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Advanced Cross-Layering Algorithm for Mobility Management Architecture in Heterogeneous Wireless Networks

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Abstract

The advantage of proxy mobility management protocol over IPv6 is that it efficiently manages the latency time caused by a handover as the router on the access network takes the role of the mobility management of a mobile device instead. However, the frequent occurrences of handovers on the nested access network causes the increase of load on the MAG, which then brings about the loss of packets and delay of the handover process. Although fast proxy mobility management protocol has been suggested to resolve this problem, various implementations of the beacon or router advertisement on the wireless network and continuous research are required to provide stable multimedia traffic services.

The proposed advanced cross-layering algorithm (ACL) builds a bi-directional tunnel between MAGs, based on the mobility prediction between the access routers on the nested network, using the reverse binding mechanism to optimize the route of the packets and therefore increase the efficiency of packet forwarding.

Keywords: *IAPP, Cross-Layering Algorithm, Reverse Binding Update, Tunneling*

1. Introduction

Recently, the growing use of smart devices and advancement of mobile communications environment have gradually increased the level of needs from the wireless network users, which has led to the need for development of new converged multimedia services. In addition, the generalization of IPv6 addressing system is one of the things that must be done for future-oriented development in the upcoming ICT (Information and Communications Technologies) industry. Currently, the most popular IP mobility protocol is PMIPv6 (Proxy Mobile IPv6) standardized by the IETF NETLMM WG. While PMIPv6, a network-based mobility management protocol, has an advantage that it can efficiently manage the wireless resources since there is no need to change the structure of the stack on the device, a problem that occurs when passing redundant routes may occur due to the increase of the multimedia streaming traffic and the support for the dual-stack technology because the services of multimedia streaming supported by the PMIPv6 networking system always pass the MAG (Mobile Access Gateway) and LMA (Local Mobility Anchor).

Therefore, this paper proposes advanced cross-layering algorithm (ACL) based on reverse binding scheme for mobility prediction at L2 level and routing optimization at L3 level to reduce the RTT (Round Trip Time) and to minimize the loss of packets in the process of transmitting the contextual information residing on the network.

In this regard, this paper is structured as follows: alternative methods for mobility management, FPMIPv6 and IAPP, are explained in Chapter 2, the structure of the proposed protocols in Chapter 3, the comparison in performance with regular protocols in Chapter 4 and the conclusion on the alternatives this paper has proposed in Chapter 5.

2. Related Works and Problem

2.1. Fast Handovers for Proxy Mobile IPv6

Although PMIPv6 has the advantage that it does not engage in any signal when handover since it supports the mobility within the network domain, the problem with handling the delayed handover process due to the overhead of the data transmission between the MAG, which has taken the role in signaling instead of the mobile device, and the LMA, which acts as the home agent, still remains as a challenge to be resolved.

FPMIPv6 operates to minimize the loss of packets caused by the delayed handover when transmitting the status data residing on the network.

