Mobility Management in Vehicular Networks

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***Abstract*— In mobile technology, vehicular network mobility becomes a major issue as the vehicle (node) is continuously in motion. Further, many research groups and telecom communities are working very hard to find solutions to provide robust, efficient and continuous connectivity to the end users in order to provide seamless connectivity. Furthermore, the goal of vehicular networks is to provide connectivity to the internet through which a user can be able to access the internet from anywhere without any geographical limitation and able to support different multimedia applications with high throughput efficiency and quality of service while in motion. Moreover, by the support of different application in vehicular networks enables the user to continuously aware from the traffic situations like accidents, traffic intensity and other useful information. There are two communication scenario vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) network in (VANET). In this report, we have discussed these two scenarios and its existing mobility management schemes. Further, there are some other open issues which are needed to be resolved, the main issues which we discuss is mobility in the vehicular networks and identify the best possible protocols through theoretical analysis.**

***Keywords*— Mobility management, V2V, V2I, handover, latency**

I. Introduction

Mobile communication has become an important part of our daily life. As the use of the mobile communication increases seamless communication and mobility becomes a challenging issue. In order to provide safety, transport efficiency, entertainment etc. there is a significant research in progress in the field of intelligent transport system. To achieve the desired goals and objectives VANET (Vehicular Adhoc Network) becomes an emerging technology. Vehicle to infrastructure (V2I) and Vehicle to Vehicle (V2V) is the part of VANET in which vehicle communicates with the infrastructure e.g. base station or access point and to another vehicle in the network. V2I communication is used to connect to the internet so that while in motion user can be able to connect to the internet. However, V2V communication is used for sending an alert or location information from one vehicle to another. For V2I, mobility management solution design is based on mobile internet protocol for internet connectivity. Mobility management in the vehicular adhoc networks is the challenging issue as the vehicle is continuously in motion and its speed is also varies from time to time so there should be a protocol or mechanism in order to provide high throughput, efficient and seamless connectivity to users.

Many researches in mobile networks focused on maintaining continuous communication or minimum latency to minimize packet loss so that quality of service can be provided. During the handoff process users may face the issue of dropping packets which will affect the quality of service. IPv6 is proposed as one of the protocols for mobility management in wireless network in order to minimize the latency and provide seamless quality of service. Further, IPv6 has larger address space as compared to the IPv4 so it can provide unique address to each mobile devices and it is more secure and provides more quality of service instead of IPv4 so we have focused over IPv6 rather than IPv4.

We have divided the report in 3 sections. In section 1 we have studied and described the overview of V2I and V2V protocols. In section 2 we have studied and described the comparison between the protocols with respect to packet losses and handover latency. Finally in section 3, we have analyzed the protocols graphs and figures and conclude the paper.

II. Problem Domain

As the usage of internet increases day by day, the requirement of its mobility is also increasing. The connectivity of the network should not be disconnected when the node is in motion or user / vehicle is in motion. In order to provide seamless connectivity to end-users mobility management becomes the main issue.

In this paper, we have focused on the issues related to the vehicular networks with respect to mobility as the node (vehicle) is continuously in motion. The basic theme is that a user should not get disconnected from the network even if the vehicle is changing its point of attachment and the continuous sessions remain active.

III. Problem Statement

"Can a user be able to remain connected from the network without dropping any packets and with minimum delay or latency when the node/vehicle is changing its point of attachment from one network to another?"

IV. Related Work

There are many researches related to this work have been conducted and there are more to come as this topic is related to the emerging technologies that how can we send information from vehicle to vehicle in order to avoid accidents and traffic turbulence. Further, to provide seamless internet connectivity while mobile node is in motion. In this paper we have studied all the mentioned papers and then we have compared the different proposed protocols according to their analysis and identified the best possible protocol for mobility management.

