An Enhancement on Mobile IPv6 : A Review

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Abstract—**The rapid growth in the number of the mobile application users nowadays has become a great challenge for the researchers to improve and enhance the performance of the technology and to ensure the smoothness when using the applications. This paper studies the Mobile IPv6 (MIPv6) protocol and their recent enhancement in order to improve the quality of service (QoS) which are Fast Mobile IPv6 (FMIPv6), Hierarchical Mobile IPv6 (HMIPv6) and Fast Hierarchical Mobile IPv6 (FHMIPv6). This enhancement has been done to reduce packet loss, handoff delay time and improve the TCP performance to provide seamless handover in mobile communication.**

Keywords-MIPv6; FMIPv6; HMIPv6; FHMIPv6; Buffer Management

I. INTRODUCTION

Internet usage is very important services nowadays because of its advantage that can save time, energy, resource and also operational cost. Today, internet not only can be accessed from personal computer, but also mobile phone can be use to surf the internet. The rapid grow of the mobile devices technology gives a big challenge to system developer to generate sophisticated and reliable application for their consumer.

The increasingly grow of internet users has create a new trend where consumer always use mobile application to interact with their friends on social websites, doing online banking transactions and others. The expansion of mobile internet users sooner will fully consume all available addresses in IPv4. As for this reason, addresses in IPv6 will compensate the shortage of IPv4 address for a greater number of users and support latest technology.

Mobile IPv6 (MIPv6) is the enhancement from the previous version, Mobile IPv4 (MIPv4) that will deal with real time application. The increasing usage of application on mobility device nowadays have made packet transfer should be done with more efficient especially when dealing with the real time application because minor loss of data in the real time application could cause the system experienced failure.

The rest of the paper is organized as follows: section 2 describes protocol overview of the current enhancement has been done to overcome the drawback cause by the MIPv6, section 3 explains the various buffer management scheme in the recent enhancement and section 4 concludes this paper.

II. PROTOCOL OVERVIEW

This section explains the current enhancements that have been done to overcome the problem arise from the existing MIPv6 protocol.

A. FMIPv6

FMIPv6 was proposed to reduce handoff latency and minimize service disruption during handovers regarding to MIPv6. It can also reduce the configuration latency of Care-of Address (CoA) and packet loss [1]. There are two mechanisms in FMIPv6 which are predictive fast handover and reactive fast handover [2]. Predictive fast handover means the handover process is initiated after the Mobile Node (MN) being attached to point of attachment [3] and handover that use this reactive ways cannot overcome the connection disruption and packet loss when handover procedure happens. The link layer information (L2 trigger) is used either to predict or respond to handover events.

FMIPv6 uses pre-registration mechanism that means the new CoA is configured before the L2 handoff occur [4]. When MN detects its movement towards new Access Router (NAR), it exchanges Router Solicitation for Proxy (RtSolPr) and Proxy Router Advertisement (PrRtAdv) messages with the previous Access Router (PAR) using L2 trigger in order to obtain information about NAR and to configure a new CoA (NCoA). After that, the MN sends a Fast Binding Update (FBU) to PAR in order to associate previous CoA (PCoA) with NCoA [5]. A bi-directional tunnel between PAR and NAR is established to prevent routing failure with Handover Initiate (HI) and Handover Acknowledgment (HAck) message exchanges.

The Fast Binding Acknowledgment (FBAck) message is use to report status about validation of pre-configured NCoA and tunnel establishment to the MN. Moreover, the PAR establishes a binding between PCoA and NCoA to tunnel any packets destined to PCoA towards NCoA through NAR's link. Then, the NAR buffers these forwarded packets until the MN attaches to NAR's link. The MN announces its presence on the new link by sending Router Solicitation (RS) message with the Fast Neighbour Advertisement (FNA) option to NAR. Then, NAR delivers the buffered packets to the MN. The sequence of messages used in FMIPv6 is illustrated in Figure 1 for MN-initiated handoff of predictive mode.