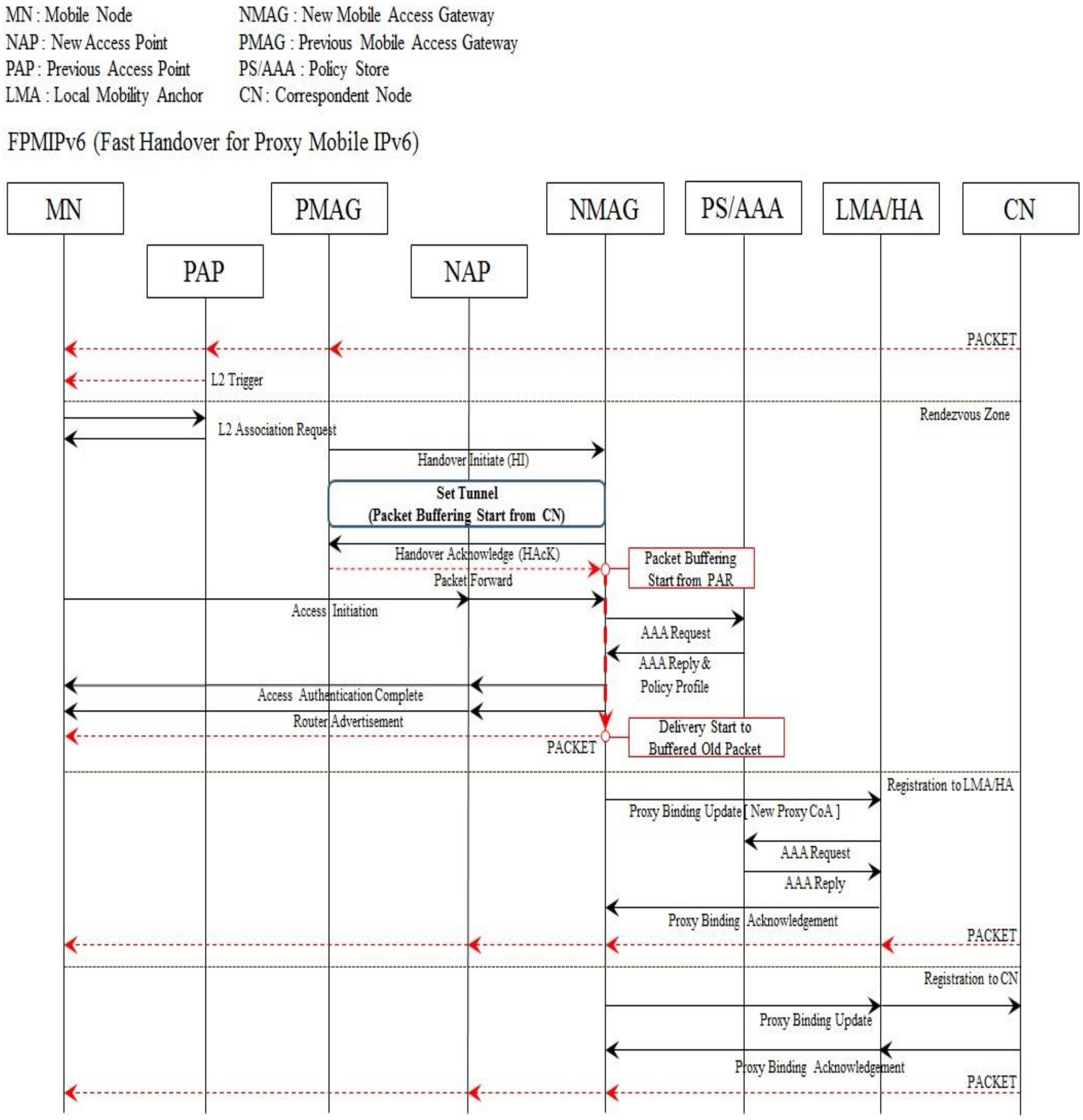

Figure 1. FPMIPv6 Handover Procedure

Figure 1 shows the process of a handover in the predictive mode. First, if the signaling from the AP (Access Point) is stronger than the previously connected AP, the MN requests for a handover and detects the handover signal through the L2 trigger. When requesting for a handover, the MN transmits the MN-ID and a new AP-ID to acquire NMAG information from NAP-ID. The PMAG that has received this request then exchanges HI/HACK messages to create a bi-directional tunnel with the NMAG, and these HI/HACK messages contain the MN-ID, HNP (Home Network Prefix) and LL-ID (Link Layer Identifier) information which are then used to verify the operations in the same interface environment. Also, U or F flag is used within the HI message if the packet is buffered or forwarded through the bi-directional tunnel, and the U flag performs the command of buffering the corresponding packet and the F flag forwarding the buffered packet. Afterward, the MAG sends the LMA and CN a message on binding update to optimize the route. Once the binding is established between the PCoA and NCoA, the packets being transmitted from the MN are sent to the corresponding node via the established route.

Although FPMIPv6 has an advantage that it can efficiently perform routing by solving the problem with tunneling overhead caused during a handover since it performs on the base prediction of the handover signals using the trigger data, the problem with the loss of packets caused by the generation of unnecessary buffer space for the prediction of the handover signals still remains as a problem to be solved in the future.