V. VEHICLE TO INFRASTRUCTURE (V2I) COMMUNICATION AND ITS MOBILITY MANAGEMENT

In V2I communication, vehicles are connected to the infrastructure i.e. base stations. V2I is used mostly for the internet access to provide the user seamless internet connectivity. Mobility management is the most important issue in order to provide seamless connectivity to vehicles since vehicles are the nodes in the vehicular network and they are continuously changing their position. Vehicles to infrastructure requires to exchange data from the internet in order to provide solution for mobility, most of the protocols are designed on the basis of internet protocol of mobility management i.e. mobile IPv6

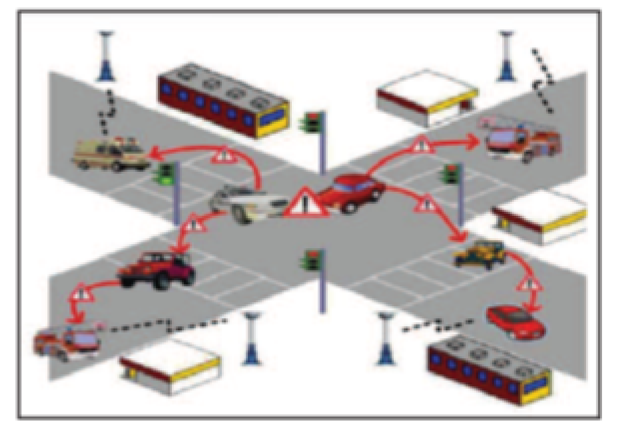

Fig 1: Basic V2V and V2I structure [14]

There are many protocols for mobility management proposed by different researchers. In this report following major mobility management protocols of V2I have been discussed:

- Mobile IPv6;
- FMIPv6;
- HMIPv6; and
- F-HMIPv6.

A. *MOBILE IPV6*

Mobile IPv6 consists of two IP addresses which are Home address (HoA) and Care of address (CoA). Further, there is a home agent whose function is to acquire the packets and deliver it transparently to the mobile node current location. The HoA is static and a permanent address which identifies the mobile node network’s origin where CoA is a temporary address used when into the foreign network a node enters and provides transparent packet transfer to the network, it also identifies mobile node current location. Moreover, Duplication address detection (DAD) is used to verify that local link address of mobile node and its new CoA is unique.

Working of mobile IPv6 is defined as when MN is moved to other network away from its current network a new CoA is assigned by new AP (Access point) or foreign agent after that DAD is executed through which CoA uniqueness is ensured. Now, in order to register the new address to its home agent the binding update (BU) message is send by MN. After the above configuration is completed the packets that are addressed, HoA of destination mobile node intercepts by home agent (HA) and then the tunnel has been established between HA and MN after which HA and packet are sent to the current CoA through the established tunnel. The operation of Mobile IPv6 is shown in figure 2.

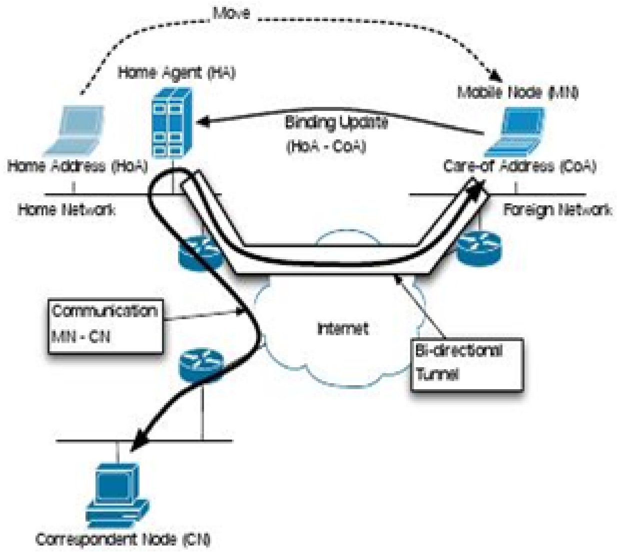

Fig 2: Operation of MIPv6

*****http://my.opera.com/blu3c4t/blog/2008/12/20/mobile-ipv6-in-briefly

The main drawback of the Mobile IPv6 is that when mobile node is far away from HA or corresponding node (CN), BU messages will travel through numerous IP networks no matter how small the movement of mobile node is, which results in larger handoff latencies. Further, without involving the home agent direct communication is possible by sending BU message to the CN but this practice adds a significant amount of load to the network.

