based Routing Protocol.

3.1 Topology Based Routing Protocol

Topology based routing protocol use the link information that is available in the existing networks to perform packet forwarding [7]. This protocol is further classified into three main protocols.

i) Proactive Routing Protocols

Proactive routing protocol will store and maintain the routing information about the paths that are currently in use and also not in use [31]. This protocol is otherwise called as Table-Driven routing protocol. When there is any change in path, every node periodically updates in the routing table throughout the whole network. The main advantage is that the packets are transmitted constantly among the nodes therefore no discovery of route is required since they maintain the route information at the background. The main disadvantage is that it also maintains unused path information that will occupy the significant part of available bandwidth and causes reduction of bandwidth in the network topology.

ii) Reactive Routing Protocol

This routing protocol is also called as On-Demand routing protocol because the routes are discovered to the destinations on-demand [32]. The routing table is maintained only for the routes that are used currently which reduces the traffic in the network. This protocol consumes less bandwidth when compared to proactive routing protocol but it takes more time to discover a route that results delay in the network. The periodic flooding is not required to update the routing table is an advantage of Reactive protocol. It saves bandwidth, since this protocol is beaconless. The disadvantage is that, though the routing table is maintained with currently used routes, due to changes in the network topology it will result in significant amount of network traffic. This will also result in loss of packets to the destination. Another disadvantage is dislocation of communication nodes in the network due to excessive flooding.

iii) Hybrid Routing Protocol

In this routing protocol, the characteristics of both Proactive and Reactive Routing protocol is combined to make the routing process more efficient and scalable. This is also called as Zone Routing Protocol (ZRP) [33].To make the route discovery and maintenance process more reliable, here the total number of nodes are divided into different zones. This protocol is to overcome the drawbacks of Proactive and Reactive routing protocols and also it solves on-demand routing by using limited number of routes. The network overhead caused by Proactive routing and network delay caused by Reacting routing are reduced by discovering the routes efficiently. The main drawback is that, this protocol cannot withstand in some environment like VANET where the node's behaviour is highly dynamic and changes rapidly. So Hybrid Routing Protocols are not involved in VANET topology.

3.2 Position Based Routing Protocol

By using the property of geographic positioning information like GPS, the position based protocol will select the next forwarding hops. Therefore it is not necessary to create and maintain routing table or to exchange routing information with neighbor nodes. The disadvantage of position based routing protocol is, it requires position determining services. The position based routing protocol is broadly classified into the following protocols:

i) Greedy Perimeter Stateless Routing (GPSR)

Greedy Perimeter Stateless Routing [16], each node finds the neighboring nodes by using beacon signal or HELLO messages and the position of the destination with the use of location service. In GPSR, each node should be capable of finding its current position. The information like current location, speed, current time and direction of vehicle will be provided by the GPS receiver. With all these information, a node forwards the incoming packets to the neighboring nodes which is closest to the destination.

The neighboring node which is close to the destination is selected as the next-hop node. This technique is known as Greedy Forwarding Algorithm. In Some cases if the HELLO messages get lost due to transmission errors then vehicles will not be aware of the neighboring nodes. In this situation GPSR uses perimeter routing algorithm traversal to find a way out of the local maximum region. The advantage of GPSR is the packet forwarding decision is made dynamically and a node needs to know only one hop neighbor location to forward the packet. The disadvantage is destination node will send the information through packet header of intermediate node but it is not updated in the routing table of that node.

ii) Greedy Perimeter Coordinator Routing (GPCR)

Greedy Perimeter Coordinator Routing will forward packets to the path that are selected previously by using greedy algorithms [17]. Here in this protocol, the decisions are made at the junction in the road that helps to communicate by providing more number of alternate paths. The advantage is it does not require any global or external information like static maps. There is no planarization problem but underlying roads will be used for representing planar graphs. Since this protocol uses junction nodes, the first approach will fail on curve road and the second approach will fail on sparse road.

iii) Connectivity-Aware Routing (CAR)

CAR is designed by combining the characteristics of both Geographic routing and Ad-hoc routing protocols [18]. In this protocol, path discovery is done by using AODV and data dissemination is done by using PGB. CAR follows four main phases like path discovery, data forwarding, guard concept and error recovery. The Path is maintained with the help of Guard concept. This protocol has very good performance but it is relatively complex when it is adapted to local conditions. The advantage of Connectivity-Aware Routing is it does not require any digital maps and no local maximum problem. The disadvantage will be selecting unnecessary node as head node and when there is any changes in the network traffic due to environment problems, it is very difficult to adapt with the sub-paths.

