CHAPTER 2

REVIEW OF LITERATURE

2.1 Technical problems in VANET

VANETs are now becoming more and more popular for real application of our lives to improve Intelligent Transport System and smart areas. Though, many areas affect VANET system a lot. So there are some key practical issues that are still required to be solved.

The key problems in VANET system are given as follows. (Naja, 2013)

1. Various obstacles situated at different location are responsible for signal disturbance on nodes movement. Obstacle can be a node itself or it could be buildings located at roadside. This kind of problem generally occurs in city area. It results in reducing throughput during transmission. (Hartenstein & Laberteaux 2008)

2. VANETs doesn’t have middle controller to control various transmission, bandwidth manager, and contention or routing operation constraint. This parameter has important roles in giving QoS in routing packets from source to destination. (Fazio et al., 2011)

3. Connectivity management between all nodes for routing packets is very poor in VANET due to frequent node movement and change in topology, network fragmentations. It could be possible to overcome this by extending
time to live parameter of packets during transmission as long as possible. This task is also possible to achieve by increasing transmission power, but it cost at severe interferences and throughput deprivation. (Viriyasitavat et al., 2011)

4. Safety and privacy are important parameters. If some vehicles are trying to be mischief or intentionally clear messages transmitted through it or send some fake message with wrong traffic data which can cause terrible accidents or loss of someone lives. Privacy can be of drivers personal information or its routine life habits that can be captured by other nodes and use it for mining it. This mining will result in vehicles velocity variation, status of driver position, living habits and social relationship by malicious observers. It can later be used to threaten driver.

5. Routing protocol design is very complex as nodes are traveling very fast and randomly. It is very difficult to guarantee about successful delivery of message to destination nodes with lowest E2ED. It is serious challenge in VANETs. In this thesis, we primarily concentrated on various problems associated to routing protocols.

2.2 Routing Protocol in VANET

Lots of protocols have been designed in VANETs for routing messages from one location to other node with goal of searching best path in wireless transmission. All these protocols are classified into different categories according to its working style or application area like topology, geographic location etc. Topology based routing protocols typically store various data in routing table for vehicles links to route messages.

Some protocols are using geographic location in routing process to send packets to destination instead of using its network address. These protocols are designed such a way that each node captures other nodes location through GPS
system. Whenever source node wants to send some packets then it typically store destination nodes location in packet header which will assist it to reach to destination node without route discovery and route maintenance. Thus these types of protocols are straight forward and appropriate for large size networks like VANETs as compared to other kind of protocols. Few drawbacks are still required to overcome like how to use real time data instead of all old or past statistical data, use all data instead of using local or overall nodes data to choose routing paths runtime in all VANET scenarios.

2.2.1 AOMDV

AOMDV (Ad-hoc On-demand Multipath Distance Vector) is a multiple path expansion to the AODV protocol. In AOMDV protocols multiple paths are generated between the source and destination node. It will use other generated routes if route failure occur. In AOMDV protocols new path detection is initiated when the entire available path stop working. AOMDV advantage is to handle the load in network and stay away from the possibility of blocking and increases consistency. (Marina & Das, 2001)

R-AOMDV is an improved algorithm of AOMDV; it has two more methods in already available algorithm like number of time it perform transmission and number of hops, taking into account minimizing E2ED and performance of intermediate links. In the route discovery process is same as AOMDV. This protocol adds two more parameters to replay packets data; to compute quality of the transmission path, one of these fields is the maximum retransmission count which is computed by the MAC layer, and the other is the total hop count which is computed by the network layer. RAOMDV does not store path in route table. When a route replay packet received to the source, an intermediate node updates its retransmission count value; in case if it was greater than the current MRC. So, the source node can easily identify which path has maximum MRC. R-AOMDV protocol enhancement is achieved by reducing rebroadcast route discovery. This protocol performs better than AOMDV in both rural and city vehicular networks. (Chen & Xiang, 2009)
2.2.2 ZRP

