PMIPv6-based Inter-Domain Handover using Efficient Buffering Scheme

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***Abstract*—Global Handover (HO) requirement between domains is increasingly in demand to provide home network accessibility in remote places. This necessity will lead continuous services between different domains by the Proxy Mobile IPv6 (PMIPv6)-based mobility. In this paper, we introduce the enhanced inter-domain HO mechanism using the efficient buffering scheme to provide continuous services and buffered data backup mechanism for the data delivery to reduce the inter-domain HO delay between different PMIPv6 domains. The simulation result shows that the efficient buffering scheme and the buffered data backup mechanism deliver buffered data among the different domains right after completion of inter-domain handover.**

Keywords-PMIPv6; handover; inter-domain; buffering scheme; backup mechanism.

I. INTRODUCTION

MIPv6 [1] was proposed to meet the global mobility demand by the development of wireless communication technology and the commodity of hand-held mobile devices. IETF introduced Proxy Mobile IPv6 (PMIPv6) for the network-based mobility protocol since MIPv6 has the long Layer 2 and Layer 3 handover latency due to the Mobile IP signaling message involving Mobile Node (MN).

Localized mobility without requiring the MN to participate in any mobility related signaling messages is PMIPv6's [2] purpose, which provides a network-based mobility. Mobile Access Gateway (MAG) typically residing in the access router detects the attachment of the MN to the access link when the MN enters the PMIPv6 domain. MAG verifies if the MN is eligible to the network-based mobility management service by RADIUS [3] or Diameter [4] protocol when a MN attachment is detected. MAG sends a Proxy Binding Update (PBU) including MN information and Proxy-CoA to the Local Mobility Anchor (LMA) for the registration of MN after an authentication & authorization procedure with AAA server. When LMA responds the Proxy Binding Acknowledgement (PBA) message including home network prefix to MAG, bi-direction tunnel is finally established for the data delivery from or to the MN between LMA and MAG. Moreover, Router Advertisement (RA) with home network prefix of MN is sent to MN after home network prefix registration for MN is done in MAG. If the address analysis for the home network prefix received from MAG is successful in MN, MN can eventually communicate with Correspondent Node (CN).

A PMIPv6-based HO and data forwarding in the inter-domain was proposed in [5] for the inter-domain HO solution. Draft NetLMM-Neumann [5] suggests the home LMA as Session Mobility Anchor (SMA) to handle all incoming and outgoing packets for MN during of mobility session. LMA of new PMIPV6 domain initializes a tunnel for SMA in the home domain to continue serving as an anchor point for MN after inter-domain HO procedures. That is, SMA in the home domain acts as the anchoring end point for the LMA of visited domain when the inter-domain HO occurs.

In [6], there was a PMIPv6-based inter-domain roaming scenario just from the home domain to visited domain with two concatenated tunnels between visited MAG and home LMA via visited LMA.

Our proposal will extend [6] to the PMIPv6-based inter-domain HO scenarios including between visited domains and returning to the home domain from the visited domain and the efficient buffering scheme and buffered data backup mechanism will be applied to reduce the inter-domain HO delay.

The remainder of this paper is organized as follows: In Section II, the related works are explained. Section III will describe the proposed schemes. In Section VI, performance of analysis of our scheme is studied. Concluding remarks will be given in Section VII.

II. RELATED WORKS

Soochang [6] introduced a PMIPv6-based inter-domain roaming mechanism using concatenated tunnel construction from visited MAG to visited LMA and from home LMA to visited LMA when MN moves to a visited domain. Visited MAG sends PBU message including home LMA address of MN received from the home AAA response message via visited AAA server when MN is attached to the visited MAG and MN is recognized as roaming user after interacting with the visited AAA server. Inter-domain tunnel is additionally established between visited LMA and home LMA when visited LMA and home LMA exchanges the PBU/PBA message. In [6], two concatenated tunnels are required to roam from the home domain to the visited domain. Two tunnels were composed of one intra-domain tunnel from visited MAG to visited LMA and one inter-domain tunnel from visited LMA to home LMA.

