Survey of Routing Protocols in Vehicle to Vehicle Communication-City Scenarios

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Abstract— Vehicular Ad Hoc Networks (VANET) is a subclass of Mobile ad hoc networks which provides a distinguished approach for Intelligent Transport System (ITS).Mainly VANET classified into two categories: Vehicle to Vehicle and Vehicle to Infrastructure Communications. In this paper we describe a survey of routing protocols in Vehicle to Vehicle communication. There are two types of scenarios: Highway and City. In this paper we discussed only Highway Scenario. This paper discusses the main 2 types of protocols for VANET Topology Based, Positioned Based Protocols. This paper discusses the advantages/disadvantages and the applications of various routing protocols for vehicle to vehicle communication. It explores the motivation behind the designed, and traces the evolution of all v2v routing protocols. Finally, we conclude that routing protocol depends on speed, position, movement and direction in vehicle to vehicle communication- highway scenarios.

General Terms: Vehicular Ad-Hoc Networks, Vehicle-To-Vehicle Communication

Key words: VANET, ITS, IVC, VRC, IRC, DSRC, FCC, GPSR, GSR, ASTAR, MFR, GPCR, GPS, AMAR, GyTAR, EBGR, BMFR, BMAR

I. INTRODUCTION

Vehicular Ad Hoc Network (VANET) is a sub class of mobile ad hoc networks which provides a distinguished approach for Intelligent Transport System (ITS). It is one kind of vehicular communication based on wireless network technology to establish the wireless ad hoc network between vehicles. It is used to reduce large number of vehicular traffic accident, improve safety, and manage traffic control system with high and reliable efficiency. Federal Communication Commission (FCC) allocated a frequency spectrum for vehicle to vehicle (V2V) and vehicle to roadside (V2R) wireless communication in 1999, (see Figure 1). The Commission then established the Dedicated Short Range Communications (DSRC) service in 2003. That communication service uses the 5.850-5.925GHz frequency band for the use of public safety and private applications.

In the future, VANET will provide safer and well-organized road and a large number of vehicular applications ranging from transport automation systems to entertainment and comfort based applications.

Mainly, three types of communication are possible in VANETs: Inter-Vehicle Communication (IVC), Vehicle-toRoadside Communication (VRC) and Inter-Roadside Communication (IRC). In IVC, communication takes place between vehicles only. IVC systems are completely infrastructure-free; only onboard units (OBUs) sometimes also called in-vehicle equipment (IVE) are needed. VRC systems assume that all communications take place between vehicle to roadside infrastructure and vehicles or OBUs. IRC systems assume that all communications take place between roadside infrastructures only. IVC systems are of great concern as most of the safety applications require communication between vehicles within no time. For IVC so many routing protocols are developed in which position-based routing protocols suits most.

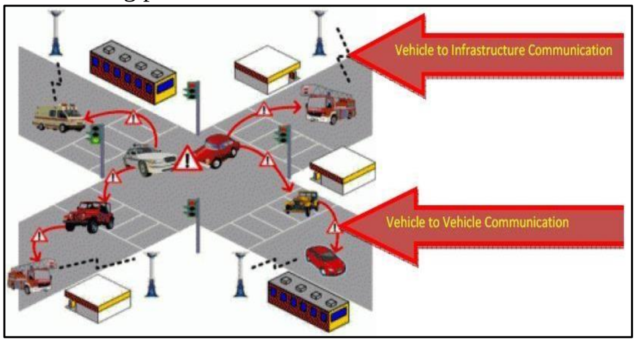

Fig. 1L Vehicular Ad-Hoc Networks [4]

VANETs has dynamically changing networking topology, finding and maintaining routes. It is very challenging in vehicle to vehicle communication-highway scenario. To facilitate communication within a v2v network, a routing protocol is used to find reliable and efficient routes between different nodes so that message delivered between them in timely manner. Routing is responsible for selecting and maintaining routes and forwarding packets along the selected routes. Routes between source and destination vehicle may contain multiple hops, this condition is more complex compare to the one hop communication. Intermediate vehicles can be used as routers to determine the optimal path along the way.