The Zone Routing Protocol or ZRP has advantages of both proactive and reactive approaches into a hybrid scheme. Advantage is achieved in pro-active by searching a vehicle’s local neighbor and in reactive protocol by communication between these neighbors. ZRP provides a structure for other protocols. The division of a vehicle’s local neighborhood from the global topology of the entire network allows for applying diverse approaches. These local neighbors group are called zones; each vehicle may be within multiple overlapping zones, and each zone may be of a different size. The ‘size’ of a zone is determined by a radius the number of hops to the boundary of the zone. By separating the network into overlapping variable-size zones, ZRP avoids a hierarchical map of the network and the overhead drawn in maintaining this map. Instead, the network may be regarded as flat, and route optimization is possible if overlapping zones are identified. While the idea of zones frequently seems to engage similarities with cellular phone services, it is significant to point out that each vehicle has its own zone, and does not depend on permanent vehicles. (Haas & Pearlman, 2001)

2.2.3 GPSR

Greedy Perimeter Stateless Routing is an algorithm that consists of greedy packet forwarding and perimeter forwarding. Greedy forwarding is used wherever required, and perimeter forwarding is used in first will not forward. A source node must know GPS location of destination node for delivery of packets which will route the packet to the destination in greedy forwarding mode. In greedy mode, the intermediate forwarding node selects a node as next neighbor if it is closest to the destination node. Packets are indexed by their source node and their destinations node. As a result, a forwarding node can make a better optimal greedy choice in selecting a packet’s next node’s hop. A beaconing algorithm is used by nodes to know their neighbor’s positions periodically. Each node broadcast MAC address, its own identifier and position in a beacon. Greedy forwarding’s advantage is its dependence only on knowledge of the forwarding node’s immediate neighbors. This approach of
greedy forwarding has one drawback. A destination node requires a message move temporarily farther in GPS distance from the destination node to source or intermediate node. In perimeter mode, next node is selected according to right-hand rule and the packet is forwarded along to that node towards the destination. (Karp & Kung, 2000)

2.2.4 GSR

Geographic Source Routing (GSR) is position based routing algorithm. This algorithm uses its neighbor’s node location. Destination nodes information can be captured by flooding message in querying node. In this mode destination node will reply with its position in reply mode. Different variation of GSR is available which can minimize flooding of packets in networks. Performance is degraded in this routing protocol through these types of variations. GSR is NDTN routing protocol in urban area. Virtual environments are not required in this routing protocol. PDR of GSR routing protocol is low while packet overhead is moderate. (Bujari et al., 2012)

2.2.5 GPCR

Greedy perimeter coordinator routing (GPCR) is a location based protocol. It uses greedy method to forward data to destination. It also has repair mechanism using graph algorithm. This protocol is designed to improve performance of GPSR in VANET. Streets and junctions are main points to achieve advantages using graph algorithm. GPCR is divided into two modules. One is forwarding data packets using greedy techniques and second is repair mechanism of route for transmission. So other types of graph making algorithm is not required in this protocol. Greedy forwarding method of GPCR is making its decision at all junctions of map. So, it is clear that junctions are better place to forward packets from source to destination than any other place.

Position information is transmitted along with its own roles during routing process by a coordinator. If source node is not situated at any junction than that node
will route packets to another node till it reaches to another junction for routing. Whenever any messages arrives at a coordinator then it will take decision about packets that which route will be travelled by packets. Any neighboring node which has highest chances to move towards destination node will be selected in greedy approach to forward packets to destination. As an outcome, the repair technique of GPCR consists of two ways: (1) Packet should follow which street is to be determined on each junction and (2) in between junctions an atypical way of greedy forwarding method is used to forward the message to destination node. Here it is assumed that maps are not available, how to identify vehicles at junctions and to keep away from missing junction when forwarding packets through greedy method. Therefore, the major results of GPCR and GPSR are almost same, but node selection is considered after road structure.