2.2. IAPP(Inter Access Point Protocol)

The IAPP, as an alternative way of efficiently supporting for the mobility of the mobile terminal, is a protocol that shares the information on the nested AP through a periodic beacon frame advertisement between the mobile terminal and the AP before a handover takes place. It first begins with searching for a new AP according to the priority list and then has the AP found go through the authentication/re-authentication process. Figure 2 illustrates the navigating process of the surrounding APs through a beacon message.

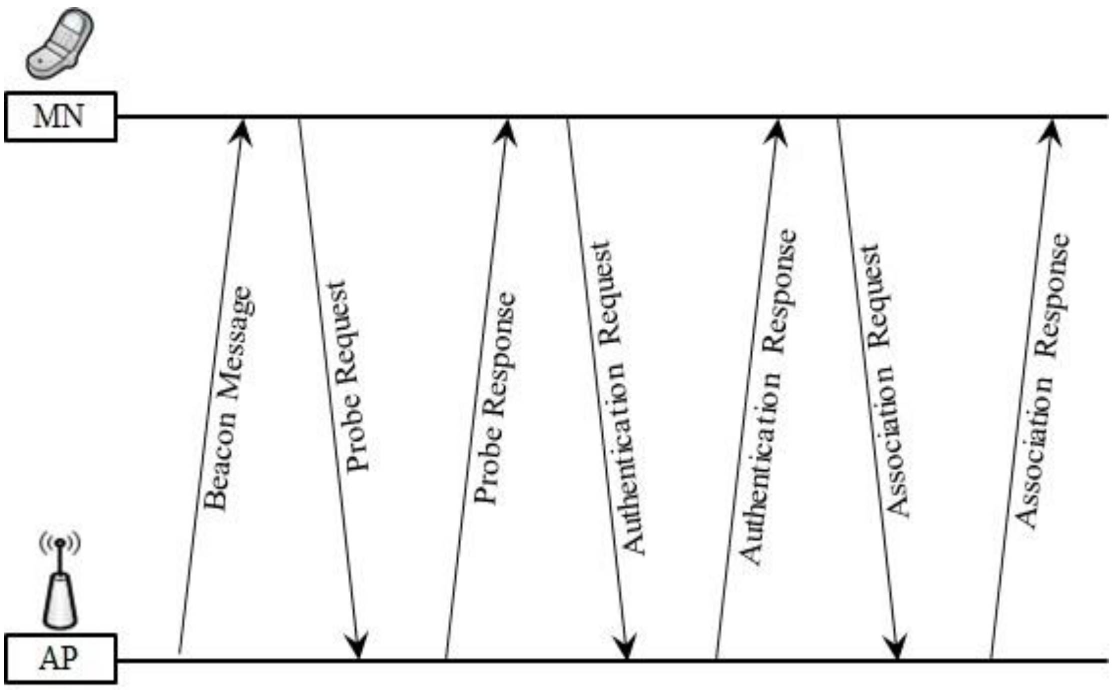

Figure 2. IAPP Initial Access Procedure

3. Routing Optimization using Advanced Cross-Layering Algorithm (ACL) for FPMIPv6 (ACL-FPMIPv6)

In this chapter, we explain advanced cross-layering algorithm (ACL) based on reverse binding scheme for mobility prediction at L2 level and routing optimization at L3 level to reduce the RTT (Round Trip Time) and to minimize the loss of packets in the process of transmitting the contextual information residing on the network. The proposed method in this paper must have a nested area present on the network and support the IAPP service based L2 layer. Figure 3 shows the flow chart on the movement detection of ACL-FPMIPv6 supporting the IAPP service.