Hyo-beom [7] proposed efficient buffering scheme to prevent the HO packet loss within the same PMIPv6 intra-domain. This scheme introduced the ARQ handling function

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similar to Go-Back-N to implement the buffered data delivery without duplicated packets between MAG and LMA. Home MAG (MAGh) and home LMA (LMAh) exchange the PBU/PBA message to construct the bi-directional tunnel when a MN is attached in home MAG. ARQ anchor handler in LMAh makes buffer per MN, temporarily stores every packet in each buffer and sends buffered packets to MAG including the sequence number located in IP-in-IP encapsulation header with destination option header according to [5]. On receiving a packet from LMA, The ARQ handler of MAGh sends packets to MN and responds the delivered sequence number to LMA. Then, ARQ anchor handler of LMAh will remove the delivered packets from the buffer by the reported sequence number. In PMIPv6 [2], efficient buffering scheme using the sequence number to check duplicated packets is required to provide the seamless mobility in ARQ handler of MAG and ARQ anchor handler of LMA since the HO start time of MN is not predictable in the network side.

III. PROPOSED SCHEMES

Roaming scenario was only proposed for a PMIPv6-based MN roaming scenario from the home domain to the visited domain in [5][6]. Our proposal extends [6] to the PMIPv6-based inter-domain HO scenarios including HO case between visited domains and HO case for the returning to the home domain using the sequence number-based efficient buffering scheme and buffered data backup mechanism to prevent the packet loss between domains. To distinguish PBU message from the LMA of another PMIPv6 domain and PBU message from MAG within the same PMIPv6 domain, flag S will be set to indicate the inter-domain PBU message, which is originated from another LMA in the different PMIPv6 domain according to [5].

Sequence number-based efficient buffering scheme in [5] can be extended to inter-domain HO using buffered data backup mechanism. Sequence number is allocated to the packet, which is sent to MAG through tunnel from the LMA to identify the packet. MAG reports to LMA whether packet is delivered to MN or not by ACK message using two flags; flag RR (Receiver Ready) is set for the periodic report by the expiry of timer in MAG and the other flag REJ (Reject) is set to inform LMA of the fact that there is the first missing packets after successful delivery for the immediate report. Namely, setting flag REJ in ACK message may indicate the HO preparation.

Figure. 1 shows the example of the sequence number-based buffering management in the inter-domain HO. When LMAh receives the data 1 destined to MN, LMAh allocates the sequence number 1 to the received packet to identify the packet, which is sent to the MAG through the tunnel and LMAh temporarily stores the data D(1) and sequence number S(1) per MN. Sequence number S(1) is sent to the MAG included in the IP-in-IP encapsulation header with new destination option header. S(2)/D(2) and S(3)/D(3) are subsequently sent to MAG and stored in LMAh. If MAGh detects the packet D(3) is not sent to MN, delivery failure is immediately reported to LMAh using the flag REJ(3) in the ACK message. In other words, it means that D(1) and D(2) are appropriately sent to MN and needs to remove the data D(1) and D(2) in the buffer. To prevent buffer overflow, flag RR in the ACK message is used for the periodic packet delivery status report to the LMAh by the expiry of the RR timer in the MAGh; RR(6) indicates that MAGh already delivered all packets to MN and buffered data less than those indexed with sequence number 6 should be cleared in the buffer of LMAh. Since data are not delivered to MN and MAGh returns the flag REJ(6) and REJ(7) to LMAh during the inter-domain HO, all the buffered data are delivered to new LMAv via the inter-domain tunnel after MN attachment to new domain and the establishment of inter-domain tunnel between LMAh and LMAv. All buffered data are eventually flushed to MN through the new MAGv. Sequence number-based buffer management is restarted in the new LMAv according to the packet delivery status report from the new MAGv after the inter-domain HO.

A. *PMIPv6-based HO from Home to Visited Domain*

Figure. 2 shows that MAGv1 performs the authentication step with visited 1 AAA when MN moves to visited domain 1. It redirects authentication messages to home AAA server according to the service level agreement between two AAA servers since the visited 1 AAA server knows that MN is involved in home AAA by the realm portion of user NAI (username@realm). Response messages including LMAh address information from home AAA server are sent to MAGv through the visited 1 AAA. For the construction of inter-domain tunnel between LMAv and LMAh, MAGv1 sends the PBU including LMAh address information to LMAv. LMAv sends the PBU message with flag S set to LMAh address received from MAGv for inter-domain tunnel establishment. Hence, after responding the PBA message to LMAv and transmitting the RA message to MN, LMAh can finally send the sequence number-based buffered data to LMAv for flushing the buffered data through MAGv according to the efficient buffering scheme. On flushing the data, LMAv newly acts as ARQ anchor handler and MAGv serves as ARQ handler.