B. *FMIPV6 (FAST HANDOVER FOR MOBILE IPV6)*

To overcome the weaknesses in MIPV6 (i.e. packet loss and large handoff latency) Fast handover for Mobile IPv6 (FMIPv6) was introduced. FMIPv6 is the advance version of MIPv6 which uses predictions and links the mobile node to the new point or network more rapidly which reduce the handover latency. This protocol is establish to reduce the time by using proactive mechanism i.e. before connecting to the New Access Router (NAR) mobile node obtain information about the NAR.

FMIPv6 exchanges multiple messages during handover between the mobile nodes. There are two types of FMIPv6 were proposed which are; the predictive and reactive fast handover [13]. In predictive fast handover mobile node can be able to forward its traffic before it connected to the NAR by sending Fast Binding update (FBU) message when it is attached to Previous Access Router (PAR). However, in the reactive fast handover approach FBU is send only when MN is attached to new access router [13].

In FMIPv6, mobile node detects the new mobile node in which it has been moved while it is still connected to the previous network. Mobile node may discover new access points by using link layer trigger mechanism and collect the subnet information from discovered access points. Two new messages Router Solicitation for proxy advertisement 'RtSolPr' and Proxy Router Advertisement 'PrRtAdv' are used to detect the movement of mobile node. By the use of PrRtAdv and RtSolPr messages mobile node generated a new CoA 'NCoA' while present in its current AP or it can be called as PAR which helps in reducing the handover latency, NAR receives the Handover Initiate (HI) from PAR after FBU is received from the MN and in response PAR receives the Handover Acknowledge (HAck) from NAR which establishes a tunnel between PAR and NAR. In response of FBU, NAR sent the FBack in order to start forwarding the traffic. Further, when Fast Binding Update (FBU) message sent to PAR (Previous access router) a tunnel is formed between NCoA and PCoA 'Previous Care of Address' and to reduce the binding update latency. Moreover, Fast Neighbor Advertisement message (FNA) is used when for some reasons mobile node not able to receive FBack message so that NCoA can still be used by the MN after announcing it attachment.

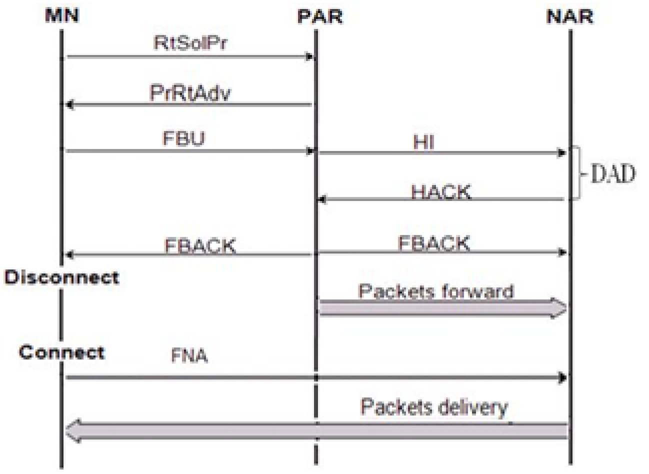

Fig 3: Operation of FMIPv6
*http://phathienhung.blogspot.com/2012/03/thu-tuc-chuyen-giao-trong-mobile-ipv4_05.html

C. HMIPv6 (Hierarchical Mobile IPv6)

Hierarchical mobile IPv6 proposed in which handover speed is improved and signaling overheads are reduced and the number of binding update messages are reduced between the mobile nodes. In HMIPv6, mobility anchor point (MAP) is added as a node which can be located in any part or level of the network and for mobile nodes it act as a home agent (HA). Further, it consist of two CoA (Care of Address) i.e. RCoA (Regional Care of Address) and MIPv6 Care of address i.e. (LCoA). MAP and RCoA has same subnet prefix which enables the mobile node to register LCoA with MAP while RCoA remain same when moving within a MAP domain. Further, RCoA helps in finding the current location of mobile node to its HA and CN.

Mobile node obtains an RCoA and LCoA when move into a MAP domain. RCoA and LCoA messages are bind together and records it in the MAP's binding cache after MAP receives the BU from a node. Further, mobile node also sends the BU message which binds RCoA and home address of MN and send it to its HA and CN. A tunnel has been formed between MAP and mobile node's LCoA after the entire configuration and messages has been exchanged. BU is required to be sent to the HA and CN when mobile node moving from one MAP to another (i.e. changing MAP).