Major decision about routing path will be taken in GPSR based on junction in maps and their connection. Though, GPCR uses data based on the vehicles density of neighboring roads and the connectivity to the target vehicle to forwards data messages. Thus, if the number of nodes in network is less then connection between vehicles is also low so it will increase E2ED and the local maximum problem goes unsolved. (Lochert et al., 2005)

2.2.6 GpsrJ+

GpsrJ+ is also a location based routing protocol. It reduces street junction node dependency. Local maxima problem can easily solved with GpsrJ+ algorithm by real binary maps. Better routing path can be calculated with better junction selection using two hop neighbours information. GPCR has better PDR than other protocol but that is sustained by GpsrJ+. The number of forwarding nodes or hops in the recovery mode of GPSR is compacted by a number of percentages. A costly planarization method is not necessary in GpsrJ+. It is not good for that kind of application which has high delay. All other city maps than grid maps are fail to apply in this protocol. This protocol follows only simple path or road for simulation while actually roads are complex than this. Therefore, the most important directional decisions are prepared at
juncti ons. When packets reach a local maximum, a point at which there is no node closer to the destination, the node switches to its recovery mode. In the second mode, messages are greedily backtracked next to the perimeter of roads. (Lee et al., 2007)

2.2.7 A-STAR

A-STAR 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. A-STAR has better recovery strategy than GSR and GPSR which is much acceptable 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. (Seet et al., 2004)

2.2.8 LOUVRE

Landmark Overlays for Urban Vehicular Routing Environments has identified greedy routing with overlay using geographic location into two parts. First part of overlay in geographic based routing with reactive strategy where node it detected based on distance of neighbor to final node of STBR or with density of network. The second part is where overlaid nodes are identified to perform geo-proactive overlay routing as it is available in GSR and A-STAR. LOUVRE belongs to the second phase. It takes note of the fact that above a given vehicular density threshold, an overlay link remains connected regardless of the vehicular spatial temporal division on the link. Therefore, by only considering superimpose links based on such mass threshold when establishing overlay paths, most paths would partially use the same overlay links. With these considerations, geo-proactive overlay routing becomes attractive as it guarantees global route optimality and reduces the delay for establishing overlay routes. The problem of this method is clearly its scalability. (Lee et al., 2008)
2.2.9 RBVT

RBVT (Road-Based using Vehicular Traffic) protocols leverages real time vehicular traffic information to make road based routes consisting of successions of road intersections that have high chance, network connectivity among them. The two protocols reactive protocol (RBVT-R) and proactive protocol (RBVT-P) are introduced and compared them with protocols representative of mobile ad-hoc networks and VANETs. Performance evaluations in urban settings show that RBVT-R performs finest in term of average PDR, with up to a 40% raise compared with few available protocols. In terms of average E2ED, RBVT-P performs finest with as much as an 85% reduce compared with the other protocols. (Nzouonta et al., 2009)

2.2.10 CAR

The Connectivity-Aware Routing (CAR) protocol divided into four main parts. They are (1) destination location and path discovery; (2) data packet forwarding along the found path; (3) path maintenance with the help of guards; and (4) error recovery. Remote Location Service is used here to locate path from one location to other location. Hello messages are regularly broadcasted by each node. Direction and speed act as velocity vector. A hello message also uses its velocity vector in searching for path. Time period for beacon packet to live during routing is updated regularly based on density of networks which work with different traffic situation. Metrics concept is used with parameters like hop count and density of neighbour. Intermediate node carry such metric which forwarding packets. Other node selects path which has highest probability of connection and minimum E2ED using information received by metrics carried out while transmission. Reply packets if transmitted back to source node based on selected path from destination node to source node with its location and sped towards source node. This property of searching a path between source and destination node is unique in CAR protocol. (Naumov & Gross., 2007)
2.2.11 VADD

As it said in VADD is a vehicular geographical based on the idea of carry and forward routing protocols that their scheme intended to improve the routing process when there is disconnected vehicular networks based on the carry and forward conception depending on the use of conventional vehicle mobility. Therefore, the most important issue is to select a forwarding path with the smallest packet delivery delay. The node creates a decision at an intersection and selects the next forwarding path with the insignificant packet delivery delay. The path is only a split road from an intersection. The best path of the packet forwarding is selected by exchanging between three packet modes (intersection, straight way, and destination). They take the advantage of the GPS information since they are in need for the location maps to determine their targeted nodes. Their main goal is to select the path with the smallest packet delivery delay. The behavior of the protocol depends on the location of the node holding the message. The main backward of these kind of protocols that since the change of the topology and the traffic so; the delay will be very large. (Zhao & Cao, 2008)