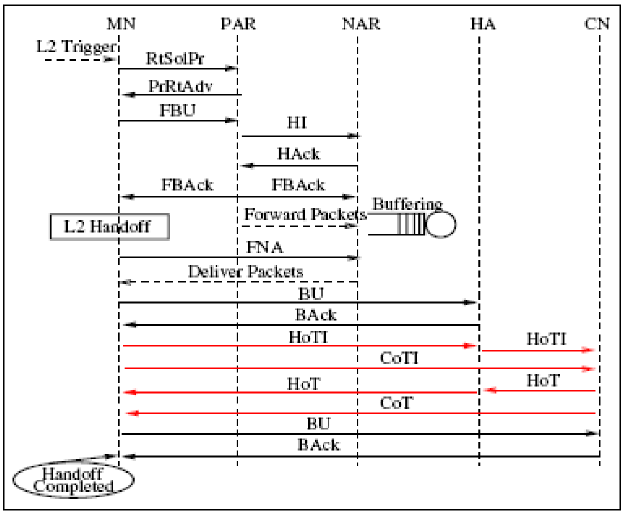

Figure 1. FMIPv6 Handoff Process [6]

[7] says that FMIPv6 is better than the normal MIPv6 protocol in two aspects; the first is FMIPv6 eliminates the delay caused by the Router Discovery, Address Configuration and Duplicate Address Detection (DAD), the second aspect is it removes delay caused by Binding Update procedures between MN, Correspondent Node (CN) and Home Agent (HA). A counterpart to predictive mode of FMIPv6 is reactive mode. This mode happens when the MN does not receive the FBack on the previous link since either the MN did not send the FBU or the MN has left the link after sending the FBU (which itself may be lost), but before receiving a FBack. Since an MN cannot ascertain whether PAR has successfully processed the FBU, it forwards a FBU, encapsulated in the FNA, as soon as it attaches to NAR.

If NAR detects that NCoA is in use (address collision) when processing the FNA, it must discard the inner FBU packet and send a Router Advertisement (RA) message with the Neighbour Advertisement Acknowledge (NAACK) option in which NAR may include an alternate IP address for the MN to use. Otherwise, NAR forwards FBU to PAR which responds with FBack. At this time, PAR can start tunnelling any packets addressed to PCoA towards NCoA through NAR's link. Then, NAR delivers these packets to the MN.

B. HMIPv6

HMIPv6 is an enhancement from the previous HMIPv4. Gateway Foreign Agent (GFA) from HMIPv4 is replaced by the new entity named Mobility Anchor Point (MAP) [8]. HMIPv6 was designed to reduce the handover latency and amount of MIPv6 signaling traffic/overhead by introducing the MAP [9-10]. MAP is a router that maintains a binding between itself and MNs currently visiting its domain [11]. Normally MAP is placed above the Access Routers (AR), to receive packets on behalf of the MN attached to that network. The MAP will limit the amount of MIPv6 signaling outside the local region. There are two types CoA that configured by MN if it is moves from its home network to foreign network which is regional care-of address (RCoA) and on link care-of address (LCoA) [10, 12-13]. RCoA is an address on the subnet of MAP.

MAP will intercept all the packet address to the MN and tunneled them to the LCoA. MN configures an RCoA when it receives a RA message with the MAP option containing MAP information. The LCoA is an on-link CoA assigned to the interface based of MN on the prefix information advertised by an access router (AR). If a MN hands off between ARs and changes its current address (i.e., LCoA) within the same MAP domain, it needs to register the new LCoA only with the MAP [2]. The RCoA is not changed as long as the MN stays within the same MAP domain. Hence, The RCoA binding update with the HA and CN makes the mobility of the MN transparent to the CN with which it is communicating. Figure 2 shows the HMIPv6 architecture.

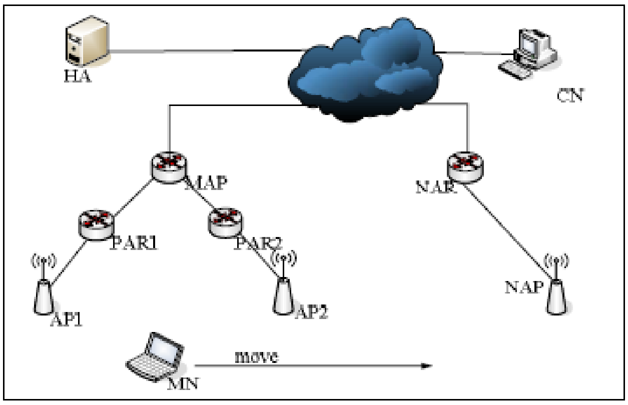

Figure 2. HMIPv6 Architecture [14]