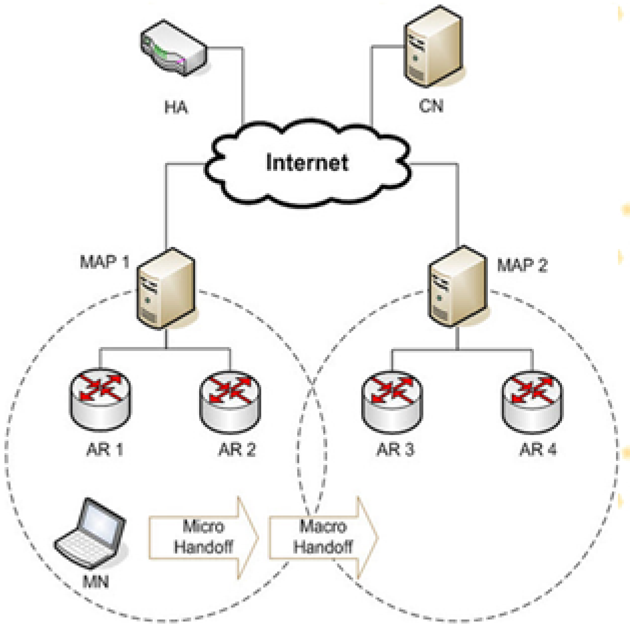

Fig 4: Operation of HMIPv6
*http://blog.naver.com/PostView.nhn?blogId=kimk345&logNo=60061051937

D. F-HMIPv6 (Fast Handover Hierarchical Mobile IPv6)

To enhance the mobility of MIPv6, FMIPv6 and HMIPv6 protocols are combined to further minimize the handover latency and provide seamless connectivity to the user which stated as F-HMIPv6. In F-HMIPv6, a tunnel between NAR and MAP is created for fast handover which enables the mobile to node to exchange the signaling messages for handover which are RtSolPr, FBack, PrRtAdv, and FBU with MAP. F-HMIPv6 uses FMIPv6 handover messages; it does not introduce or define any new messages for handover signaling purpose. In F-HMIPv6, a new flag is introduced in the HMIPv6 MAP domain which is used to indicate that when mobile node comes into the MAP domain, whether the mobile node may or may not use F-HMIPv6 within MAP domain. Further, in F-HMIPv6 MAP address is used instead of PAR because some of the FMIPv6 messages contain different source and destination IP addresses.

MN enters in the MAP it performs the same signaling messages for registration as per MIPv6 and HMIPv6, if the fast handover is required at the same time between MN and CN in an ongoing session then F-HMIPv6 is used.

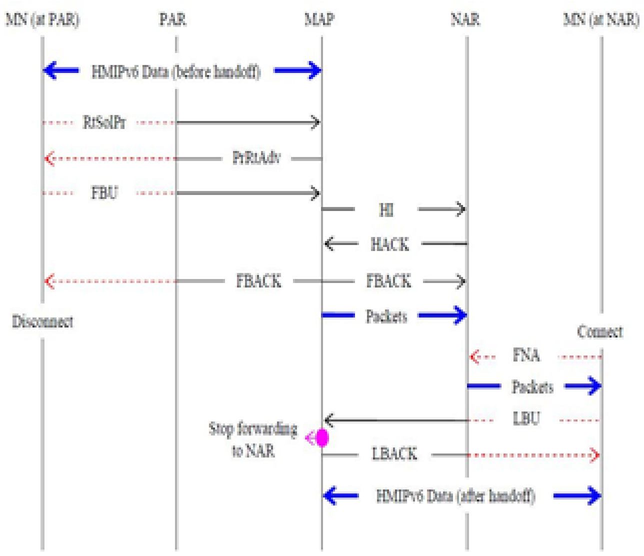

Fig 5: Basic F-HMIPv6 Operation [18]

The above figure illustrates the operation of F-HMIPv6. As shown in figure, F-HMIPv6 handover mechanism is activated when FBU is received by MAP from MN. Then, NAR receives a HI message from MAP which in response sends back the HAck message after which between MAP and NAR a bi-directional tunnel has been established. When a tunnel has been established MAP sends FBack to MN after that data start transferring between MAP and MN. FNA message is sent by MN when it moves into the link layer to NAR after which a LBU message is send to MAP, in response MAP sends back LBACK which stops the packet sending process and clear the fast handover established tunnel between MAP and NAR.

