A Comparative Investigation of Factors affecting the Performance of Mobility in IPv6 environment

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Abstract- The huge development in the field of wireless and communication technologies encourages the use of handheld mobile devices. These devices are capable to provide seamless services to mobile users with multiple wireless network. The Internet Engineering Task Force (IETF) suggested host-based and network-based protocols as a mobility management solution. This paper carried out extensive research on existing mobility management protocols and qualitatively analyzed the various Quality of Service (QoS) parameters such as registration delay, handover delay, packet loss, etc. in host-based as well as network-based mobility management protocols.
Keywords – MIPv6, FMIPv6, HMIPv6, PMIPv6, FPMIPv6, Packet Loss, Handover Latency.

I. INTRODUCTION

Recently technological growth has made the world to become mobile. People have started communicating using wireless enabled devices such as Mobile phones and laptops. Most of these devices are used to communicate over the wireless networks, which allow users to be mobile; this trend has introduced the concept of mobility, which allows users to communicate anytime anywhere. For seamless IP mobility, researchers have proposed numerous solutions. In IPv6, mobility is categorized as host-based [1] and network-based mobility [4]. For seamless access to the Internet during change of location, a Mobile Node (MN) creates a new connection to Access Router (AR) through Access Point (AP). Since, the AP's have limited coverage area, MN can attaches to any authenticated access point to get uninterrupted services. The movement from one AP to another known as Layer-2 (L2) or Data Link Layer handover. Among these mobility solutions, the Mobile IPv6 (MIPv6) [1] first protocol introduced by Internet Engineering Task Force (IETF) as host based mobility management solution. In MIPv6, the MN is responsible for initializing and maintaining the signaling overhead. Subsequently, A number of solutions such as Fast Mobile IPv6 (FMIPv6)[2], Hierarchical MIPv6 (HMIPv6)[3], Fast Hierarchical MIPv6 (FHMIPv6) etc. suggested by IETF. As an extension of MIPv6, Network-based Localized Mobility Management (NETLMM) proposed Proxy Mobile IPv6 (PMIPv6)[4] and standardized by IETF in 2008. Before proposing the protocol, IETF described the common local mobility problems and situations in localized mobility domain in the Problem Statement for Network-Based Localized Mobility Management (NETLMM) [16]. The document described where network based mobility management protocols are advantageous and problems associated. In another document [17] describes more comprehensive solutions and goals of network based approach. Here gap analysis with host based mobility approach is also given. In network-based mobility management, network devices like Local Mobility Anchor (LMA) and Mobile Access Gateway (MAG) are responsible for signaling overhead. The MAG is responsible for movement detection of MN movement along with commencement of mobility related signaling. During review a deep qualitative investigation on various IPv6 enabled protocols is performed. For investigation a number of parameters are chosen that affects the mobility management.

Rest of paper is organized as follows: section II deals with literature review. In section III, working qualitative analysis of various mobility management protocols and at last, paper is concluded in section IV.

II. LITERATURE REVIEW

In this section various IPv6 enabled protocols are discussed.

2.1 Mobile IPv6 (MIPv6)-

To provide transparent mobility MIPv6[1] uses two IPv6 address named as Home Address (HoA) and Care-of Address (CoA). The HoA is always static and CoA is aggined each time when MN moves from one network to another. MIPv6 dynamically binds CoA and HoA on change of network at Home Agent (HA). Figure 1 shows registration process in MIPv6.