The MN will register with the visiting region and assign the second CoA known as RCoA. If the MN moves within the region, it will get a new LCoA in the link but the RCoA remain intact. When moves to the new region, MN will get the new LCoA and RCoA and send Binding Update to all its CN. After that, MN send its RCoA to its external CN and LCoA to the MAP or its local CN. This situation different from the normal MIPv6 that sends Binding Update to the HA because sending Binding Update to the MAP can reduce the link delay, improves the efficiency of Binding Update, reduce the lost packet and make the MN more transparent under the situation of most optimized route [12]. MN must register with the MAP and send its BU containing LCoA to all local CN each time it moves within the region.

[14] says that HMIPv6 only concern with the latency due to Binding Update and does not touch the latency related to Movement Detection and CoA configuration. MAP may become a single point of bottleneck if it handles so many MN [10, 15] because MAP not only handles BU but also the encapsulation and decapsulation packets from or destined to the MN. Pack, Choi et al. [16] proposed an optimal multi-level Hierarchical Mobile IPv6 to solve the MAP bottleneck problem. HMIPv6 will cause longer handoff latency and packet loss than MIPv6 and FMIPv6 because MN has to register with two CoAs [13].

C. FHMIPv6

Fast Hierarchical handover support in Mobile IPv6 was proposed to reduce the signaling overhead and unacceptable handoff latency concerned with the Binding Update. In the F-HMIPv6 architecture, there are three types of CoA that represent the current location of the MN. The RCoA is the CoA based on the subnet of the MAP and indicates the rough location of MN, while LCoA indicates the on-link address of the MN and is divided into the previous on-link care-of address (PLCoA) and new on-link care-of address (NLCoA) [17]. Figure 3 shows the handover procedure for F-HMIPv6.

The MN initiates a fast handover procedure by using the L2 pre-handover trigger that contains the link layer address of NAR when it knows its movement toward the NAR. The MN will initiate a handover by sending a RtSolPr message to the MAP to request the information of NAR and new LCoA. After receiving the request, the MAP replies a proxy router advertisement (PrRtAdv) message that contains the network prefix of NAR.

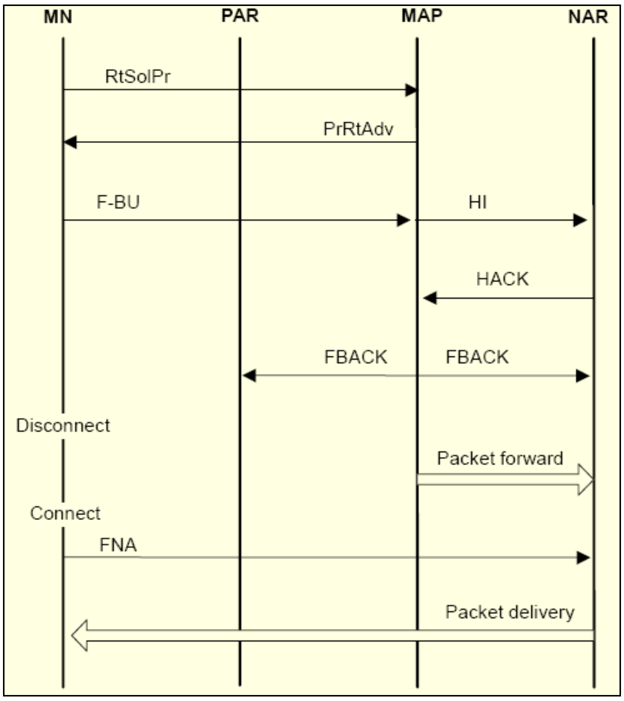

Figure 3. F-HMIPv6 Handoff Procedure [18]

MN configures the new CoA using the prefix information of the NAR. Then, MN sends a FBU containing the new LCoA. After MAP has received the FBU, it starts a handover procedure between the MAP and NAR by sending a HI message to the NAR that contains a request for verification of the new LCoA and establishment of a bi-directional tunnel between MAP NAR to prevent any routing failure during the handover. The NAR performs duplicated address detection (DAD) to verify the availability of the new LCoA. Then, NAR sends a HACK message as a reply to the HI. After that, the MAP sends a FBACK message to the MN. Finally, MN sends Fast Neighbour Advertisement to Nar to inform its presence and starts forwarding the packets to the NAR.