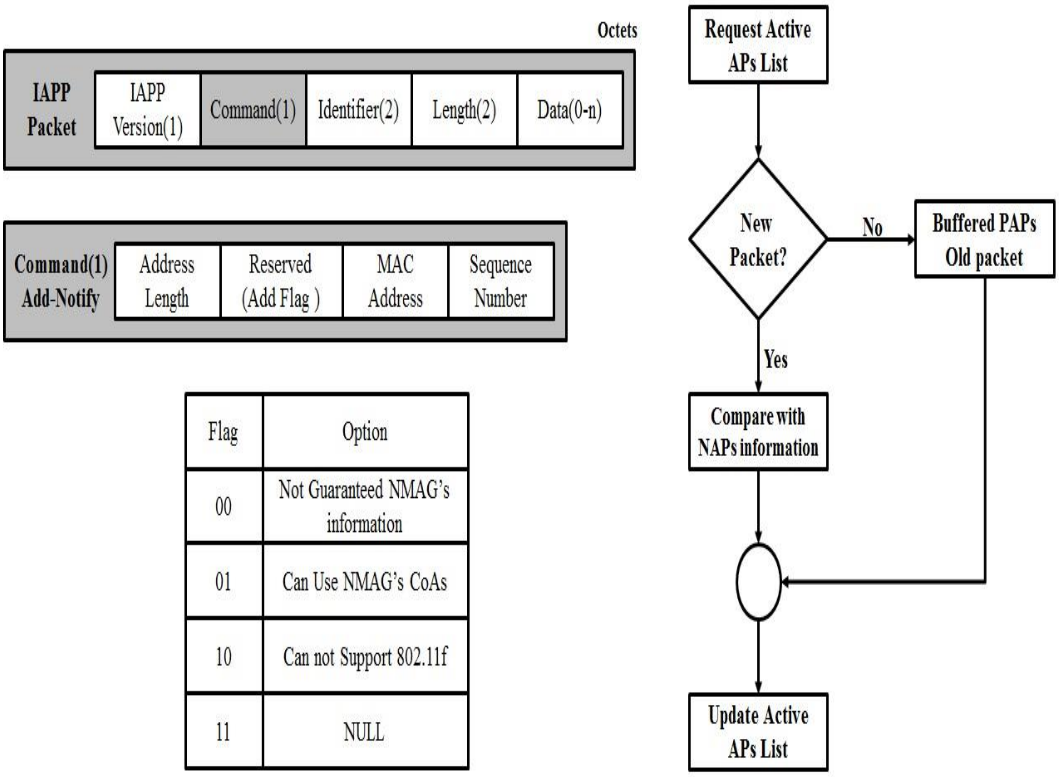

Figure 3. IAPP Add-Notify Message Format / Flow Movement Detection to IAPP Service

The MN sends add-notify messages to the NAPs nested and located in the service area to perform the active scanning process for seamless mobility support within the network while connected to the MAG (PMAG) on the access network. In the meantime, the messages undergo an authentication procedure for an access request to the network by the AAA server. If the NAPs in the overlapped service area do not support the IAPP service, an option field is added to the add-notify messages to perform the NDP (Neighbor Discovery Protocol) procedure which is used to route, search for the prefix data and defined the relationship with the router connected on the link. Figure 3 illustrates the structure of an add-Notify that is added for IAPP procedure.

Using the IAPP service, the MN which receives MAC (ID) data of the devices in the surroundings from the NAPs in the vicinity sends a handover indication message to the PMAG based on the L2 trigger information and adds an option field (D Flag) to send a selective message into the HI/HACK message if a temporary, bidirectional tunnel is requested to be created between NMAGs based on the information about the overlapped area. Figure 4 shows the format of HI/HACK message with the option.

Figure 4. HI/HACK Message Format

The message contains MD-ID, HNP (Home Network Prefix) and LL-ID (Link Layer ID), and all the packets destined for the MN are transmitted through the pre-set tunnel. If a packet has been decapsulated before the handover, it is buffered to the NMAG and stored in the form of a queue until the NMAG receives a FNA (Fast Neighbor Advertisement) message from the MN that informs the completion of the handover, and the buffered packets are transferred to the MN.