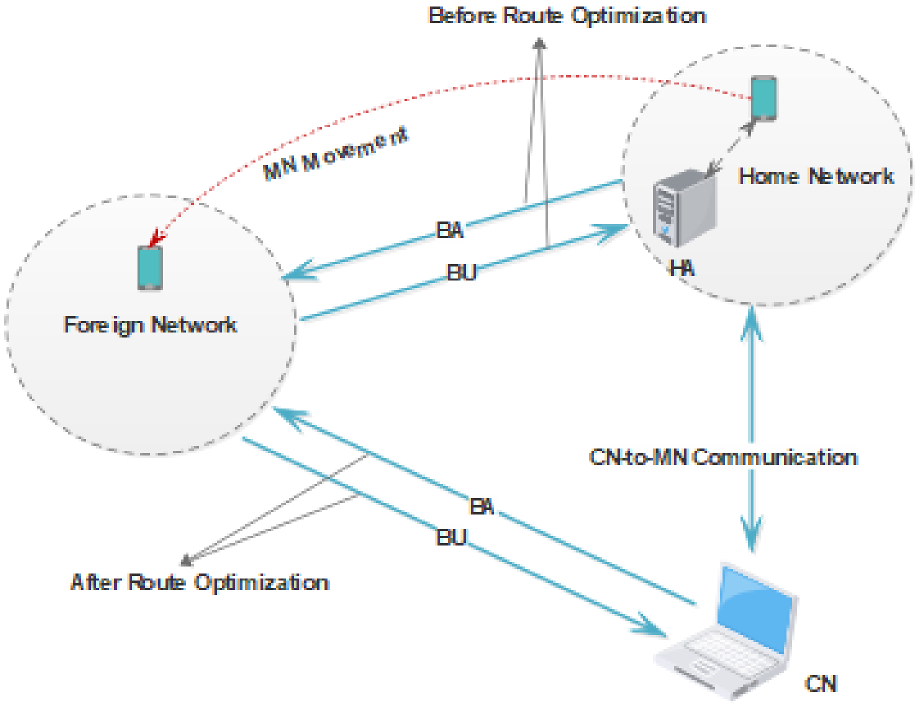


Figure 1: Registration Process in MIPv6

The steps in registration process are as follows:

1. MN performs Duplicate Address Detection (DAD)[15] for uniqueness of configured IP address and sends Binding Update (BU) message to HA to update binding cache entry in HA.
2. HA informs back about successful registration to MN by sending Binding Acknowledge (BA) message.
3. Now the messages from Corresponding Node (CN) are redirected to MN by HA after encapsulation to CoA as per entry in binding cache. This process is known as triangular routing and responsible for wastage of bandwidth [10].
4. To overcome from triangular routing, the MN uses Return Routability Procedure (RRP). For this, MN verifies the trustworthiness of CN by exchanges four messages Home Test Init (HoTI), Home Test (HoT), Care-of Test Init (CoTI) and Care-of -Test (CoT).
5. Once the credibility is verifies the MN sends BU message coning CoA to CN and CN replies back to MN by sending BA message after updating its binding cache entry. Now the MN and CN can directly communicate without involving HA in communication.

