New Binding Update Method Using GDMHA in Hierarchical Mobile IPv6

Jong-Hyouk Lee, Young-Ju Han, Hyung-Jin Lim, and Tai-Myung Chung

Cemi: Center for Emergency Medical Informatics,
School of Information and Communication Engineering,
Sungkyunkwan University,
Chunchun-dong 300, Jangan-gu, Suwon, Kyunggi-do,
Republic of Korea
{jhlee, yjhan, hjlim, tmchung}@imtl.skku.ac.kr

Abstract. Mobile IPv6 is a protocol that guarantees mobility of mobile node within the IPv6 environment. However current Mobile IPv6 supports simple the mobility of the mobile nodes and does not offer any special mechanism to reduce the handoff delay. For the purpose of reducing the handoff delay, Hierarchical Mobile IPv6 has been studied. However Hierarchical Mobile IPv6 supports the micro mobility only in the area managed by mobility anchor point. Therefore, the handoff delay problem still has been unsolved when mobile node moves to another mobility anchor point. In this paper, we propose GDMHA (Geographically Distributed Multiple HAs) mechanism to provide macro mobility between the mobility anchor points. Using this mechanism, a mobile node performs Binding Update with the nearest Home Agent, so that the delay of Binding Update process can be reduced. It also reduces the handoff delay.

1 Introduction

The user demand for mobile service has increased today. However, current IP protocol has a fatal problem that the MN (Mobile Node) can not receive IP packets on its new point when the MN moves to another network without changing its IP address. To solve this problem, IETF (Internet Engineering Task Force) has proposed a new protocol entitled 'Mobile IP'.

MIPv6 (Mobile IPv6) is a protocol that guarantees Mobility of MN within the IPv6 environment. Especially, it basically provides the route optimization and doesn't need FA (Foreign Agent), which is used for MIPv4 (Mobile IPv4). In MIPv6 world, a MN is distinguished by its home address. When it moves to another network, it gets a CoA (Care of Address), which provides information about MN's current location. The MN registers its newly given CoA with its HA (Home Agent). After that, it can directly communicate with CN (Correspondent Node) [1], [2]. The basic operation of MIPv6 is shown in Fig. 1.

MIPv6 supports just the mobility of MN and does not offer any special mechanism to reduce the handoff delay. For the purpose of reducing the handoff delay, Fast MIPv6 (Fast Handoff for Mobile IPv6) and HMIPv6 (Hierarchical Mobile IPv6) have been studied [3], [4].

O. Gervasi et al. (Eds.): ICCSA 2005, LNCS 3480, pp. 146 – 155, 2005.

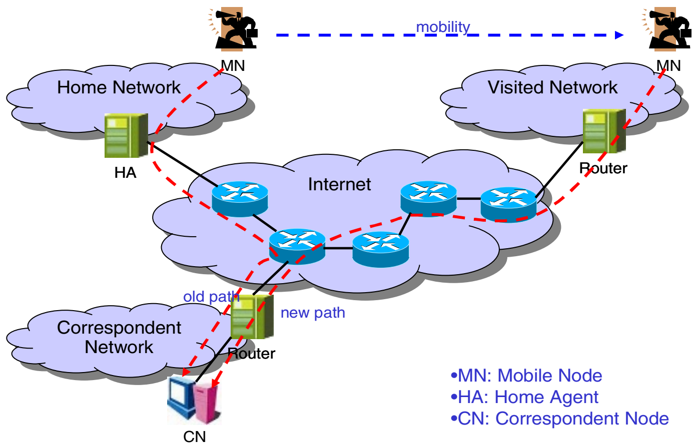

Fig. 1. The basic operation of MIPv6

Fast MIPv6 mechanism uses layer 2 triggers. HMIPv6 mechanism introduces MAP (Mobility Anchor Point) to manage the movement of MN locally. HMIPv6 supports the micro mobility only in the area managed by MAP. In other words, HMIPv6 does not care about its outside world. Therefore, the handoff delay problem still exists when MN moves to another MAP.

In this paper, we propose using geographically distributed multiple HAs to provide macro mobility within the HMIPv6 environment. When MN moves from a MAP to another MAP, it performs BU (Binding Update) with the nearest HA, so that the delay of BU process can be reduced. Since those HAs have the same Anycast Address, the nearest HA can be chosen easily.

In Chapter 2, we will see how the handoff process takes place section by section when a MN moves to a new network. Then, we will analyze the delay caused during BU. Also, we'll see the technique involved in regional MN management by HMIPv6 utilizing the MAP. At the end of this chapter, we will see about the GIA (Global IP Anycast), which is used for BU between multiple HAs and MN. Chapter 3 describes the GDMHA (Geographically Distributed Multiple HAs), which introduces GIA into HMIPv6, and Chapter 4 compares and analyzes the existing mechanisms that import HMIPv6 and GDMHA mechanism. Chapter 5 discusses this research's conclusion and the consequent technology.

2 Related Works

2.1 Mobile IPv6 Handoff

When a MN detects an L3 handoff, it performs DAD (Duplicated Address Detection) on its link-local address and selects a new default router in result of Router Discovery, and then performs Prefix Discovery with that new router to form new CoA. It registers its new primary CoA with its HA. After updating its home registration, the MN updates associated mobility bindings in CNs which are performing route optimization.