Topology-based routing protocols are not suitable for VANETs. Position-based routing protocols such as GPSR, GPCR, GSR, A- STAR, MFR,B-MFR, AMAR, BMAR, etc. are more suitable than other v2v routing protocols. In the past few years many researchers proposed variety of routing protocols.

II. FEATURES OF VANET

- The nodes in a VANET are vehicles and infrastructure unit (Like obstacle, road side unit)
- The movement of these vehicles is very fast
- The motion patterns are restricted by road dynamically topology
- Vehicle acts as transceiver i.e. sending and receiving at the same time while creating a highly dynamically network, which is continuously changing
- The vehicle density varies from time to time for instance their density might increase during peak office hours and decrease at night times.

III. VEHICLE-TO-VEHICLE (V2V) COMMUNICATION

V2V communication will be required to extend the effective range of v2v network. It is the pure ad hoc communication.

In V2V communication each vehicle is equipped with Global Positioning System (GPS), different sensor, networking device, digital map which has the road segment information, and computing device. Vehicles" sense its own traffic messages and communicate with its neighboring vehicles by broadcasting beacon or HELLO messages periodically. V2V communication uses both unicast and multi-cast packet forwarding techniques between source and destination vehicles. Unicast forwarding means that a vehicle can only send/ receive packet to/from its direct neighbors. While multicast forwarding enables the exchange of packet with remote vehicles using the intermediate vehicles as relays. In V2V communication (see Figure 2), both types of forwarding are used for different type of applications and protocols.

Fig: 2 Vehicle to Vehicle Communications [4]

The IEEE 802.11p standard is used for V2V communications in highly mobile vehicular traffic environments. Installing fixed infrastructure such as access point, base station, Internet gateways, etc. on roads acquire great expense, so V2V communication will be necessary to extend the effective range of networked vehicles.

IV. ROUTING PROTOCOLS IN V2V COMMUNICATION

Routing protocols can be mainly classified into two categories: Topology based and Position based routing protocols (see Figure 3).

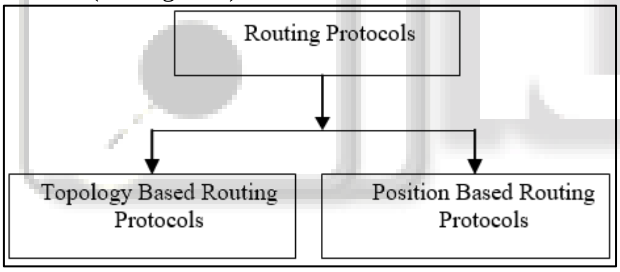

Fig. 3: Classification of Routing Protocol [4]

A. Topology based Routing Protocols

Topology based routing protocols depend on the information about existing links in the network and use them to perform packet forwarding. The topology based routing protocols can be subdivided into following categories: proactive, reactive, and hybrid protocols.

1) Proactive (Table-Driven) Routing Protocol

Proactive protocols maintain routing information about the available paths in the network even if these paths are not currently used. The disadvantage of proactive routing protocols is the maintenance of unused paths may occupy an important part of the available bandwidth if the network topology changes frequently. However, proactive protocols may not always be suitable for highly mobile networks such as VANETs. Ex. DSDV, OLSR etc.

2) Reactive (On-Demand) Routing Protocols

Reactive routing protocols maintain only the routes that are currently in use, thus reducing the burden on the network when only a few of all available routes is in use at any time. Reactive protocols consume less bandwidth than proactive protocols, but the delay in determining a route can be substantially large. Other disadvantage is that, route maintenance is limited to the routes currently in use; it may still generate a specific amount of network traffic when the network topology changes dynamically. Finally, packets can be transmit to the destination that are likely to be lost if the route to the destination changes. Ex. AODV[1], DSR[2] etc.

3) Hybrid Routing Protocol (ZRP) [3]

Hybrid routing protocol (ZRP) [3] combines both proactive and reactive approaches to achieve a higher level of efficiency and scalability. However, a combination of both approaches still needs to maintain at least those network routes that can be currently in use. Therefore, limiting the amount of topological changes, that can be tolerated within a given amount of time.