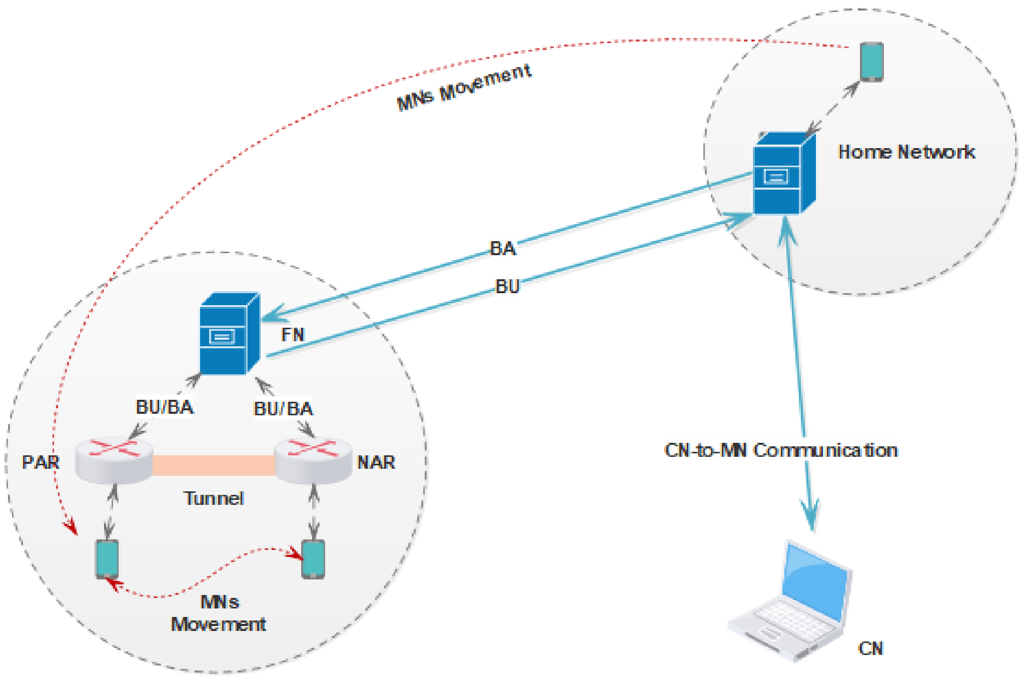
MIPv6 suffers from handover latency, signaling overhead packet loss [12] etc. The major cause of it is DAD. To overcome from signaling overhead and packet loss the IETF proposed FMIPv6 as discussed in next section.

2.2. Fast Mobile IPv6 (FMIPv6)

FMIPv6 [2] has been projected by IETF as an extension to MIPv6. It supports the mobility management with improvement in the performance of MIPv6. In FMIPv6, this can be accomplished by improving the Access Routers (ARs) capabilities for sending the fast binding update message between the previous access router and the new access router. In this process, mobile node is available for sending and receiving the packets, once it is attached to the new network link. FMIPv6 protocol works into two modes, one is predictive mode and another is reactive mode. FMIPv6 supports two modes of handover. These are predictive mode and reactive modes. Predictive mode works when MN is moving slowly and going to the range of New Access Router (NAR). In this mode packet loss is very less by buffering the packets at Previous Access Router(PAR). Following steps are involved in Predictive FMIPv6:

1. When handover is initiated in this mode, Fast binding update message is sent by the NAR to the PAR.
2. The FBU contains the new CoA. The PAR extracts this new CoA and binds this CoA with current CoA. This new CoA is used for forwarding the packets to NAR.

3. After Receiving the FBU message PAR sends the handover initiate (HI) massage to NAR. The NAR reply to PAR by handover acknowledgement (HAck) packet.
4. After this fast binding acknowledgement (FBack) is sent from PAR to MN. Now PAR can forward the buffered packets to NAR.