B. *PMIPv6-based HO between Visited Domains*

In Figure. 3, buffered data in LMAv1 should be firstly returned to LMAh in HO scenario from visited domain 1 to visited domain 2 in order to prevent the inter-domain tunnel from extending the repeated ARQ handler from the home domain to another visited domain via visited domain 1. LMAv1 returns the buffered data to LMAh after receiving the PBU with flag S set from the home domain according to buffered data backup scheme. When MN moves to visited domain 2 and is attached to MAGv2, MAGv2 will send the PBU to LMAv2 for the establishment of inter-domain tunnel between LMAh and LMAv2 and then, LMAv2 will notify LMAh that the inter-domain HO occurs by sending the PBU with flag S set to LMAh, LMAh requests the LMAv1 to return the sequence number-based buffered data to LMAh by sending PBU with flag S set. After inter-domain tunnel establishment between LMAv2 and LMAh, LMAh can eventually transfer the sequence number-based buffered data to the LMAv2, which requested the PBU for the buffered data flushing through the MAGv2. Old intra-domain tunnel between MAGv1 and LMAv1 is terminated by predefined timer. According to this backup mechanism from the previous LMAv2 to LMAh for the buffered data, LMAv2, which acts as new ARQ anchor handler does not need to know the information of previously anchored LMA information and it is not required to trigger additional signaling message between AAAh and LMAh for the buffered data delivery.

C. PMIPv6-based HO for Returning to Home Domain

Figure. 4 indicates that MN can directly receive the buffered data from LMAh when MN comes back from the visited domain 2 to the home domain and is attached to MAGh because buffered data in previous LMA is already transferred to LMAh according to the buffered data backup mechanism. Predefined timer also terminates the old intra-domain tunnel between MAGv and LMAv.

IV. EXPERIMENTS

The simulation using NS-3 network simulator was performed in IEEE 802.11 wireless environments. Simulation network topology is shown by Figure. 5.

There are three inter-domain HO scenarios and each domain has one LMA connected with each different domain and two MAGs are linked each other within domain. The link delay of all wired links is 10msec and the link capacity is 50Mbps for the wired links and 11Mbps for the wireless links according to the 802.11a standard. As for the wireless delay, propagation delay model is applied to the simulation. MN moves with velocity 10m/sec across the PMIPv6 domains from the home domain to the visited domain 2 via visited domain 1 and then finally returns to the home domain. CN is attached with link capacity 50Mbps & link delay 100msec and communicates with MN through CBR over UDP with rates 1 Mbps. Sequence number will be measured to check the packet delivery in the simulation because ARQ anchor handler in LMA makes buffer per MN, temporarily stores every packet in each buffer and sends buffered packets to MAG including the sequence number located in IP-in-IP encapsulation header with destination option header according to [5]. In the simulation, inter-domain HO delay will be compared to the test case without efficient buffering scheme and buffered data backup mechanism to measure the sequence number for the packet delivery performance in the following cases: inter-domain HO to visited domain, inter-domain HO between visited domains, and inter-domain HO returning to the home domain.

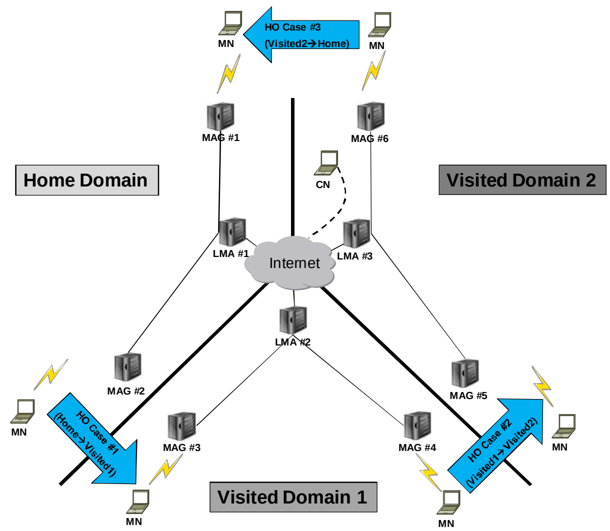

Figure 5. A network topology for simulation.