iv) Geographic Source Routing (GSR)

GSR protocol consists of topological knowledge with the combination of position-based routing protocol. Like GPCR [19], the shortest path is preselected by using Greedy forwarding algorithm and the same path is calculated with the help of Dijkstra algorithm. This algorithm uses street map to gain knowledge about city topology and Reactive Location Service (RLS) to find the destination node. It determines the junctions through which the packets have to be forwarded first and then applies greedy forwarding algorithm in between the junctions. The advantage is when compared to AODV and GPSR, this GSR protocol exceeds them in packet delivery ratio and average delay time. It is scalable than AODV and DSR. The disadvantage is it fails to have enough packets for forwarding, when there is low traffic density in sparse network.

v) Anchor-Based Street and Traffic Aware Routing (A-STAR)

A-STAR [20] is designed for the purpose of inter vehicle communication system especially for city environment. For an end-to-end communication, high connectivity in packet delivery is assured with the help of city bus traffic information. This is the advantage of this routing protocol even in low traffic density. When compared to GSR and GPSR, A-STAR is using a new local recovery scheme which is more desirable for city network. Though A-STAR has low packet delivery ratio but it has high connectivity for selecting path. The disadvantage of A-STAR will be connectivity problem for finding a path from source to destination.

3.3 Cluster Based Routing Protocol

In Cluster Based Routing, a Cluster is made with group of nodes or vehicles. Every cluster has one Cluster head which will be responsible for all inter-cluster and intra-cluster communication. Each node in the cluster will describe them as a part of the cluster. In Inter-cluster communication, each node within the cluster is connected through Cluster head whereas in Intra-cluster, the connection with each cluster is made through direct link. In Cluster based protocol, the Cluster head will send the packets to the cluster which results in good scalability. There are different types of Cluster based routing protocol exists which we will discuss in the subsequent sections.

i) Hierarchical Cluster Based Routing (HCB)

The HCB routing protocol is designed for MANET with the help of clustering techniques [21]. HCB have two layers communication architecture. In Layer I, the nodes will communicate with each other through multi-hop path and they have single radio interface whereas in Layer II, the nodes will communicate with each other through base station. Due to large number of packet loss, the number of retransmission is high.

ii) Cluster-Based Directional Routing Protocol (CBDRP)

This protocol [22] is designed especially for the vehicles that will move in same direction. Here, the source node will forward its packet to the cluster head and it is transmitted in the same cluster by cluster head. This CBDRP is similar to CBR but during packet forwarding the direction and velocity is considered. The advantage of this protocol is reliability and rapid data transfer. It also solves link stability problem. The disadvantage is that the number of retransmission is high and it has average control packet overhead.

iii) Cluster Based Location Routing (CBLR)

Though CBLR protocol is cluster based protocol, it also possess the properties of Reactive and On-Demand routing protocols [24]. Every cluster head maintains a routing table which has the information like address and location of each cluster members. With the help of neighbor's routing table, a cluster head can track the information about its neighbor clusters. To send a packet from Source to destination, first the packet will be forwarded from source node to nearest neighbor node and then it is transmitted to destination when it is also in same cluster. In case if the destination is in another cluster, then the packet will be stored in the buffer and then Location Request (LREQ) packets are transmitted by starting the timer. The main advantage is CBLR protocol will suit for all high mobility networks and it makes use of digital maps. Here, it has low control packet overhead. Like CBDRP, it has the disadvantage of large number of retransmission.

iv)Cluster Based Routing (CBR)

CBR protocol is based on position and cluster protocols in which the geographic area is divided into square grids [23]. That geographic information will help to forward data packets from every node to its neighbor node. When a vehicle in the square grid is chosen as cluster head, then a LEAD message is transmitted to each neighbor node. If that cluster head leaves the grid, then the LEAD message is transmitted to the nodes which possess the grid position currently. The CBR will not find route discovery is an advantage of this protocol which results in less routing overhead. The important parameters like velocity and direction is not considered in CBR protocol is the main disadvantage.

v) Location Routing Algorithm with Cluster-Based Flooding (LORA-CBF)

This protocol is similar to greedy routing protocol. The information about each and every node is maintained by the cluster head [25]. The gateway is the place where two clusters are connected through a node. LREQ message will be sent by the cluster head and gateways if the destination node is not present in the respective cluster. Since LORA-CBF is similar to greedy routing protocol, it has the advantage of same packet forwarding technique. The disadvantage is it results in heterogeneous performance.