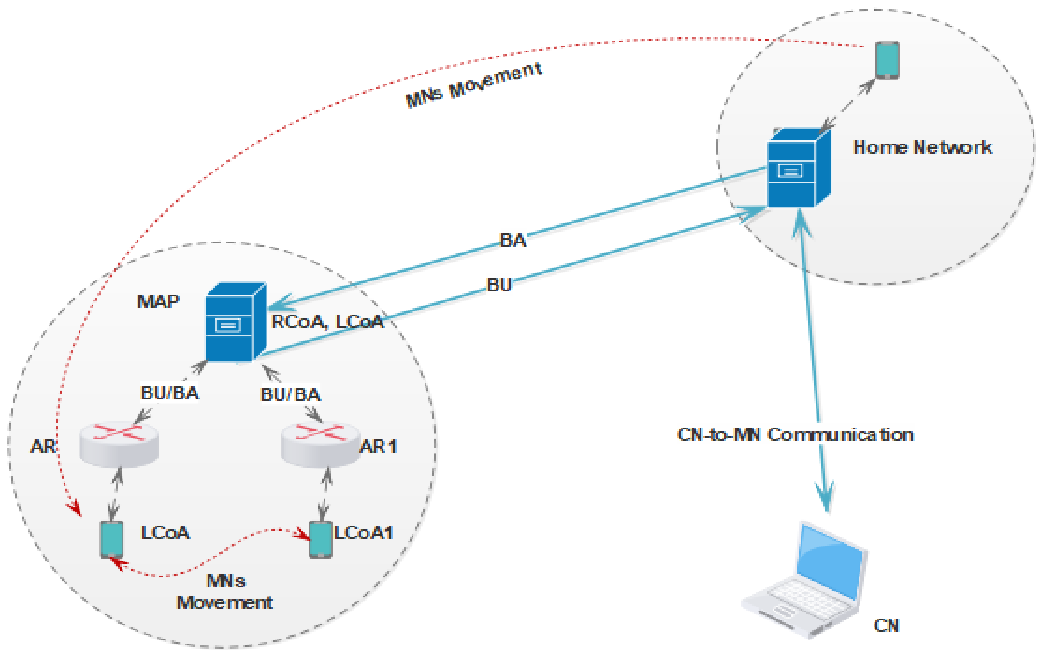


Figue 2: Registration Process in FMIPv6

The other mode of FMIPv6 is called reactive mode in which MN moving fast and unable to receive the FBAck message. In this mode MN can have left the PAR. In this case after attaching with NAR, MN send the FBU again to the PAR. Now tunnel is established between PAR and NAR and NAR will reply to the MN with FBack.
FMIPv6 improves registration process delay but still suffers from handover latency [7], signaling overhead packet loss etc. The major cause of it is DAD. To overcome from signaling overhead and packet loss the IETF proposed HMIPv6 as discussed in next section.

2.3. Hirarchical Mobile IPv6 (HMIPv6)
HMIPv6[3] is also an extension of MIPv6. It uses a special entity known as Mobility Anchor Point (MAP) and works as a proxy server. MAP works same as HA inside the domain and responsible to keep track of mobile node. Steps involved in HMIPv6 are as follows:

1. When a mobile node enters into a new network, it will keep track by two special addresses known as Regional care of address (RCoA) and Local care of address (LCoA).
2. Only RCoA has been sent to the HA agent through the binding update. RCoA will not change, till mobile node is roaming within the same mobility domain.
3. When mobile node changes access router with in the domain only LCoA is required to changes at MAP. It can be accomplished by sending BU to the MAP.
4. MAP is managing the locally the inter domain movement and has reduced the handover latency [9] and signal overhead.
5. If domain is changes, BU is sent to the HA for updating the RCoA.