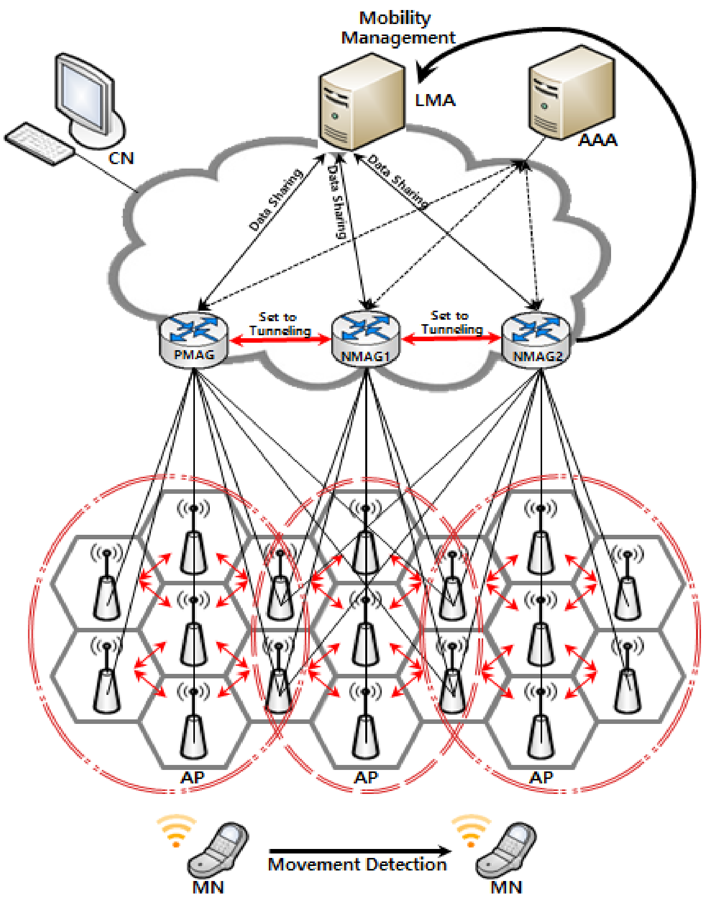

Figure 5. Conceptual Design Procedure

Figure 5-6 illustrates the procedure of ACL-FPMIPv6 (Advanced Cross-Layering algorithm for FPMIPv6) handover in the predictive mode.