2.2.12 IGRP

In (Saleet et al., 2011) authors propose IGRP (Intersection-based Geographical Routing Protocol) where an efficient choice of road intersections through which the message must pass takes place. The choice of the road intersections is prepared in a way that maximizes the connectivity probability of the chosen route while satisfying QoS constraints on the endurable wait within the network, bandwidth usage, and error rate. Between any two intersections in the same route geographical forwarding is used so as to decrease routes sensitivity to individual vehicle movements. Compared to other protocols, IGBR achieves considerable performance. However simulations are performed in a custom discrete-event simulator in MATLAB which introduces some difficulty on direct comparisons with other simulator results.
2.2.13 MURU

The MURU (MUlti-hop Routing protocol for Urban VANETs) protocol is a multi-hop protocol based on some quality factors like speed, trajectories and position of the node and find strong path in the network. The protocol performs better in metropolitan areas and has low overhead and better in packet delivery ratio. MURU introduces a new metric called Expected Disconnection Degree for assess candidate path quality. Further, the EDD imitates the likelihood that a route would break in a convinced time phase. EDD computes the vehicle node movement trajectory and speed information and initiates the request message for route discovery. Then, in between mode, protocol estimates link quality and update the present value of path EDD. The destination node finally comes with the smallest probability of broken path. The protocol MURU uses a back off method to decrease the control overhead by suppressing avoidable control messages. (Mo et al., 2006)

2.2.14 GPSR+AGF

The GPSR+AGF protocol was proposed in as an enhancement of GPSR. The author observed two issues in GPSR, due to VANET high mobility the routing table is frequently comprised and overcrowded and second issue about position of original node and final node, which is updated in the routing table. When the source node forwards the data packet to destination, the location of the destination save in the routing table, during transmission the destination position changed due to high mobility, and this new information is not updated in the routing table. (Naumov et al., 2006)

2.2.15 GeOpps

GeOpps is a delay tolerant network routing algorithm that exploits the availability of information from the GPS in order to opportunistically route a message to a certain geographical location. It takes the advantages of the vehicles’ GPS suggested routes to select vehicles that carry the information. The model of selecting
next carrier is the neighbor vehicles that chase suggested routes to their driver's destination compute the adjacent position that they will get to the final node of the message. Then they use the closest point and their map in a convenience function that expresses the minimum projected time that this message would need in order to reach its destination. The vehicle that can transmit the packet quicker/closer to its destination becomes the next packet carrier. (Leontiadis & Mascolo, 2007)

2.2.16 CBF

Contention-Based Forwarding (CBF) (Fussler et al., 2007) is position-based unicast forwarding, without neighborhood knowledge. The forwarding decision is based on the actual position of the nodes when a packet is forwarded. The Packet is forwarded from source node to other or destination node in position based routing is done based on the local GPS location of the nodes. (Füßler et al., 2003)

2.2.17 DGR

Directional Greedy Routing (DGR) uses two types of forwarding: position based forwarding and direction based forwarding. Position based forwarding tries to discover the nearby vehicle in the direction towards the destination as the next hop. Direction first forwarding will select the nodes which are moving toward destination node. Out of all of these, the one nearest to the destination node will be chosen as next hop. DGR uses combination metrics of position based and direction based forwarding. The node which has largest weighted score among current node itself and its neighbors will be selected as next forwarding node or hop. If the current node has the highest score, it will carry and forward the packet. (Gong et al., 2007)

2.2.18 PDGR

Predictive Direction Greedy Routing (PDGR) predicts the future neighbors. The PDGR calculate the weighted score for the current node, its existing neighbors,
and probable upcoming neighbors. It uses two-hop neighbors to the generation of possible future neighbors. According to all these weighted scores, next forwarding node or hop is then determined. So PDGR has two parts. First is same as DGR and second is used for upcoming neighbors in a small period. (Prasanth et al., 2010)