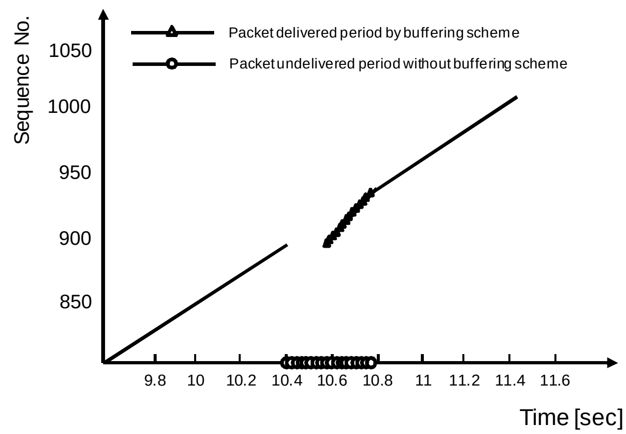

Figure 6. Received sequence number after inter-domain HO from home domain to visited domain 1 with buffering scheme when CN sends packets to MN.

Figure. 6 shows that inter-domain HO occurs around 10.39s from the home domain to the visited domain 1. Buffered packets are delivered from LMAh to LMAv1 through the inter-domain tunnel for the data flushing in 10.59s before MAG in the visited domain 1 can deliver packets to MN without the efficient buffering and buffered data backup scheme in 10.77s.

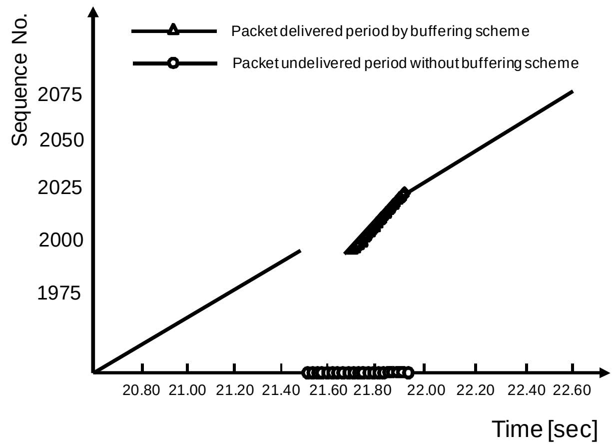

Figure 7. Received sequence number after inter-domain HO from visited domain 1 to visited domain 2 with buffering scheme when CN sends packets to MN.

Figure. 7 shows that inter-domain HO occurs around 21.50s from visited domain 1 to visited domain 2. Buffered packets are delivered from LMAv1 to LMAv2 through the LMAh using the backup mechanism for the buffered data flushing in 21.69s before MAG in the visited domain 2 can deliver packets to MN without the efficient buffering and buffered data backup scheme in 21.87s.

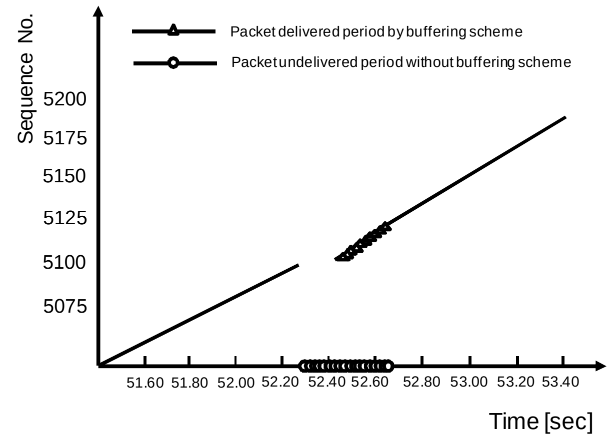

Figure 8. Received sequence number after inter-domain HO from visited domain 2 to home domain with buffering scheme when CN sends packets to MN.

Figure. 8 shows that inter-domain HO occurs around 51.12s from visited domain 2 to the home domain. Buffered packets are delivered from LMAv2 to LMAh for the data flushing in 52.42s before MAG in the visited domain 1 can deliver packets to MN without efficient buffering and buffered data backup scheme in 52.65s.