3.4 Broadcast Based Routing Protocol

Broadcast routing protocol is used in VANET to broadcast the information for maximum number of nodes when an unexpected event like accident, traffic jam occurs. When these packets are broadcast into the network it leads to collision, utilization of high bandwidth consumption, and reduce the overall performance. This Broadcast routing protocol is suitable for smaller network where less number of nodes are connected .There are large number of broadcasting protocols available and they are as follows:

i) BROADCOMM

BROADCOMM [8] is designed specifically for highway network and this protocol is mainly based on hierarchical structure. The highway is split into virtual cells and those cells will move along with that vehicle. The highway node has two level hierarchy. At first level, each and every node in the cells are included in the network. At the second level, few nodes in each cell is called as cell reflectors that are responsible for managing message forwarding and receiving them from neighboring cell reflectors. The advantage is it has better outperformance for a highway network that has less number of nodes. The only disadvantage is the position information is entirely based on cell formations.

ii) Edge-Aware Epidemic Protocol (EAEP)

The main function of this EAEP is to transmit messages over all the vehicles [9]. This special kind of protocol will allow each vehicle to possess its own geographical position. Within the given period of time the total number of transmission takes place from source to destination, EAEP will determine whether the nodes will retransmit the new rebroadcast message which is received. In EAEP, the node is not aware of a message that is lost during transmission. The advantage of EAEP is, it will overcome even simple flooding problem and by rejecting hello packets, this protocol will decrease control packet overhead. The main disadvantage is it results in large number of data transmission with high delay and also the issues that caused by intermittent connectivity is not handled in this protocol.

iii) Secure Ring Broadcasting (SRB)

Based on the receiving power, the secure Ring Broadcasting divides the nodes into three groups such as Inner node, Outer node and Secure Ring nodes [10]. The Inner nodes are the nodes that are present nearest to the source node whereas Outer nodes are present away from source node and the node with preferable distance from source node is called as Secure Ring nodes. By reducing number of retransmission messages, more stable routes are gained. This is the only advantage of SRB. Here, this protocol has more control packet overhead as disadvantage.

iv)Preferred Group Broadcast

This protocol is specially designed to prevent the problem that is caused due to broadcast storm from transmitting route request [11]. Every node has the ability to sense the signal strength level from neighbor broadcasting. It will retransmit the message to the node which has shortest timeout. It has the advantage of decreasing RREQ broadcasting. This PGB protocol is not a reliable broadcasting protocol.

v) Urban Multihop Broadcasting (UMB)

During message transmission in multi hop broadcasting it will come across lot of problems like Collision and hidden node problem, this UMB protocol is designed to overcome this issues [12]. Here the sender node will try to collect the prior information about the next node for sending the packets and also to acknowledge for it. The

advantages are the performance is good in case of high packet loads and vehicle traffic density. It also solves collision and hidden node problems. The only disadvantage is this protocol has unused bandwidth.

3.5, Geocast Based Routing Protocol

The message will be sent to all vehicles in the predefined geographical area since this protocol depends on location based multicast routing protocol. The Zone of Relevance or ZOR is the place selected for the purpose of transmission. There is no need of sending packets to the nodes that are outside ZOR. When there is packet flooding, the amount of overhead and network congestion is decreased with the help of direct flooding strategy. This protocol has different routing protocols as follows:

i) Inter-Vehicle Geocast (IVG)

When the vehicles are moving on highways [13], this protocol will broadcast messages to those vehicles. Timer based mechanism is used when messages are broadcasted in the network to obtain the current messages. Periodic broadcasting takes place to overcome network fragmentation.

ii) Robust Vehicular Routing (ROVER)

The ROVER protocol is especially designed for sending messages to all the vehicles that are present in a specific Zone of relevance [14]. Here the control packets are transmitted throughout the network and it has unicast data packets. The advantage is it depends on geographical multicast protocol. Due to redundant message, the data transfer will result in more delay is the main disadvantage of ROVER. Another disadvantage is it has more number of retransmissions and control packet overhead.

iii) Dynamic Time-Stable Geocast Routing (DTSG)

The DTSG protocol is used for sparse density networks and it is designed with two phases [15]. In Pre-stable phase, the message will be broadcasted inside the network whereas in Stable period phase, the message will be stored in intermediate node and then it is forwarded inside the network in a predefine time period. The advantage of this protocol helps to align the network density and speed of the vehicles dynamically that result in better performance. Similar to Rover protocol, it also has large number of retransmission.