B. Position based Routing Protocols

Position is one of the most important data for vehicles. In VANET each vehicle has to know its own position as well as its neighbor vehicle"s position. Position based routing protocol can be need the information about the physical location of participating vehicles be available. This position can be obtained by time to time transmitted control messages or beacons to the direct neighbors. A sender can be request the position of a receiver by means of a location service. Position based routing protocols are more suitable for VANETs since the vehicular nodes are known to move along established paths. Since routing table cannot be used in these protocols therefore no overhead is incurred when tracing a route.

ID	Location	Speed	Current Time	Direction

Fig. 4: Element of Vehicle Hello Message [14]

In VANETs, route is composed of several pair of vehicles (communication links) connected to each other from the source vehicle to the destination vehicle. If know the current information of vehicles involved in the routes, predict their positions in the near future to predict the link between each pair of vehicles in the path. VANET is a self-organizing mobile ad hoc network in which to acquire the position information of neighboring nodes, each node time to time exchanges a list of all neighbors it can reach in one hop, using a HELLO control message or a beacon that contains its ID, location, speed, and a timestamp (see Figure 4). One of the main advantages of using position based routing protocol is that it's characteristic of not requiring maintenance of routes, which is very appropriate for very dynamic networks such as VANETs.

It is assumed that all the nodes know their position, speed and direction using any navigation system e.g. GPS. It is also assumed that the transmission range of a node is fixed. All the nodes that are within the transmission range of source node are its one hop neighbor. It is assumed that the source node has information about its neighboring nodes. Source node obtains this information through the periodic exchange of beacons or HELLO packets with its neighbors. Beacons include the position of the node, its speed, direction of motion and current time.

	Topology Based Routing Protocol	Position Based Routing Protocol
Route Maintenance	Required	Not Required
Bandwidth	Large	Not large
Forwarding Decision	Based on source node	Based on the position of destination and the next-hop neighbor.
Example	DSDV, OLSR, AODV, DSR, TORA, ZRP, etc	GPSR, A-STAR, AMAR, GyTAR, EBGR, MFR, B- MFR, BMAR,etc.

Table 1: Comparison of Routing Protocol

V. POSITION BASED ROUTING PROTOCOLS FOR V2V COMMUNICATIONS

Here, discussed about some recently position based routing protocols such as Greedy Perimeter Stateless Routing (GPSR), Greedy Source Routing (GSR), A- STAR, Adaptive Movement Aware Routing (AMAR), Improved Greedy Traffic Aware Routing (Gytar), Edge Node Based Greedy Routing (EBGR), Border Node Based Most Forward Within Radius (B-MFR) Routing, Border-Node Based Movement Aware (B-MAR) Routing specific to V2V Communications Highway Scenarios have been proposed.

A. Greedy Perimeter Stateless Routing Protocol (GPSR)

In Greedy Perimeter Stateless Routing (GPSR) [5], a node forwards a packet to an immediate neighbor which is geographically closer to the destination node. This mode of forwarding is termed greedy mode. When a packet reaches a local maximum, a recovery mode used to forward a packet to a node that is closer to the destination than the node where the packet encountered the local maximum. The packet resumes forwarding in greedy mode when it reaches a node whose distance to the destination is closer than the node at the local maximum to the destination.

GPSR recovers from a local maximum using perimeter mode based on the right-hand rule (see Figure 4). The rule states that when a node x first enters into the recovery mode, its next forwarding hop y is the node that is sequentially counterclockwise to the virtual edge formed by x and destination D. Afterwards, the next hop z is sequentially counterclockwise to the edge formed by y and its previous node (see Figure 5). While walking the face, however, if the edge yz formed by the current node and the next hop crosses the virtual edge xD and results in a point that is closer than the previous intersecting point x, perimeter mode will perform a face change in that the next hop w is chosen sequentially counterclockwise to the edge yz where the closer intersecting point was found. Such routing is called face routing because the packet traverses many faces formed by nodes in the network until it reaches a node closer to the destination than where the packet entered in the perimeter mode and where the face routing started.