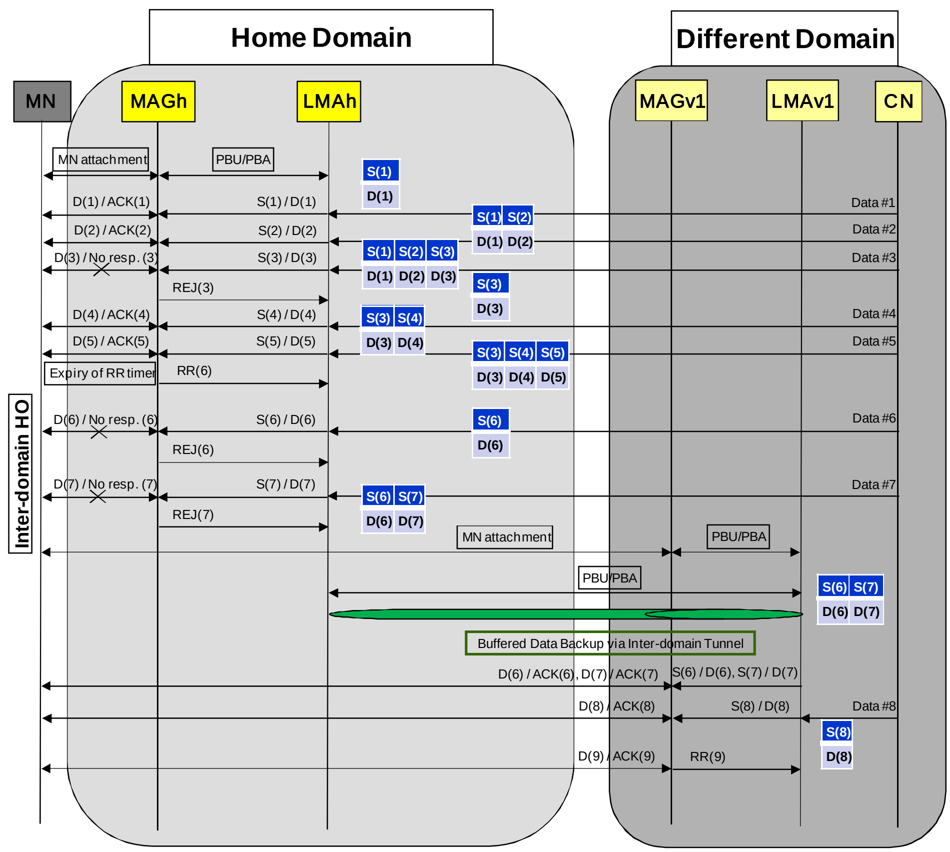

Figure 1. A sequence number and buffered data management in the inter-domain HO

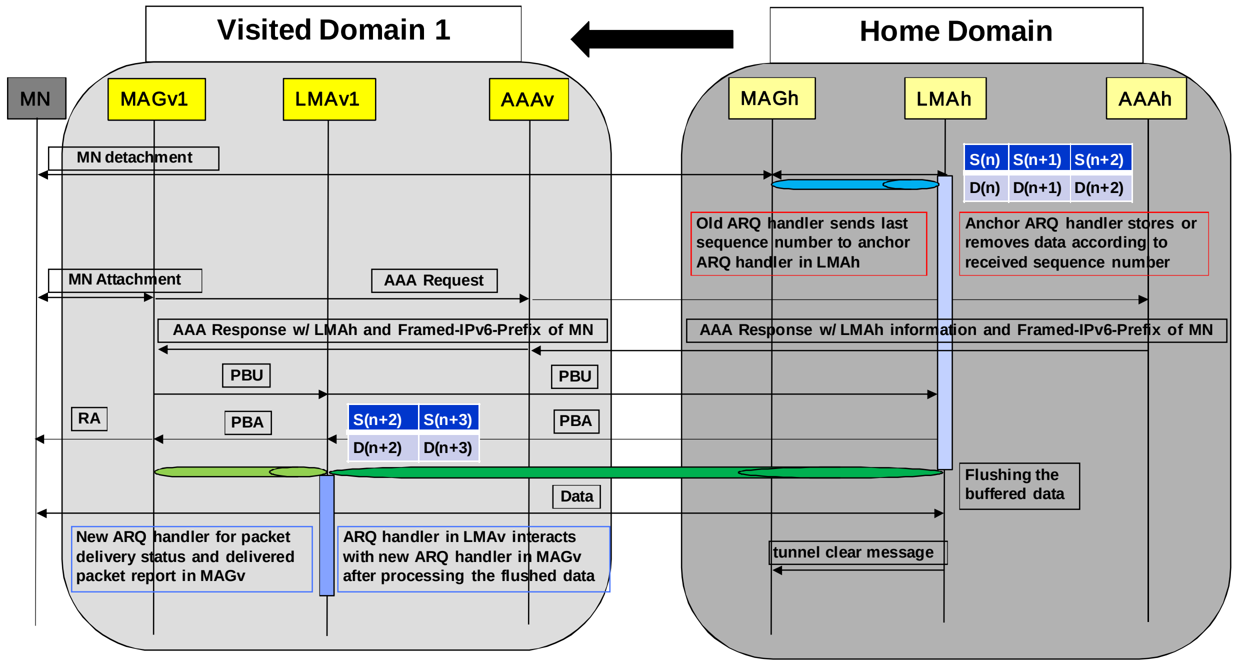