4, Routing protocols based on V2I communications

To obtain the services that is provided by the road side unit like traffic data, multimedia files, maps and also to check emails and news update. The Communication takes place between vehicles to infrastructure i.e. RSU. Various protocols like Reliable routing for R2V communication, SADV, Efficient Routing Protocols for Connecting Vehicles with Internet are used.

A. Reliable Routing For Roadside To Vehicle (R2V) Communications

With the help of Internet, this novel approach is proposed to maintain the connections between the vehicles, based on Access Points (AP) in rural roadways [27]. This routing protocol will address the issues that are related to characteristics of terrain factor. When there is a lack of fixed communication infrastructure for vehicles, the only solution is to connect the Multi-hop inter vehicle communication to AP. In case of V2V communication, the warning messages will be sent from one vehicle to another vehicle without using RSUs. But in case of R2V, the message will be sent first to RSU and then it will be forwarded to every vehicle available within that communication range.

B. Static Node Assisted Adaptive Routing Protocol In VANET (SADV)

In SADV, the static nodes are placed at the intersection of roads. This node will store the packet and it will wait for the vehicle to communicate with them. The static node [28] consists of digital street map to calculate packet forwarding. There are three modules in SADV such as Static Node Assisted Routing (SNAR), Link Delay Update(LDU) and Multi Path Data Dissemination(MPDD). In SNAR, the static node will store and forward the data through optimal path. In LDU, the delay at the intersections will be measured. In MPDD, to identity the best path the packets that are arrived at the intersection will be sent to the adjacent static node. When comparing all

three modules, SNAR will forward packet to the best path, the time delay for packets is calculated by LDU and MPDD will help to reduce the delay in packet forwarding.

C. Efficient Routing Protocols For Connecting Vehicles With Internet

Here in this type of protocol, a hybrid gateway [29] is discovered to avoid the problem of high velocity and overhead. When the vehicle is in transmission range, then the communication between the vehicle and the gateway is directly established or in the other case through a multi-hop path. Here if all the vehicles are equipped with GPS then the location, speed, direction and also the future location of neighbors can be predicted. Each gateway broadcast message using geocast within a specific area. These messages contains position, speed and direction of the sender, addresses of the relay nodes, time of the expiration of the route, zone of broadcast message and the location of the gateway. From the information about the distance of gateways and the density of traffic, a zone of broadcast is defined for each gateway. This zone delimits the process of broadcasting. When vehicles receive the broadcast message it checks the timer of the message and the zone of broadcast. This mechanism reduces the problems related to the flooding of the network and also insures the selection of more stable path.

D. Vertex-Based Multihop For V2I Routing

In this protocol, a new path is identified for the vehicle to connect with the nearest AP [30]. Every vehicle has digital map and with the help of that, the shortest path between the vehicle and AP is calculated. The packet header consist the path sequence which is a predicted between the source and intersection. When the road is identified, the data transmission starts. Vehicles will exchange the beacon message with a list of their possible future neighbors. The weighted score for each current andfuture neighbor will be calculated. The weight is calculated based on the position, direction and the distance between nodes and destination (Infrastructure). Based on this, the highest weighted score is selected for carrier packet between intersections.

5, Conclusion and Future Enhancement

In our paper, a literature survey was made on various protocols used for communication in VANET. The communication in VANET takes place in two different ways Vehicle-To-Vehicle (V2V) communication and Vehicle-To-Infrastructure (V2I) communication. The existing routing algorithms used for communication between vehicle to vehicle are analyzed individually with their advantages and disadvantages. All these approaches tend to focus on V2V and require GPS. They also utilize the absolute or relative locations of each node to predict the location of a relay vehicle and/or forward messages toward the next relay vehicle or a destination vehicle. A survey is also made on V2I communication. RSU helps the vehicles to access the Internet. To increase the range and reliability of V2I, RSU provides improvement in routing for vehicles. RSU plays an important role in load balancing traffic by reducing network congestion. Thus design of an efficient routing protocol has taken significant attention. By studying different routing protocols in VANET, we have seen that further performance evaluation is necessary for routing protocol based on various traffic scenarios.

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