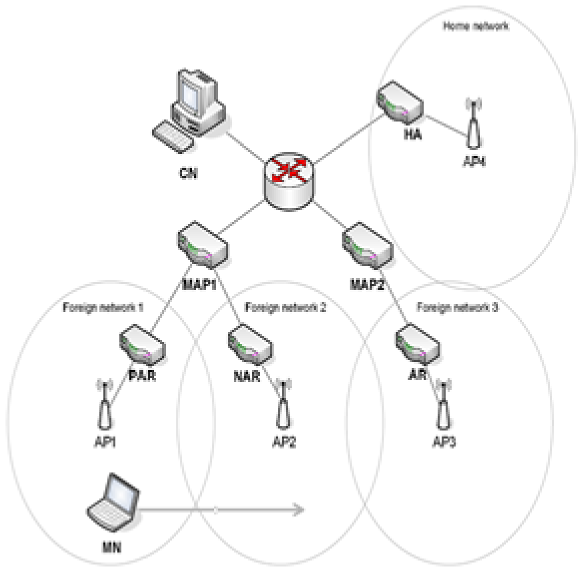

Fig 6: Basic F-HMIPv6 Operation [16]

VI. Vehicle to Vehicle (V2V) Communication and its Mobility Management

In V2V, vehicles are connected to other vehicles; it is used to transfer information from one vehicle to another to get update about the traffic and other important informations like speed of other car etc. As compared to V2I, V2V is a cost effective communication as it works on short range bandwidth. Further, V2V communications among vehicles can be direct or multihop.

There are many protocols for mobility management proposed by different researchers. In this report following major mobility management protocols of V2V have been discussed:

- Greedy Perimeter Stateless Routing (GPSR).
- Edge node Based Greedy Routing (EBGR);
- PDGR (Predictive Directional Greedy Routing); and
- Improved Greedy Traffic Aware Routing (GyTAR).

A. *GPSR (Greedy Perimeter Stateless Routing)*

GPSR uses positions of the router and make packet forwarding decisions. Further, in GPSR router gets the information about the neighbor routers present in the network. In GPSR, greedy forwarding mechanism as shown in figure [9] is used to make decisions in which it detects the neighbor node and closest to the destination and start forwarding the packets on that path and this step continues until the packet reached to the destination. However, when packet comes into the region where greedy forwarding is not possible it uses perimeter routing i.e. it routed around the perimeter of the region by using right hand rule [10] or by using planar graph [10]. Further, routing decisions are dynamically made and node only needs to remember the location information of the one hop.

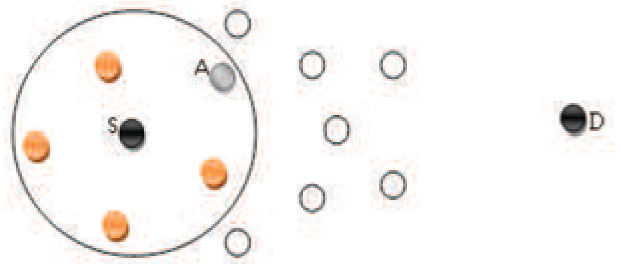

Fig 7: It shows that A is the nearest neighbor of S which is closest to D (Greedy forwarding) [14]

B. *EBGR (Edge node based greedy routing protocol)*

EBGR is position based routing protocol, it can send the messages from one node to another or to all other nodes in adhoc networks. It is designed to provide high reliability with high mobility to deliver the packets. EBGR uses an edge node in a limited communication range as a next hop node to send the messages from source to destination.

EBGR uses 3 different basic methods during packet transmission which are as follows [14]:

- The first method is used to collect the information of all nodes which are present within a communication range of the source node called identification of neighbor node;
- The second node is used to identify the node direction in which they are moving in the direction towards destination stated as identification of node direction; and
- The final and the third method is selection of edge node which is used to select the edge node within a communication range of a source node as a next hop node in order to forward the packets towards destination. EBGR

helps in minimizing the number of hops and maximize the throughput.