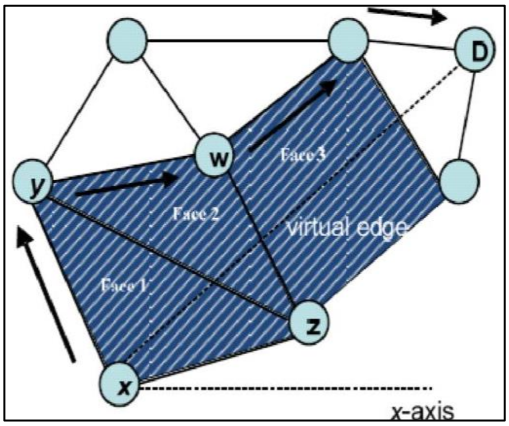

Fig. 5: Right-Hand Rules in GPSR's Perimeter Mode

If the graph is not planar, that is, there are cross edges in the graph, routing loops may occur. Consider Figure 6, x tries to reach D in perimeter mode. The packet will eventually loop around face 3 with no intersecting point closer than p. Had the cross edge ut been removed, the packet would travel the exterior face u, s, x, v, t, and w to reach D. Given that perimeter mode must operate on planar graphs to avoid routing loops, GPSR provided two distributed algorithms that produce Relative Neighborhood Graph (RNG) (Toussaint, 1980) and Gabriel Graph (GG) (Gabriel, 1969) which are known to be planar. Both RNG and GG algorithms yield a connected planar graph so long as the connectivity between two nodes obeys the unit graph assumption: for any two vertices, they must be connected by an edge if the distance between them is less than or equal to some threshold distance d and must not be connected by an edge if the distance between them is greater than d. However, the unit graph assumption is not true in VANETs due to channel fading (obstacles and mobility). As a result, planar graphs are usually hard to achieve in VANETs

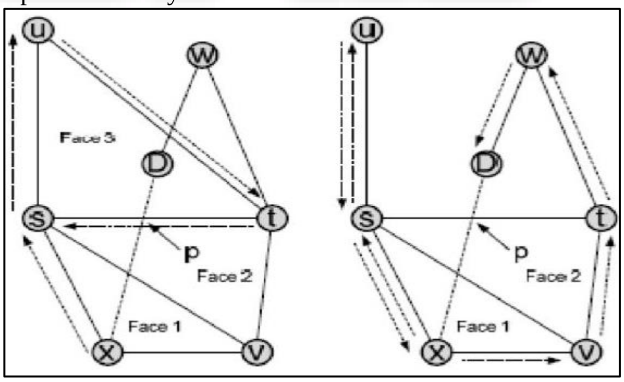

Fig. 6: Left, Packet Will Loop Around Face 3

In Right, packet will eventually route to D through u, s, x, v, t, and w F¨ußler in 2002 proposed a work to compare the results in packet delivery between GPSR [5] and DSR [2] in the highway scenario and showed that the successfully delivered packets for DSR diminish when the communication distance becomes larger. This is due to the fact that DSR needs to maintain a route from the sender. The maintenance becomes harder when the length of the route increases. GPSR packet delivery remains at close to 100% despite larger communication distance. The topology of highway favors GPSR since local maximum rarely happens on a highway. However, results of this work established GPSR to be used in a vehicular environment.

In some cases, when HELLO messages get lost due to temporary transmission errors, some vehicles become unaware of existence of its neighbors. However in any region of the network, a local maximum may occur when a forwarding node has no neighbor which is closer to the destination than itself. In this situation GPSR uses a most advance recovery strategy called perimeter routing which uses an algorithm of planer graph traversal to find a way out of the local maximum region. Although that advancement, consider only position information may lead packets to be forwarded in a wrong direction and loses therefore, good candidates that ensure its delivery. Since the topology of VANET in urban or city environment is likely to meet local maximum, we have turned perimeter mode recovery strategy on during experiments.