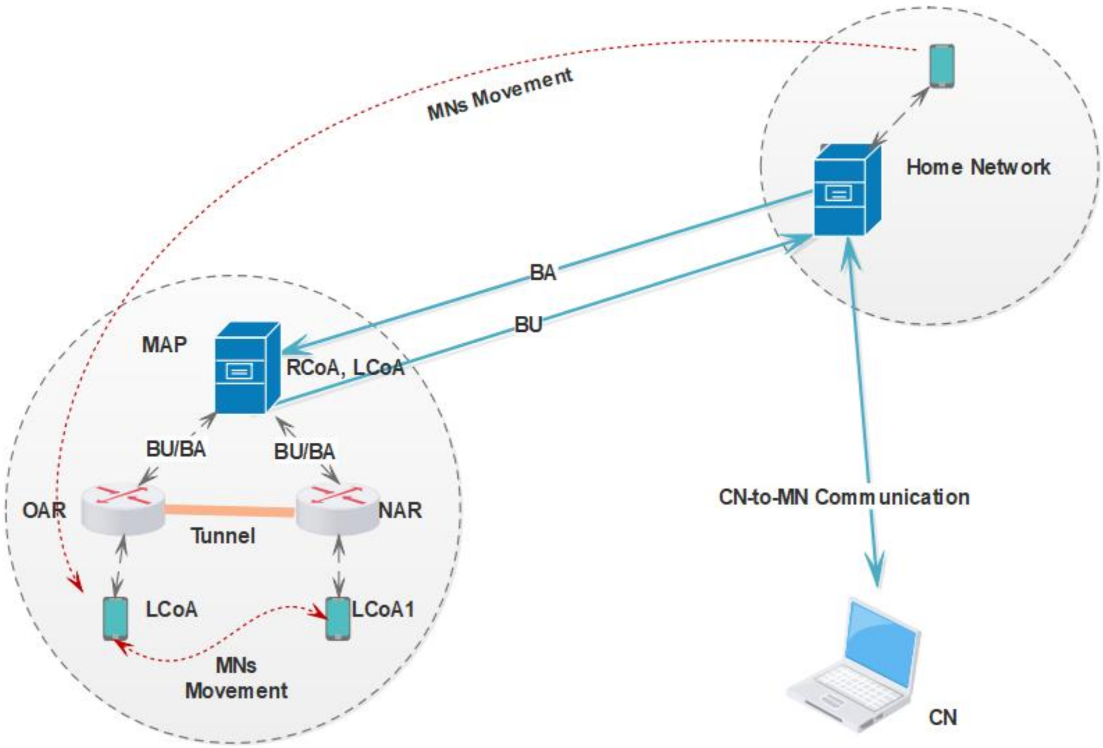
Figue 3: Registration Process in HMIPv6

HMIPv6 improves registration process delay [11] but still suffers from handover latency, signaling overhead packet loss etc[6]. The major cause of it is still DAD [15]. To overcome from signaling overhead and packet loss the IETF proposed FHMIPv6 as discussed in next section.

2.4.Fast Hirarchical Mobile IPv6 (FHMIPv6)

FHMIPv6[18] is an efficient and optimize approach. It combines the benefits of FMIPv6[2] and HMIPv6[3] protocols. FHMIPv6 uses similar process as in HMIPv6 in handover to reduce the binding update delay and signaling overhead time. On the otherhand, FHMIPv6 uses similar process as in FMIPv6 to plummeting the MN arrival finding latency and new CoA configuration delay. Following steps are used in FHMIPv6:

1. In FHMIPv6, MN sends the FBU to the OAR (Old Access Router), as MN experiences the signals are less than threshold value.
2. FBU message is also sent to the OAR to MAP to inform about handover initiation process.
3. The MAP ensures about handover process with NAR using Handover Initialization (HI) and Handover Acknowledgement (Hack) messages.
4. If data packets are sent by CN to MN, before MNs registration with NAR, the OAR buffers all packets incoming packets to MN.
5. MAP send the flush messages to the OAR for confirming registration has been done successfully completed with NAR and the caches entries have been updated.
6. Now, MAP sends the FBack to the NAR with new LCoA for the MN. Meanwhile, the OAR sends all the buffered packets to the NAR.
7. Now MN is connected with NAR and now MN will do all the communication through the NAR.