C. PDGR (Predictive Directional Greedy Routing)

PDGR is a prediction based position routing protocol in which the weighted score for current neighbor node is calculated and predict the possible neighbor for packet carrier. By the use of PDGR weighted score of immediate node which may be 2 hops away can also be calculated. Hence, the selection of next hop is based on prediction so it is not a reliable mechanism at all cost. PDGR cannot guarantee the packet delivery which is present in the communication range which may leads to high packet loss and frequent network disconnection. Further, PDGR may makes too many hops for communication as it is a prediction based routing protocol and in high traffic intensity large delay or latency will occur.

D. GyTAR (Improved greedy traffic aware routing protocol)

GyTAR is based on geographical position routing protocol; it helps to find routes within a city traffic environments. GyTAR is like GPS (Global Positioning System) it monitors the real time traffic variation and it can also get information about the vehicles speed and directions. GyTAR uses two methods for transmission of packets which are:

- Intersection or junction selection; and
- Improved greedy forwarding.

The first method is used in which GyTAR uses a junction in order to reach to its destination packet must pass through the junction. The second method is used when a junction is selected for sending the packets towards destination the improved greedy forwarding method is used to forward the packets between the junctions. The term junction in GyTAR is referred as a point where two or more roads are meeting together. Each vehicle maintains the information about the velocity, direction and position of each neighbor vehicle in a table which is updated by all vehicles via messages which are exchanged periodically. GyTAR can be used to forward packets successfully where large number of vehicle requiring connectivity. Each vehicle can analyze the location of the neighbor vehicle by using the saved information in the table and pick the closest neighbor with the destination. GyTAR protocol is helpful in providing connectivity to large number of vehicles in forwarding the packets

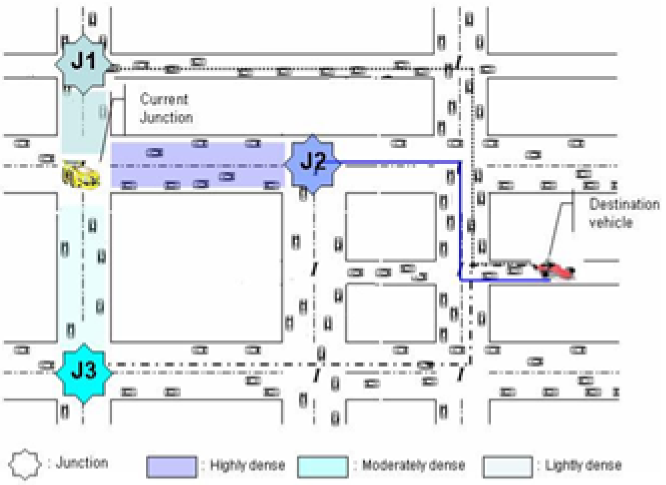

Fig 8: Junction selection (send packets to destination vehicle) [14]

VII. Analysis of V2I and V2V Mobility Management Protocols

We have studied the following graphs and figures obtained from different sources in order to identify the best possible mobility management protocol from the above mentioned V2I and V2V protocols. In this section we have studied the comparison graphs and figures of V2I and V2V protocols. Details are shown below:

A. V2V protocols Analysis

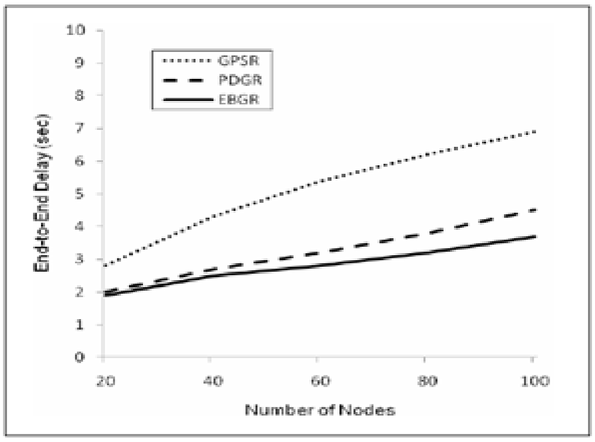

Fig 9: Delay vs Nodes number [17]