Figure 2. A call flow for HO from home to visited domain.

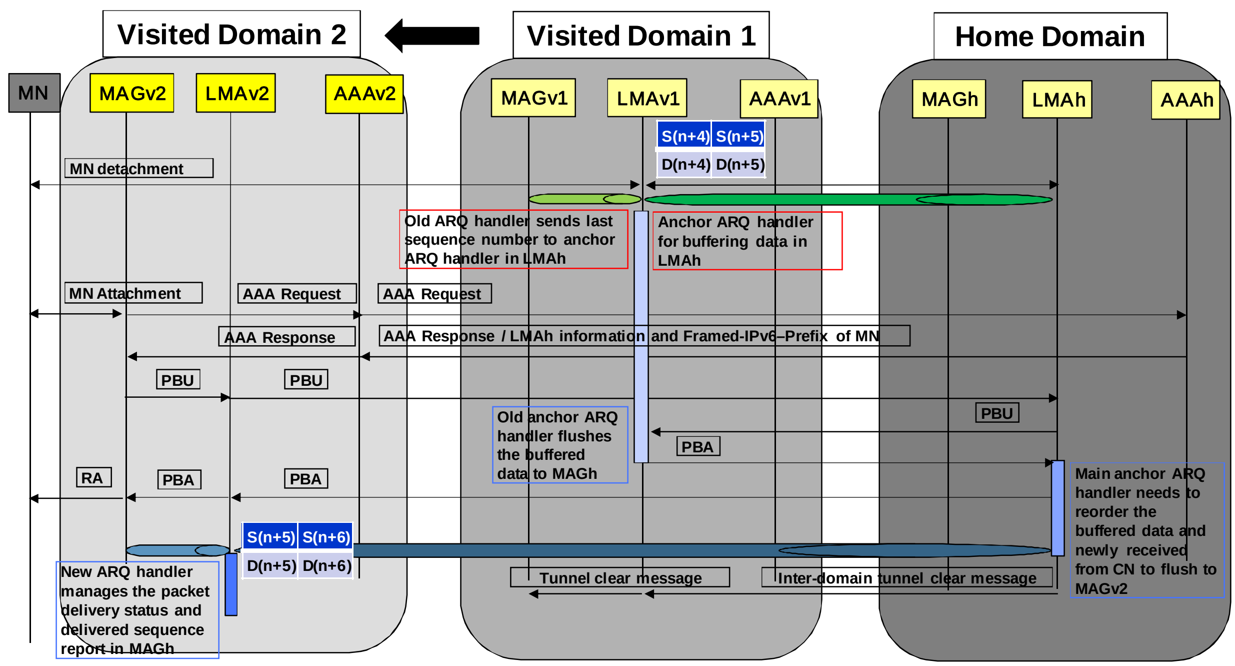

Figure 3. A call flow for HO from visited domain 1 to visited domain 2.