B. Greedy Source Routing (GSR)

As a strategy to deal with the high mobility of nodes on the one hand and with the specific topological structure of a city on the other hand, chosen a position-based routing method that is supported by a map of the city. It is called Geographic Source Routing (GSR) [6]. The presence of a map is a valid assumption, e.g., when vehicles are equipped with onboard navigation systems.

RLS is a direct translation of the route discovery procedure used in reactive non-position-based ad- hoc routing protocols to the position discovery of position-based routing. Essentially, the querying node floods the network with a „position request" for some specific node identifier. When the node that corresponds to the requested identifier receives the position request, it sends a „position reply" back to the querying node. In order to avoid extensive flooding as well as the well-known „broadcast storm problem", several optimizations have been implemented for RLS. An extensive analysis of RLS is given in [7].

With this information, the sending node can compute a path to the destination by using the underlying map of the streets. In other words, the sender computes a sequence of junctions the packet has to traverse in order to reach the destination. The sequence of junctions can either be put into the packet header – as it would be done in a geographic source routing approach [8] – or it can be computed by each forwarding node. Clearly, there is a trade-off between bandwidth consumption and required processing performance when choosing between these two options. But one can see that there are only differences in the result if a node uses information about its neighborhood, i.e., to look for connectivity breaks of a route which was chosen before and therefore recomputed another route to the destination. Forwarded a packet between two successive junctions is done on the basis of greedy forwarding since here no „obstacles" should block the way.

C. Anchor-Based Street And Traffic Aware Routing (A-STAR)[9]

Anchor-Based Street and Traffic Aware Routing (A-STAR) [9] is similar to GSR [6] in that packets are routed through anchor points of the overlay. However, A-STAR is traffic aware: the traffic on the road determines whether the anchor points of the road will be considered in the shortest path. ASTAR routes based on two categories of overlaid maps: a statically rated map and a dynamically rated map. First, statistically rated map is a graph that displays bus routes that typically imply stable amount of traffic. Dijkstra paths computed over the statistically rated map are in general connected because of the extra knowledge. A dynamically rated map is a map that is generated based on the real-time traffic condition on the roads. Road-side deployment units can monitor the city traffic condition and distribute this information to every vehicle. Thus, the difference between a statically rated map and a dynamically rated map is accuracy of road traffic; while a statically rated map is based on bus routes that typically have high traffic volume; a dynamically rated map is based on the traffic monitored dynamically by road-side units. A- STAR also proposes a different recovery algorithm when the packet gets stuck due to disconnectivity of the current path to the destination. The node will recomputed a new anchor path and the road segment where the packet is currently located will be marked as "out of service" temporarily to prevent other packets from entering into the same problem. The notification of "out of service" is piggybacked in the recovered packets. Nodes that receive the recovered packets update their map and recomputed anchor paths accordingly. The mobility model and propagation model are based on the M-Grid mobility model, a variant of the Manhattan model that considers not only the vehicular movement in a typical metropolis where streets are set out on a grid pattern but also the radio obstacles. A-STAR is compared to GSR and GPSR. Its packet delivery ratio is lower than GSR and GPSR with or without recovery as A-STAR can select paths with higher connectivity.

D. Improved Greedy Traffic Aware Routing Protocol (Gytar)

Improved GyTAR [10] is an intersection-based position based routing protocol capable to find robust routes for V2V communications within city traffic environments. GyTAR is based on anchor-based routing scheme with street awareness. GyTAR protocol has two methods for packet transmission: (i) Intersection or Junction Selection: In this method, GyTAR are uses junction through which a packet must pass to reach its destination. (ii) Improved Greedy Forwarding Method: Once the destination junction determined, the improved greedy forwarding is used to forward packets between two junctions. GyTAR are uses real time traffic density and movement prediction information to forward packet to the destination in VANETs through V2V communications. Hence GyTAR protocol uses to forward packet successfully to the destination along streets where there are large number of vehicles to provide connectivity.

E. Edge Node Based Greedy Routing Protocol (EBGR)[4]

EBGR [4] is the position based routing protocol based on greedy forwarding strategy. EBGR protocol uses unicast for sending message from any node to any other node or broadcast for sending message from one node to all other nodes in highly dynamic networks. This routing method selects the edge node of the limited transmission range as a next hop node for sending message from source to destination. In this routing method, a packet is sent to the edge node with consideration of nodes moving in the direction of the destination.