From figure 1 in which end to end delay is compared with increase number of nodes between GPSR, PDGR and EBGR, as we can clearly see that end to end delay of GPSR increases rapidly as compared with other protocols because with the increase of number of nodes GPSR start uses perimeter routing mode which increases the delay. But PDGR shows low end to end delay as compared to GPSR because when number of nodes increases, PDGR will forward the packets more easily however as it is a prediction based routing protocol so it is not reliable at all situations. As compared to other two routing protocols i.e. PDGR and GPSR, EBGR efficiently outcomes the other two protocols as it shows minimum delay and work efficiently with increase number of nodes.

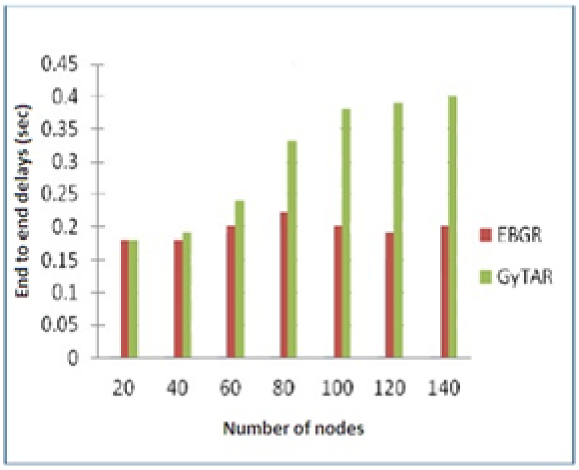

Fig 10: Delay vs Nodes number [14]

In this figure comparison of two protocols i.e. GyTAR and EBGR about end to end delay with number of nodes has been shown. From this figure we can clearly see that as the nodes increases the delay of GyTAR also increases while there is a slightly change in the delay of EBGR with increase of number of nodes. This concludes that EBGR outperforms the GyTAR protocol in terms of delay.

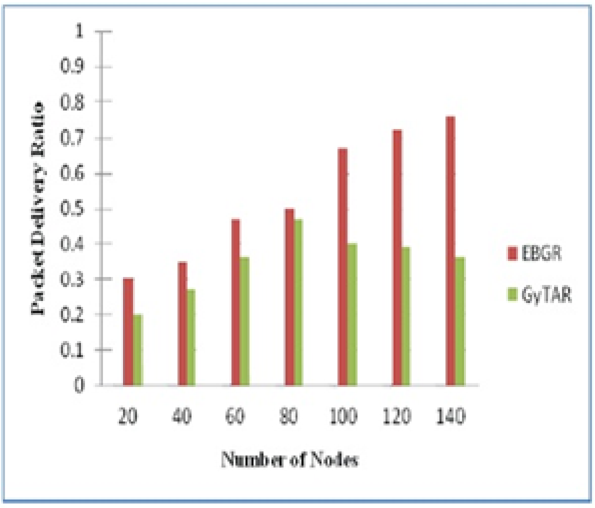

Fig 11: Ratio of packet delivery Vs Nodes number [14]

In this figure, comparison of two protocols with respect to packet loss and nodes number between GyTAR and EBGR. As we can see from this figure that ratio of packet delivery increases of EBGR when the nodes number increases however, GyTAR delivery ratio of packet increases till 80 and then starting to reduce as nodes number enhances. So we can clearly see that EBGR outperforms GyTAR in this figure.

So as per above analysis we can put it in table as:

Protocol	Hop Count	Delay or latency	Packet delivery rate
GPSR	High	High	Low
EBGR	Low	Low	High
GyTAR	Medium	High	Low
PDGR	High	High	Low