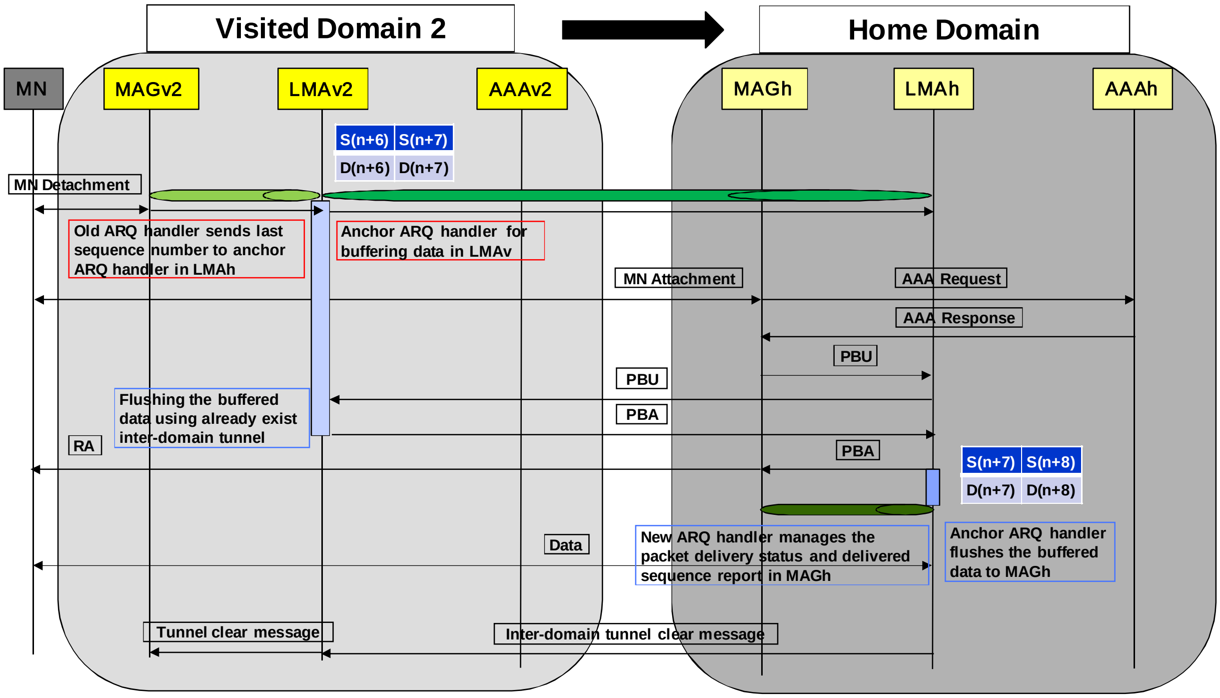

Figure 4. A call flow for HO from visited domain 2 to home domain.

V. CONCLUSIONS

Our proposal expands Draft NetLMM-Neumann [5] and Soochang [6] to inter-domain HO scenarios including the case between visited domains and the case for the returning to the home domain by using the buffered data backup scheme. In inter-domain HO between visited domains, buffered data backup mechanism is proposed to prevent inter-domain tunnel from extending the sequential buffered data relay through the multiple LMA to reach the target LMA. For the seamless mobility and service continuity in the inter-domain HO, efficient buffering scheme [7] in the intra-domain HO is extended to inter-domain HO scenario.

The simulation results show that efficient buffering scheme provides the reduction of inter-domain HO delay and the enhancement of seamless services by supporting the sequence number-based data management between MAG and LMA and the buffered data delivery from the old LMA to new target LMA through the inter-domain tunnel.

REFERENCES

[1] C. Perkins, Ed., D. Johnson, and J. Arkko, “Mobility Support in IPv6,” RFC6275, July 2011.

[2] S. Gundavelli, Ed., K. Leung, V. Devarapalli, K. Chowdhury, and B. Patil ”Proxy Mobile IPv6,” RFC5213, August 2008.

[3] J.Salowey and R.Droms, “RADIUS delegated-IPv6-Prefix attribute,” RFC4818, April 2007.

[4] P. Calhoun, J. Loughney, E. Guttman, G. Zorn, and J. Arkko, “Diameter base protocol,” RFC3588, September 2003.

[5] N. Neumann, X. Fu, and J. Lei, “Inter-Domain Handover and Data Forwarding between Proxy Mobile IPv6 Domains,” draft-neumann-netlmm-inter-domain-02, March 2009.

[6] Soochang P. and Euisin L., “Inter-Domain Roaming Mechanism Transparent to Mobile Nodes among PMIPv6 Networks,” Vehicular Technology Conference (VTC 2010-Spring), pp. 1608-1611, May 2010.

[7] Hyo-Beom L., Sung-Gi M., Kyoung-Hee L., and Hyun-Woo L. “PMIPv6-Based NEMO Protocol with Efficient Buffering Scheme,” Ubiquitous Information Technologies and Applications (CUTE), pp. 1-6, December 2010.