During packet transmission from source to destination, EBGR uses three basic methods: (i) Neighbor node selection method (ii) Node direction identification method and (iii) Edge node selection method. First method is responsible to collect information of all direct neighbors within the transmission range of the source node. Second method is responsible to identify the direction of moving nodes towards the direction of destination. Finally, third method is used to select edge node as a next hop node within the transmission range for further forwarding the packet. EBGR can be used to minimize number of hops between source and destination and maximizing the network throughput.

F. Border-Node Based Most Forward Within Radius Routing Protocol (BMFR)

Next-hop forwarding method like greedy forwarding scheme for linear network does not support well in highly mobile ad hoc network such as vehicular ad hoc network. Therefore, other position based routing protocols such as MFR [11], GEDIR [11], Compass routing, etc. can be used for VANET to improve its performance for non-linear network in a high vehicular density environment. These routing protocols can be further improvement by utilizing farthest one-hop node in a dense and highly mobile network. Border-node based Most Forward within Radius (B-MFR) [12] is a position based routing protocol that uses Border-Nodes with maximum projection.

The B-MFR utilizes the border-node to avoid using interior nodes within the transmission range for further transmitting the packet. This routing method selects the border-node as a next-hop node for forwarding packet from source to destination. In this routing method, a packet is sent to the border-node with the greatest progress as the distance between source and destination projected onto the line drawn from source to destination.

For this decision, border node is the best candidate in [12]. The border node is selected as the next forwarding node since the border node is the only neighbor node which is maximum away from the source node and nearest to the destination. By projecting all the border nodes on the straight line connecting the source and destination, [12] selects the one which is maximum towards the destination.

See Figure 7 node A is a border-node of source node S, since node A is positioned at maximum transmission range and has maximum progress distance SA‟ where A‟ is projection of A on SD. Therefore, A is selected as the next-hop forwarding node that node A is the next-hop forwarding node when it receives the message from S. It uses previous same method, to find the next forwarding node with greatest projected distance towards destination. In this case, node B is selected as a border node of A for forwarding packets to destination. Finally node B directly delivers the message to destination node D.

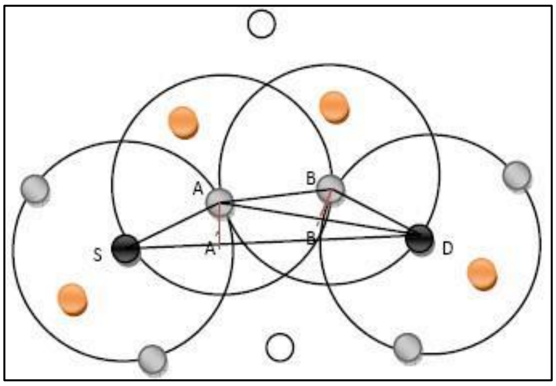

Fig. 7: B-MFR Forwarding Method [4]

1) Problem in BMFR

There is some problem in above mentioned protocol. For example (see Figure 8), border nodes A and B are projected on the line segment SD joining source S and destination D.

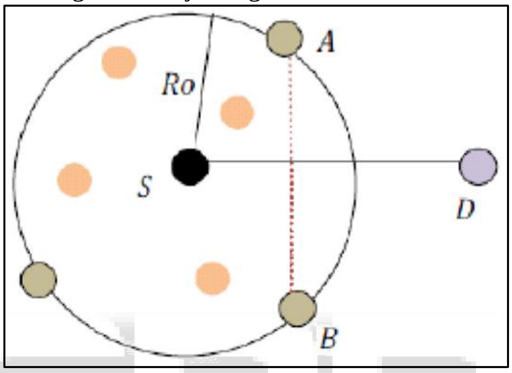

Fig. 8: Problems in BMFR [14]

Both nodes are projected to the same point on SD. Both are at the same distance from source and destination. That means, there is a conflict between nodes A and B. The decision for the next forwarding node becomes very difficult.