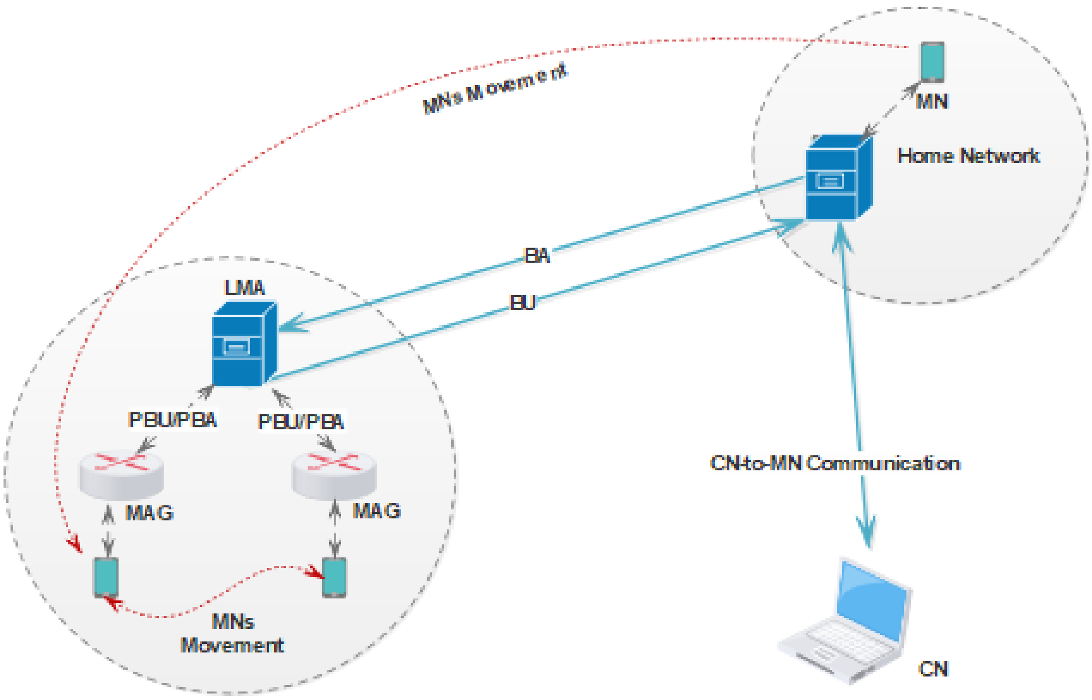
Figue 4: Registration Process in FHMIPv6

FHMIPv6 improves packet loss significantly but still suffers from handover latency, signaling overhead packet loss etc. The major cause of it is still DAD. To overcome from signaling overhead and packet loss the IETF proposed network based mobility management protocols as discussed in next section.

2.5.Proxy Mobile IPv6 (PMIPv6)

To overcome from problems associated with host based mobility protocols, IETF and NETLMM jointly proposed network based mobility management protocols. In this approach, most of the signaling overhead is carried out by network devices rather than MN. The steps handover process of PMIPv6[4] are as follows:

1. In PMIPv6, MAG has same responsibilities as AR in MIPv6. As mobile node migrates from Previous MAG (PMAG) to New MAG (NMAG) within the same locality domain.
2. The PMAG sends deregistration request of MN using Proxy Binding Update (PBU) message to the LMA. The LMA waits for a specified time interval before deregistering the MN.
3. Meanwhile, the MN gets connected to NMAG. The NMAG requests to the LMA for registering the MN using PBU message.
4. The LMA searches for MNs ID in its Binding Cache Entry (BCE) table. If entry is found, it immediately update PMAG to NMAG id. Otherwise, LMA creates a new entry for MN.
5. After successful registration LMA sends PBU messages to PMAG and NMAG about successful deregistration and registration respectively.
6. Now NMAG creates a tunnel between NMAG and LMA for communication.