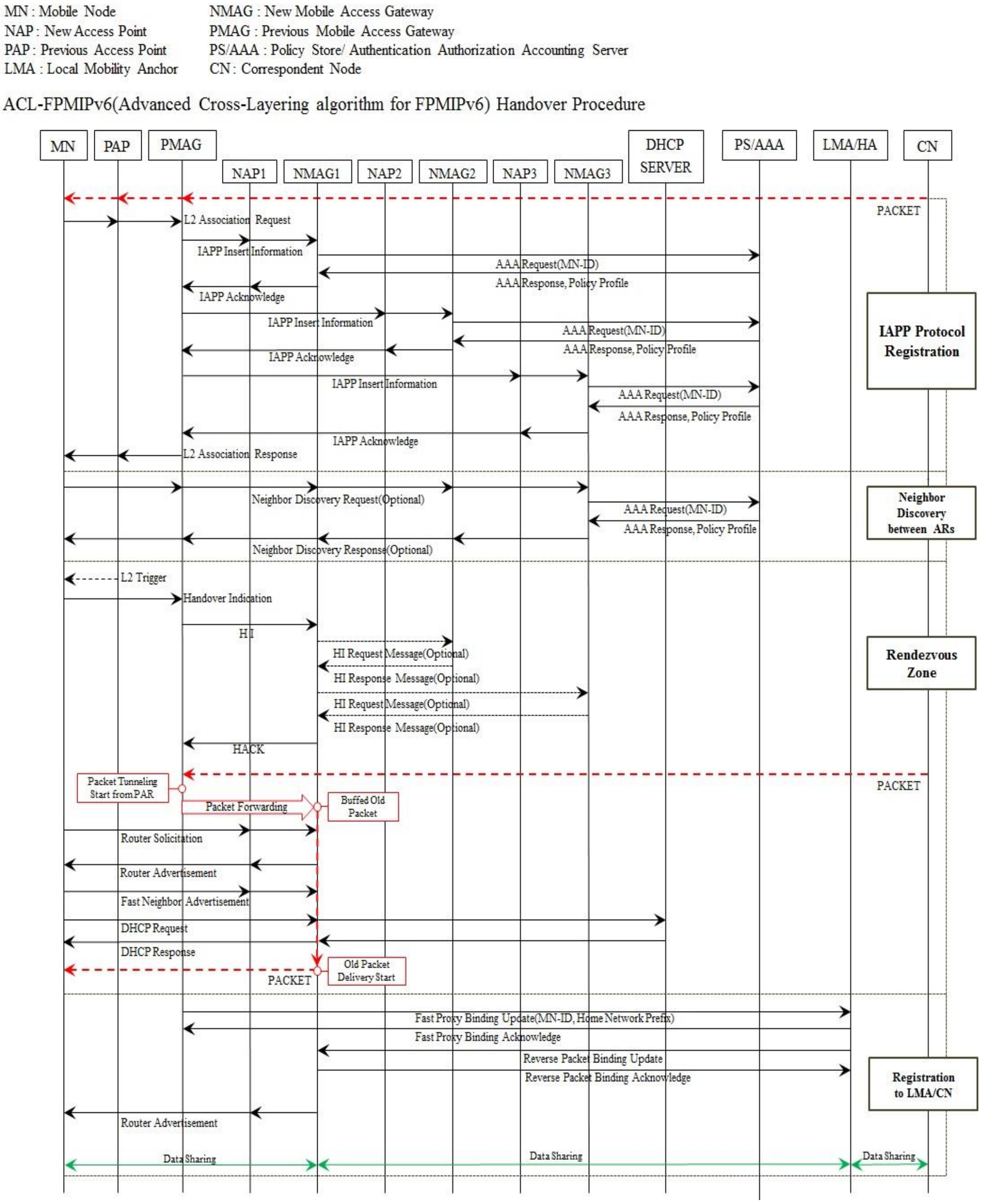

Figure 6. ACL-FPMIPv6 Handover Procedure

The MN that has predicted the mobility on the network by the movement detection process updates the location of the NMAG to connect and any security issues and sends a LMA the FPBU (Fast Proxy Binding Update) / FPBAck (Fast Proxy Binding Acknowledge) message, which contains required fields for the mobility option by the PMAG, to check if such data are identical with the BCE (Binding Cache Entry) data stored in the LMA. In the course of this process, if it is not possible to identify the data by the NAI (Network Access Identifier) option that is used to identify devices, the MN adds an optional field into the response message to block (discard) the packet transmitted from the PMAG to the NMAG, and if the data match, it sends a RPBU (Reverse Packet Binding Update) / RPBAck (Reverse Packet Binding Acknowledge) message to the NMAG. The entire handover procedure is finally completed by the information about the NMAGs acquired by this message transfer, sending a RA (Router Advertisement) message to the MN. Therefore, the ACL-FPMIPv6 procedure proposed in this paper is expected to enable reliable data transmission between the PMAG, NMAG and LMA as well as reduce the handover latency.

4. System Performance Analysis and Comparison

4.1. The Existing/Suggested Method's Time Diagram & Formula

ACL-FPMIPv6 proposed in this paper has increased the mobility of the mobile terminal through pre-sharing on the same access network, and it was assumed that the router and all router APs located in the nested area of the wireless network. Also, the time taken to perform the handover was reduced by notifying the corresponding nodes of the policy profile in advance brought from the AAA/Policy Store to shorten the handover latency at L3.

The handover latency time for PMIPv6 and ACL-FPMIPv6 were compared to effectively show the process procedure as well as the evaluation and comparison of the performance, and the part about the support for the IAPP service was dealt separately to help with understanding of the performance analysis.

Figure 7-8 is the time diagram that illustrates the handover procedure with ACL-FPMIPv6 depending on the support for the IAPP service. As shown in the time diagram, the method proposed in this paper will reduce the handover latency by a great deal if the accuracy of the traffic analysis is improved although pre-sharing of data between the MAG and AP on the same access network may cause a problem with unnecessary signaling and lowered networking quality.