2.2.19 GRANT

In Greedy Routing with Abstract Neighbors Table (GRANT), every node finds the best route from its x hop neighborhood. Next forwarding neighbor F is decided based on the node S which is N node or hop away from F and the Destination which has the shortest distance from S to F. The smallest matrix for neighbors F will be selected at the next hop. It is very necessary to select the most promising neighbor as in beacon transmitting n-hop neighbors is creating too much overhead. It divides the whole map into small areas and has one representative neighbor node per area. (Schnaufer & Effelsberg, 2008)

2.2.20 STBR

Street Topology Based Routing update algorithm of A-STAR where junction node has the information about road connectivity. A node at the junction will compute the link up to the next junction and it will find that link is up or down. This junction node is called as a master node. Master node will broadcast their link information to other master nodes. It calculates the geographic distance from current node position to the destination node, and sends the packet to next node which has less geographic distance. (Forderer, 2005)

2.2.21 TO-GO

TOpology-assist Geo-Opportunistic Routing (TO-GO) is a geographic routing protocol which uses the information from via GpsrJ+'s two-hop neighbor information and it selects the best node forwarder from the forwarding set between
the source and the destination node. The target node is next promising node other than the junction node which is normally chosen by greedy or recovery mode. (Lee et al., 2009)

2.2.22 Geographic DTN

Geographic DTN Routing with Navigator routes packets in greedy and perimeter mode. In greedy mode, a neighbor is chosen to forward a packet to the destination by choosing a neighbor which has a bigger progress towards destination node among all its neighbors. If the packet has no neighbor closer toward destination node then it will be in a local maximum situation. In this case, the perimeter mode is selected to remove packets from local maxima and later on it will return to the greedy mode. The PDR is achieved at its maximum value as long as the network is connected to all nodes. The network is connected that kind of assumption may not always be true. In sparse network mobility of VANET is high and it is common that the network is disconnected or divided into various partitions. The third mode is known as Delay Tolerate Network (DTN) mode, which can deliver packets even after the system has few nodes by taking more time to deliver packets. (Cheng et al., 2008)

2.2.23 PBRS

In Probabilistic Bundle Relaying Scheme (PBRS), communications between nodes are achieved by RSUs. RSUs cannot cover all the areas of the road in the network because of more deployment cost. Thus, communications over moving nodes are used as solutions to increase the remaining non covered areas by RSUs. The RSU transmits its message to that node which comes in its transmission range. Replicated copies of messages are produced in the network if a RSU sends its data to all the nodes coming in its transmission range. PBRS proposed a decision-based scheme on the basis of few criterions which makes RSUs decide whether or not to release its data to a node. (Khabbaz et al., 2011)
2.2.24 ACSF

Adaptive Carry Store Forward also uses RSUs to cover all the road uncovered areas same as PBRS. ACSF uses a store and forward method for transmitting a message. ACSF is focusing on the outage time of a selected node in non covered area. A message delivering techniques was proposed to reduce the outage time for nodes. The authors implemented ACSF using two RSUs partially deployed in a fixed location by making other areas are uncovered between them. RSU selects the node which probably ensures to be connected for more time period for transmission in non covered area to decrease the outage time. The outage time can be calculated by the velocity of each vehicle. Since RSU knows its transmission range and the moving speed of nodes. If nodes move out of the coverage area, RSU will select the other node with a maximum connectivity time. The node itself adjusts its speed in another area for a longer connection with a relaying node chosen by RSU. (Wu et al., 2013)

2.2.25 DARCC

Distance-Aware Routing with Copy Control determines that how to make a replica of a message or forward packet copies to the other nodes. DARCC applies this concept of Delay tolerant network routing to VANET networks. The nodes in DARCC determine whether to send data or not to other nodes with 2 principles. If the position of the final node of data is reachable, the data is transmitted to the node that is nearer to the final node. Otherwise, it prefers broadcast of data to different direction to increase the probability to reach the destination node. Each node equipped with a GPS system, thus the node can calculate its current motion vector. The MV contains speed and direction of a node. Each node regularly broadcasts a beacon packet including its position, current MV, and the list of the packets it has to transmit. If the nodes are moving in different directions, the replication helps to get the successful PDR, because the other nodes may reach before the source. (Lo et al., 2012)
2.2.26 DAWN