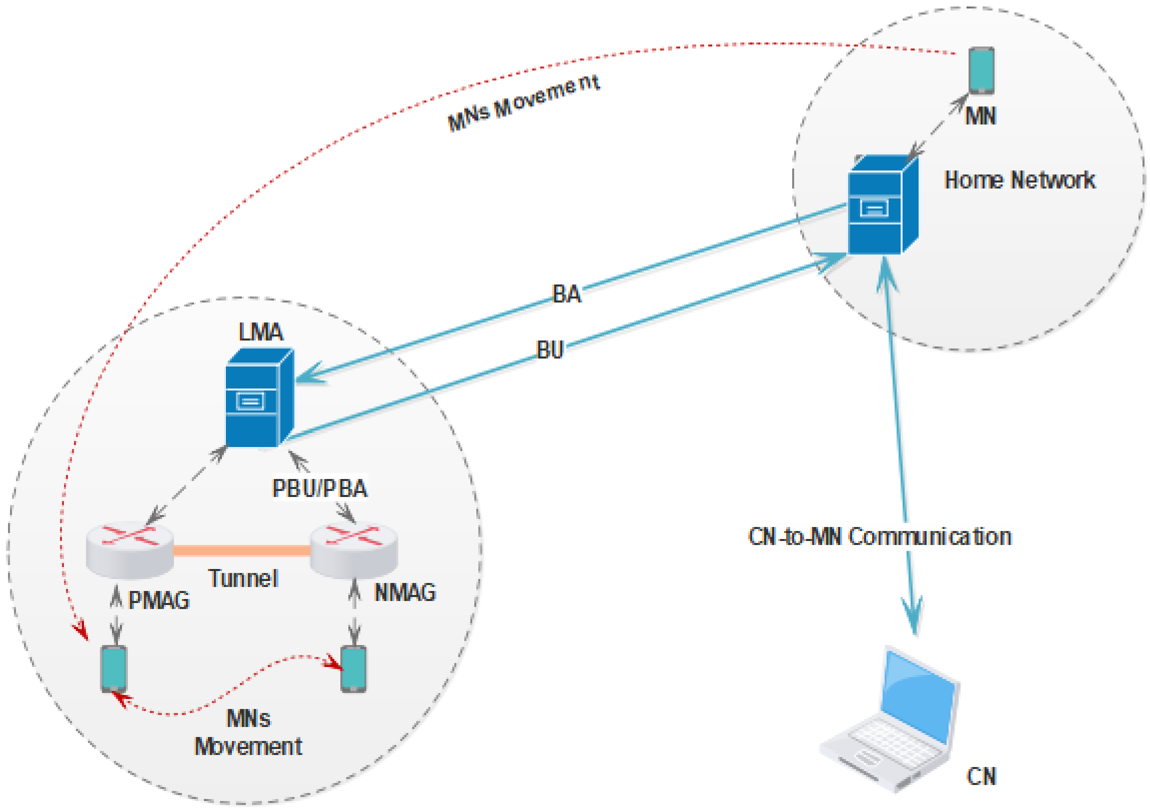
Figue 5: Registration Process in PMIPv6

PMIPv6 improves registration process delay and reduces the handover latency [8] significantly also reduces the packet loss by removing DAD process [14]. The IETF proposed FPMIPv6 as an improvement in PMIPv6 as discussed in next section.

2.6.Fast Proxy Mobile IPv6 (FPMIPv6)

FPMIPv6[5] has been developed for reducing the handover latency and avoiding the packet loss. It combines the features of PMIPv6 and FMIPv6 by establishing a tunnel between PMAG and New MAG. In FPMIPv6 handoff operates in two different modes, one is predictive and another is reactive. In predictive mode of FPMIPv6 establishes a bi-directional tunnel between the PMAG and NMAG prior to the MN's attachment to the NMAG. In the reactive mode, bidirectional tunnel establishment takes place after the attaches to the NMAG. For discussion, this paper considered predictive FPMIPv6 for discussion. The steps in FPMIPv6 are as follows:

1. The working FPMIPv6 is same as PMIPv6 with some improvement in PMIPv6. The PMAG informs about handover process by sending HI message to the NMAG.
2. The NMAG creates a new an entry for the MN and reverts back to PMAG by sending a HAck message.
3. PMAG sends handover instruction to MN containing information about NMAG.
4. MN establish connection to NMAG prior to disconnect from PMAG.
5. Meanwhile a bi-directional tunnel is also establishes between PMAG and NMAG to forward the accumulated data packets at PMAG.
6. NMAG request to LMA for MNs registration by sending MNs profile to the LMA in PBA message.
7. LMA updates its Binding Cache Entry (BCE) and revert back to NMAG after updating the BCE by sending PBA message.



Figue 6: Registration Process in FPMIPv6

FPMIPv6 is most optimized and efficient protocol among compared [13]. To show it, numbers of parameters are taken into consideration in the table 1.