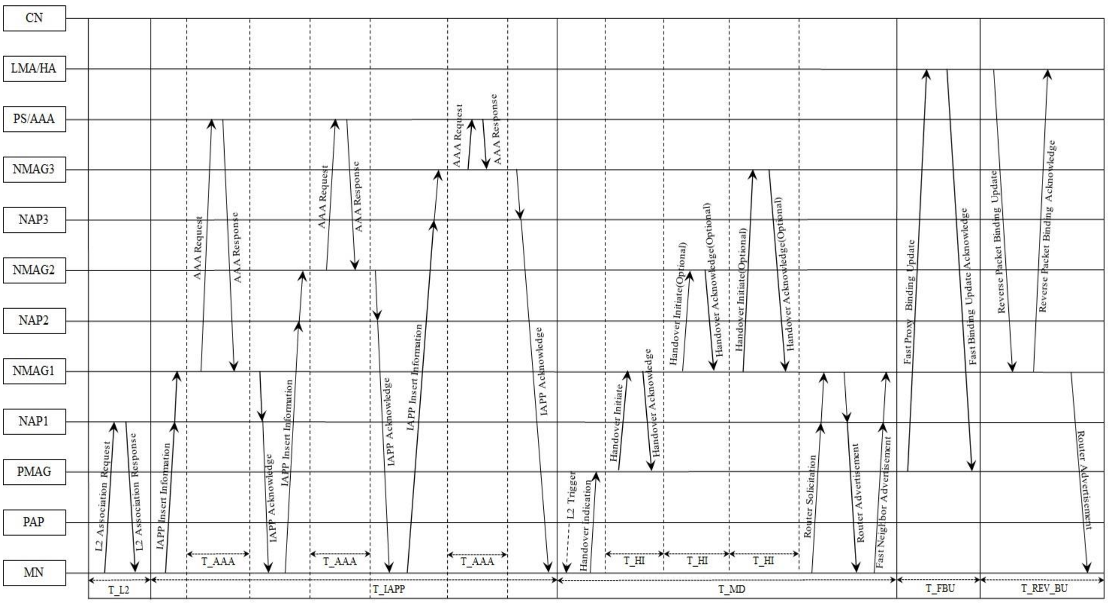

Figure 7. ACL-FPMIPv6 Handover Procedure timing diagram (1)

$$T_{ACL\_FPMIPv6} = \alpha \{2(6t_1 + 5t_2 + 3t_3 + t_4 + 2t_5 + 3t_6)\} \quad (1)$$

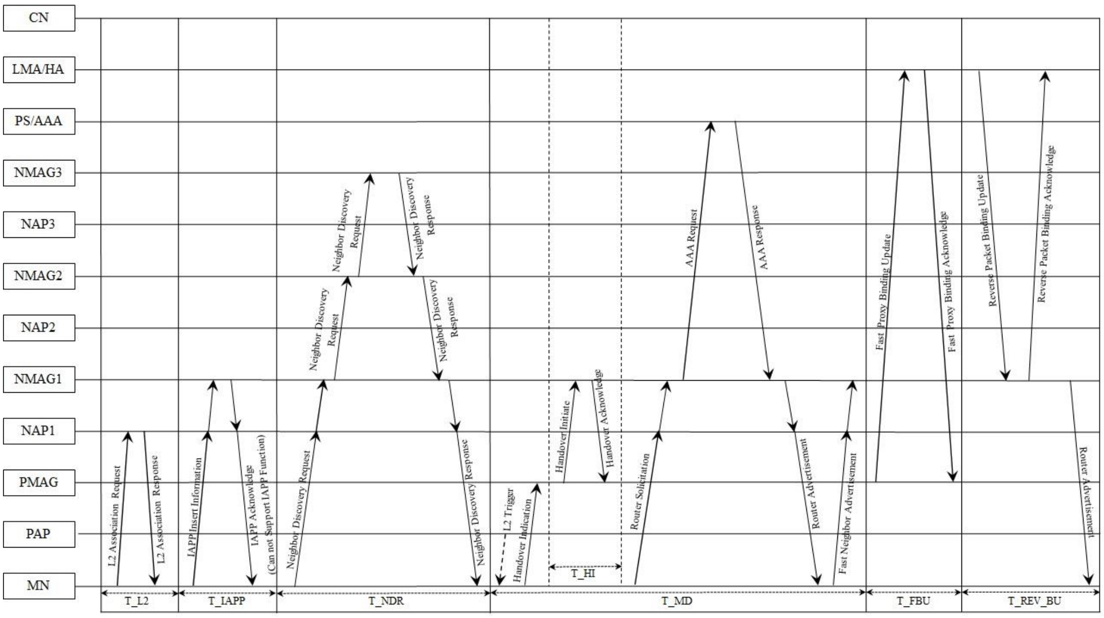

Figure 8. ACL-FPMIPv6 Handover Procedure timing diagram (2)

$$T_{ACL\_FPMIPv6} = \alpha \; \{2(4t_1 + t_3 + t_4 + 2t_5 + t_6) + 5t_2 + 2\beta\,(t_1 + t_2 + 2t_6)\} \qquad (2)$$