G. Adaptive Movement Aware Routing Protocol (AMAR)

In the greedy routing scheme, a packet is forwarded to the next-hop neighbor node by unicast manner. In this method a sender node finds the position information of neighbor nodes, and selects the neighbor node which is closest to the destination node as the next hop node. AMAR [13] is a

Movement Aware Greedy Forwarding (MAGF) based on the greedy forwarding scheme to select next-hop node towards the destination. AMAR scheme makes use of additional information about vehicle movement to select an appropriate packet‟s next-hop that ensures the data delivery. This scheme is more suitable for highly mobile vehicular ad hoc network and even it performs better in case of pure greedy forwarding failure. In this routing protocol every vehicle calculates its position, speed and direction by using the GPS or navigation system. Then after its significant role is to assign priority between neighbors while selecting a next-hop node for forwarding a packet.

The AMAR [13] protocol can be used to solve the above described problem of BMFR. This protocol makes use of additional information about vehicle movement to select an appropriate packet‟s next-hop that ensures the data delivery. In this scheme, a border node is selected out of the two conflicting nodes by making use of mobility awareness i.e. by using some parameters like speed and direction.

The basic idea of this approach is to compute a weighted score Wi which depends on three factors: the position, the speed, and the direction of vehicle nodes. The weighted score Wi can be computed by current packet forwarder for neighbor node I as follows:

$$Wi = \alpha Pm + \beta Dm + \gamma Sm$$

Where α, β, and γ are the weight of used metrics Pm, Dm, and Sm representing respectively the position, the direction and the speed factors with $\alpha + \beta + \gamma = 1$.

The AMAR movement aware greedy forwarding can be improve the data delivery and exploits the concepts of link lifetime to address the inaccuracy of traditional position-based routing and also to avoid sending data to an old neighbor becoming out of the neighbor‟s communication range.

A sorted list of next hop candidates can be defined ased on the computed score Wi: the node with the highest weighted score among all the border nodes of the current forwarder will be selected as the best candidate for next forwarding node. It also improves the data delivery.

1) Problem in AMAR

AMAR protocol solves the problem of BMFR but there is still some problem in it. Suppose that i and j are two border nodes and Wi and Wj are their respective calculated weighted score. If the weighted score of two border nodes i and j i.e. Wi and Wj are equal, again a dilemma will occur.

H. Border-Node Based Movement Aware Routing Protocol (BMAR)

BMFR uses border node as the next hop node to reduce the hop count as border node is closest neighbor to the destination. But in city scenario or in situations where traffic density is very high, probability of two or more border nodes which are equidistant from the destination increases. BMAR [14] uses the features of AMAR to resolve the conflict between two border nodes. It calculates speed and direction parameters and determines the weighted score of candidate border nodes. Then the border node which is moving with high speed and in the direction of destination will be chosen as a next hop node. Since the traffic density is high, again a conflict may occur. BMAR resolves it using the probability factor. Probability of changing the direction at intersection is high so BMAR discards the nodes with intersection in their route. If it does not suit in the situation then the node with highest successful transmissions is selected as next hop node.

VI. CONCLUSION

Vehicular Ad Hoc Networks (VANET) is a subclass of Mobile ad hoc networks which provides a distinguished approach for Intelligent Transport System (ITS).Mainly VANET classified into three categories: Vehicle to Vehicle, Vehicle to Infrastructure and Infrastructure to Infrastructure Communications. This paper discusses various routing protocols Designing an efficient routing protocol for all V2V Communication-highway scenarios‟ applications is very difficult. Hence a survey of different V2V routing protocols, comparing the various features of vehicle is absolutely essential to come up with new proposals for V2V communication in VANET. The performance of VANET routing protocols depend on various parameters like mobility model, driving environment and many more. So this paper has come up with an exhaustive survey. From the survey it is clear that position based protocols are more reliable for most of the applications in VANET. Finally, we conclude that routing protocol depends on speed, position, movement and direction in vehicle to vehicle communication-highway scenarios.

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