B. V2I Protocols Analysis

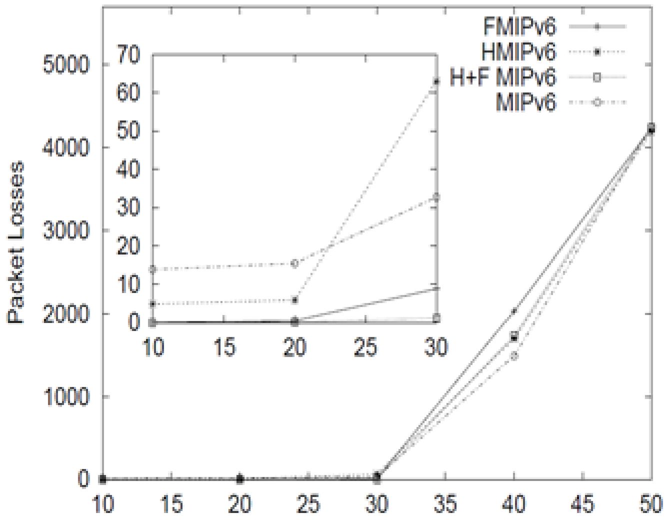

Fig 11: Packet Delivery ratio vs Number of stations [11]

In this figure V2I protocol comparison is shown in terms of packet losses with increase in number of stations. From above figure we can see that as the F-HMIPv6 outperforms the other protocols in terms of packet losses till 30 stations but as the number of stations increases all protocols changes their behavior and in the end number of packet losses are same of all protocols.

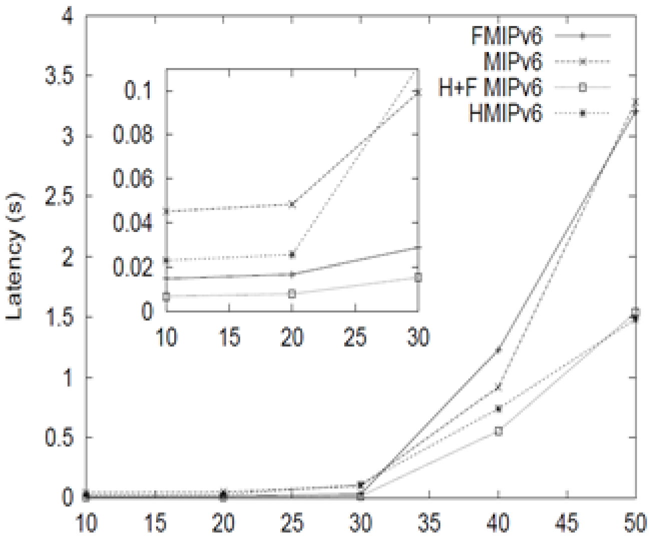

Fig 17: Latency vs Number of stations [[]

From above figure we can see that the F-HMIPv6 outperforms all other protocols in terms of latency till 30 stations but as per the number of stations increases all protocols changes their behavior and in the end HMIPv6 and F-HMIPv6 outperforms the other two protocols. Further, HMIPv6 shows slightly better latency than F-HMIPv6 due to the buffering packet mechanism due to fast handover.

Further according to the Hsieh and Seneviratne handover latencies has been shown which are:

Protocol	Handover Latency
MIPv6	814
FMIPv6	358
HMIPv6	326
F-HMIPv6	270

There is also another figure presented by Gwon et al. which are:

Protocol	Handover Latency
MIPv6	1300
FMIPv6	200
HMIPv6	300-500
F-HMIPv6	200-400

So as per above protocol comparison in terms of latency and packet losses we can write it in table as shown below

Protocols	Handover latency	Packet losses
MIPv6	Very High	High
FMIPv6	Low	Low
HMIPv6	Low	Low
F-HMIPv6	Low	Low

VIII. CONCLUSION

The Mobile IPv6 is the main or key to provide seamless communication between mobile or fixed network as the demand of internet connectivity is increasing whether it is wired or wireless. However, typical Mobile IPv6 cannot provide the seamless connectivity or fast handover as handover latency is very large so many researches proposed different protocols for mobility management.

In this paper we have discussed existing different V2V and V2I communication mobility management solutions and discussed their pros and cons. After studied the analysis of different protocols and compare them according to their performance i.e. latency and rate of packet delivery. We conclude that F-HMIPv6 is currently a better protocol as compared to other studied protocols for mobility management in V2I network and for V2V EBGR is the best possible position based routing protocol for mobility management. Further, there are some other open issues other than mobility management such as quality of service, security etc. underway to provide robust and seamless connectivity to end users. Moreover, in this report there is also a NEMO protocol which is the latest protocol among the mentioned protocol on which researches are currently underway to make it better and robust to provide better connectivity to end users.

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