Table 1. Performance Analysis Parameters

Symbols	Parameter	Value
t1	T_{MN_AP}	30ms
t2	T_{AP_MAG}	50ms
t3	T_{MAG_AAA}	80ms
t4	T_{MAG_CN}	200ms
t5	T_{MAG_LMA}	100ms
t6	T_{MAG_MAG}	80ms
α	Packet Re-Transmissions Rate	Variable
β	Can not Support IAPP function Rate	Variable

Table 1 is a list of parameters defined for performance analysis. The procedure to derive a formula for a time diagram was conducted in consideration of the amount of signals depending on the support of the mobile device for the IAPP service and the rate of re-transmission by the message transfer interval. The value α refers to the rate of the packet loss caused when the packets are exchanged between the routers, and the value β is the amount of signaling increased when the IAPP service is not supported.

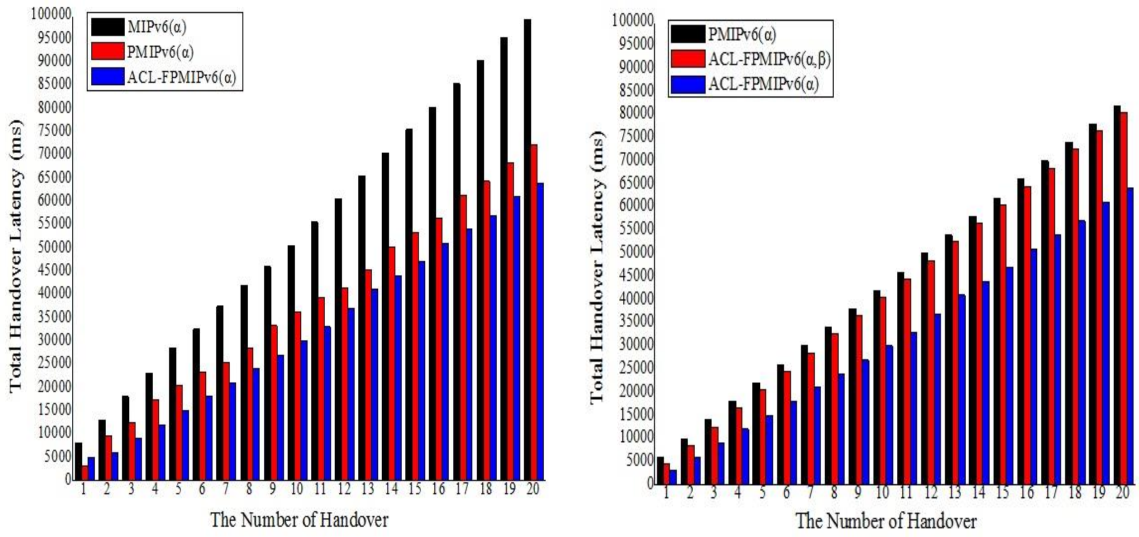

Figure 9. Performance Test Results Analysis

Figure 9 is a diagram that indicates the results of the handover the latency time processed in consideration of these conditions. As shown in the diagram, the overall handover latency reduces when compared to the existing protocols as the number of the mobile device movements increases.

5. Conclusion

ACL-FPMIPv6 procedure in the predictive mode suggested in this paper implemented the advanced cross-layering algorithm (ACL) mechanism to resolve the problem with the inefficient data signaling in the handover process and to minimize the packet loss, and the support for the high speed motion detection facilitated setting up a bi-directional tunnel between the PMAG and NMAG. Also, if the support for the IAPP is not available, a flag was added to the IAPP packet format to provide with efficient mobility for the multi-device requirements, and the reverse binding mechanism was used to optimize the route of the data packets being transmitted to the corresponding nodes that are to service, based on such high speed motion detection. This is expected to provide seamless mobility between the mobile node and the corresponding node when a handover takes place.

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