Density Adaptive routing With Node awareness assumes urban sensing applications. There are $N$ fixed sensors in roadside like RSU and one base station for data gathering and processing. The sensors are regularly deployed or changed according to the requirement and the base station is located at the center of the network area. The data packets are generated by the sensors, and each packet includes its original location and generation time. The vehicles and mobile nodes are more like traveling in the random cells. When the vehicles move into new cell or area then they will collect the data packet from sensors and store it in its buffer. If two vehicles meet, they replicate their packets to each other. The data forward strategy in DAWN is decided based on the density of the area. If density is low the forward strategy is the same as an epidemic, that is, a node replicates all the data it has to encounter nodes. On the other hands, if the density of cell increases, then the throughput is restricted by congestion due to the limitation of wireless channel capacity. Therefore, in DAWN the utility incremental value is proposed to give priorities to the packets. The packets with higher utility incremental values should be sent with higher priority. The utility incremental value is calculated by all nodes to increase chances of packets to be delivered to the BS before it lost. (Fu et al., 2011)

2.2.27 GeoSpray

Geographical Spray in VDTN uses the ideology of one copy with one path GeOpps to perform multiple copies with multiple path bundle routing method. Multiple copy routing schemes are used for their high PDR, a low average end to end delivery delays, and high overheads due to duplicated copies. Thus, GeoSpray uses the duplication method of the spray-and-wait protocol to bind the number of duplicated copies of transmitted data. In starting, it uses a multiple copy scheme, which spreads a few copies to locate predictable routes. Then after, it moves to a one copy forwarding scheme. GeoSpray clears the delivered bundles from nodes’ storage by propagating the release information. As a result, it achieves better PDR than
GeOpps at the cost of high duplication overhead. However, this overhead is fewer as compared to the epidemic protocol but similar to spray and wait. (Soares et al., 2014)

2.2.28 FFRDV

Fastest-Ferry Routing in DTN-Enabled VANET is a protocol which was proposed for sparse ad hoc networks to support a freeway or highway road environment where vehicles are moving at high speeds and with very few traffic lights. In FFRDV, the roads are divided into few different blocks based on geographic information. Each vehicle can get its current location by GPS and it shares its location and speed with other vehicles in the same block by hello messages. When an emergent event occurs, FFRDV selects message ferries which have the responsibility of relaying data according to velocity-based strategy. First, the vehicle which senses an event becomes an initial ferry. It selects the fastest vehicle within its block as a next ferry. Second, if the ferry enters a new block Bi, it broadcasts a hello message to find a new ferry. Any nodes, which are able to receive a new data, send a response message, including their current speed. The ferry node compares the speeds and finds the fastest vehicle $V_k$. If $V_k$ is faster than it, it sends the data to $V_k$ or it holds the data. This mechanism is performed repeatedly block by block. (Yu & Ko., 2009)

2.3 Literature Summary

In this chapter, we have reviewed a number of works related to the different design of routing protocol which are used in VANET. All protocols are designed to work in different model or on different parameters. Each protocol has their own advantages in achieving good result on parameters like PDR, E2ED, Hop count etc. Few protocols works in either urban and some works in only rural areas. It is clear from all literature review that some protocols quickly take its routing decision to route its packet to destination node in non delayed tolerant network. NDTN network needs to complete packet forwarding in small amount of time. Some protocols take more time to forward packets from source to destination node in delayed tolerant network.
Delay in packet forwarding is tolerable in DTN network. Networks with low density of nodes behave the same as DTN network while networks with high density of nodes behave the same as NDTN network. Protocol designed for DTN network performs badly in NDTN networks and vice versa. Protocol which supports both low and high density of nodes is still not designed. So it is required to design protocol which can work in both DTN and NDTN network.