III. BUFFER MANAGEMENT

A. Buffer in MIPv6

[19] use packet-pair technology to control the buffered packets forwarding. Packet-pair technology is a probing technology used to probe physical or available bandwidth of a targeted path. This technology allows a source to infer the physical bandwidth in the network when the queuing discipline in router is First-In First-Out (FIFO). If a source sends two packets back to back (i.e. a packet pair), the receiver can infer the physical bandwidth for that flow from the spacing of the packet pair and the packet size.

Chou and Shin [20] claims that they manage to improve the TCP throughput up to 30%. They proposed the Last-Come-First-Drop (LCFD) buffer management policy, instead of the existing First-Come-First-Drop (FCFD) policy (to be employed by mobility agents) and post-handoff acknowledgement suppression (to be used by MNs) to improve the TCP performance. The LCFD policy will take over the FCFD policy if the handoff-induced retransmission timeout occur and packet drops cause by buffer overflow.

Lee, Fu et al. in their simulation [21] sets the buffer size of the AR larger than the send window of TCP to avoid packet loss due to the buffer overflow of link layer, which eliminates the impact of link layer factor.

Choi, Kim et al. [3] use Smart Buffering scheme to prevent packet loss by buffering packets in a current point of attachment and forwarding it to a new point of attachment after MN successfully connected without needing any information regarding the new point of attachment. Smart Buffering also manage to remove redundant packet at PAR and adjust the packet reordering in NAR.

B. Buffer in FMIPv6

Yao and Chen [22] says that buffering packet is a feasible approach to prevent packet loss during the link down time. The problem might happen when using buffer is the scalability of the buffer size itself. If the buffer size is too large, there will be delay when sending the packet into the buffer. Since not the entire packet needs the real-time transport such as WWW and FTP packet, the buffer management can make the different type of packet treated differently according to their priority to optimize the usage of buffer.

TABLE I. . BUFFER OPERATIONS

Case	Traffic Type	Buffering Operation
(1) NAR(Yes), PAR(Yes)	Real-time	Buffer at NAR only. If buffer full, drop the first real-time packet
	High Priority	Buffer at both PAR and NAR
	Best Effort	Buffer at PAR when PAR > α
(2) NAR(Yes),	Real-time	Buffer at NAR only. If buffer full, drop the first real-time

PAR(No)		packet
	High Priority	Buffer at NAR only
	Best Effort	Forward to NAR only (Do not buffer)
(3) NAR(No), PAR(Yes)	Real-time	Forward to NAR only (Do not buffer)
	High Priority	Buffer at PAR only
	Best Effort	Buffer at PAR when PAR > α
(4) NAR(No), PAR(No)	Real-time	Forward to NAR only (Do not buffer)
	High Priority	Buffer at NAR only
	Best Effort	Drop at PAR (Do not forward to NAR)

Based on Table 1, the packet is divided into three categories which are real-time, high priority and best effort. The handoff delay for real-time packet should be reduced, while the high priority packet is loss sensitive and this packet must be prevent from being dropped during handoff process and lastly best effort packet is a low priority packet that can be discarded if the buffer is full. If the status of the AR is "yes" means that the buffer for the AR is available while if the status is "no", it means that the buffer is full.

C. *Buffer in FHMIPv6*

Zheng and Wang [2] proposed FM-HMIPv6. In the procedure, MAP forward all the packet to the neighbor ARs when the link down trigger is started and each AR will buffers the packet until the handoff process is complete. This will ensure that the packet will arrive to the destination after the MN had established new connection to the NAR.

Zhang, Fang et al. [23] proposed Integrated Mobile IPv6 (IMIPv6) that combines the FMIPv6, HMIPv6, buffer management and two layer trigger. The study manages to reduce the packet loss rate, decrease the handoff delay time and reduce wireless signaling message that will save the traffic from being congested.

IV. CONCLUSION

This paper analyzes the existing schemes on solving the problems that occur during the handoff procedure. Recent improvements on the buffer management part have been discussed in this paper for further possible enhancement to resolve the drawback in the MIPv6. Future works will be proposed to integrate the FHMIPv6 protocol with the improved buffer management scheme as a solution to achieve seamless handover.

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