III. COMPARATIVE INVESTIGATION

The mobility management protocols are classified into host based and network based protocols. Each of protocols has its merits and demerits. The performances of these protocols are investigated on various parameters as given in Table 1.

Table 1: Comparative Analysis of IPv6 enabled protocols

Protocol comparison criteria	MIPv6	FMIPv6	HMIPv6	FHMIPv6	PMIPv6	FPMIPv6
Proposed in	2004	2005	2008	NA	2008	2010
Standardized in RFC	3775	4068	5380	NA	5213	5949
Protocol Category	Host Based Mobility	Host Based Mobility	Host Based Mobility	Host Based Mobility	Network Based Mobility	Network Based Mobility
Addressing Model	Shared-prefix model	Shared-prefix model	Shared-prefix model	Shared-prefix model	Per-MN_prefix model	Per-MN_prefix model
Participating Network Entities	Home Agent	Home Agent and Improved	Home Agent, Access	Home Agent, Mobility Anchor Point	Local Mobility Anchor	Local Mobility Anchor

		Access Router	Router and Mobility Anchor Point	and Access Router	Mobile Access Gateway	Mobile Access Gateway
Handover Latency	Highest	Good	Moderate	Good	Very Good	Least
Local Routing	No	No	Yes	Yes	Yes	Yes
Support for Multihop	No	No	No	No	Yes	Yes
Domain of Mobility	Global	Local or Global	Local	Local or Global	Local	Local
Packet loss during handover	Largest	Moderate	Moderate	Moderate	Very Less	Least
Mobile Node alteration	Yes	Yes	Yes	Yes	No	No
Mode of operations	Single	Proactive and Reactive	Single	Reactive and Predictive	Single	Reactive and Predictive
Power Consumption	High	Moderate	Low	Low	Least	Least
Security	Encapsulating Security Payload (ESP), IPSec, IKE	ESP, IPSec, IKEv2	ESP, IPSec, IKEv2	ESP, IPSec, IKEv2	AAA, IKEv2	AAA, IKEv2
Signal overhead	High	High	Low	Low	Least	Least
Registration Messages	Binding Update and Binding Acknowledgement	Binding Update and Binding Acknowledgement	Binding Update and Binding Acknowledgement	Binding Update and Binding Acknowledgement	Proxy Binding Update and Proxy Binding Acknowledgement	Proxy Binding Update and Proxy Binding Acknowledgement
Strengths	Route optimization	Prior Registration, Route optimization	Localized Handover	Lesser Packet loss and handover latency	Lesser handover latency than host based and reduction in signaling overhead	Least Handover latency
Limitations	Highest Hanover Latency due to Duplicate Address Detection, More on air Tunneling overhead	Pre-registration overhead, More on air Tunneling overhead	RCoA and LCoA binding overhead, Tunneling overhead	Pre-registration and RCoA and LCoA binding overhead, Tunneling overhead	Tunneling overhead, Tunneling overhead	Pre-registration overhead, Tunneling overhead

IV.CONCLUSION

The recent development in the field of electronics and communication permits seamless services to hand handled devices. Each mobile device must be uniquely identified with an IP address. Mobile IPv6 provides a vast range of IP addresses. The paper carries out a survey on merits and shortcoming of various IPv6 enabled mobility management protocols. In 2004 and consequent years, IETF proposed MIPv6 and it’s subsequent as host based mobility management protocols. Later on, in 2008 and consequent years IETF proposed PMIPv6 and it's subsequent as network based mobility management protocols. Host based mobility family is able to provide uninterrupted services to mobile devices however sufferer from higher handover latency and packet loss. In host based protocols mobile nodes are responsible for signaling overhead and duplicate address detection is mainly responsible for delay and packet loss. On the other hand, in network based mobility management protocols, the network entities are responsible for signaling overhead. Since these devices have uninterrupted power supply and greater processing power than mobile nodes. Hence, network based protocols have lesser handover latency and packet loss.

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