The time is needed to detect MN's movement detection, to configure a new CoA in the visiting network, and to resister with the HA or CN together make up the overall handoff delay.

Movement detection can be achieved by receiving RA (Router Advertisement) message from the new access router. The network prefix information in the RA message can be used to determine L3 handoff by comparing with the one received previously. After movement detection, the MN starts address configuration which makes topologically correct addresses in a visited network and verifies that these addresses are not already in use by another node on the link by performing DAD (Duplicated Address Detection). Then the MN can assign this new CoA to its interface. This CoA must be registered with the HA for mobility management and CN for route optimization [5], [6]. Fig. 2 illustrates the handoff process occurring as the MN is transferred to a new network.

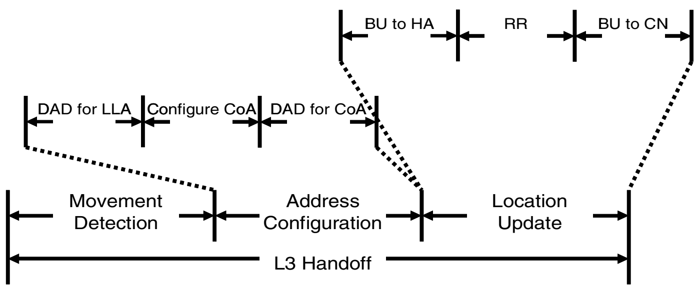

Fig. 2. MIPv6 Handoff

Fig. 2 illustrates the MN carrying out BU to HA of the new network during the Location Update process. Such a process increases the delay required within the BU process as the MN moves further away from HA and incurs the final result of increasing the Location Update delay. HMIPv6, whose research purpose is to reduce handoff within Layer 3, can carry on the role of an assumed HA by utilizing the MAP and can reduce Location Update.

2.2 Hierarchical Mobile IPv6

HMIPv6 introduces a special conceptual entity called MAP and regionally manages MN. The MAP acts as the local HA for the MN and it is a router that manages a binding between itself and MN currently visiting its domain. When a MN attaches itself to a new network, it registers to the MAP serving that domain. The Fig. 3 illustrates architecture and operation of HMIPv6.

MAP intercepts all the packets destined for the MN within its service area and tunnels them to the corresponding on-link CoA of the MN. If the MN moves into a new MAP domain, it needs to configure a regional address and an on-link address. After forming these addresses, the MN sends a binding update to the MAP, which will bind the MN's regional address to its on-link address. In addition to the binding at the MAP, the MN must also register its new regional address with HA and CNs by sending another binding updates that specify the binding between its home address and the regional address. If the MN changes its current address within a local MAP domain, it only needs to register the new on-link address with the MAP [3], [7], [8].

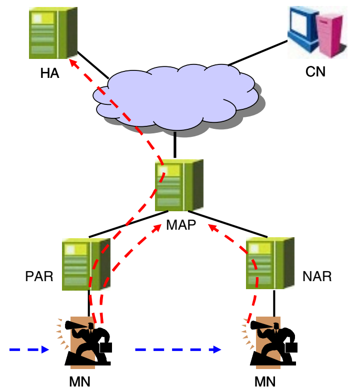

Fig. 3. Architecture and operation of HMIPv6

Since the location update delay mainly depends on transmission delay between MN and HA or CNs, this hierarchical architecture can reduce the location update delay drastically. This process is no concern of supporting the micro mobility, therefore it cannot reduce the delay occurring during the MN transfer between MAPs.

2.3 Global IP Anycast

Anycast routing arrives onto the node that's nearest to the Anycast's destination address. The nodes with same address can be made to function as Web mirrors and can gain the function of dispersing the node traffic function and can be chosen and utilized as the nearest server by the user. For example, this process can be considered when a user wishes to download a file from a Web page. In order for the user to download a file from the nearest file server, the user doesn't choose a file server but it can be automatically directed to the nearest file server to download the file via the operation of Anycast [9], [10].

The file download speed via Anycast not only has an improved speed but can reduce the overall network traffic. Fig. 4 illustrates the general operation process of Anycast.

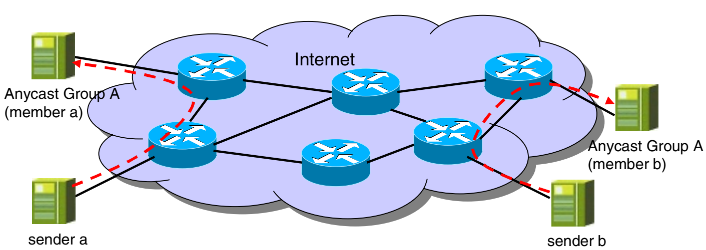

Fig. 4. Operation of Anycast

Although the existing Anycast operates within the nodes of the identical prefix, GIA supports global routing [10]. Because of that, a node that exists within a different network can be included in Anycast.

This research provides GDMHA mechanism to support macro mobility between the MAPs. When the MN carries out BU outside its MAP administrative domain, the geographically distributed HA carries out the nearest HA and BU and reduces the BU delay via GIA.

3 Mobility Management Between MAPs

We proposed GDMHA mechanism uses GIA to find the nearest HAs among several HAs. The HAs are geographically distributed. And these are belong to the same anycast group. A packet sent to an anycast address is delivered to the closest member in the GIA group. A MN performs BU to nearest HA by the GIA mechanism. According to the GIA, the BU sent to an anycast address is routed to the nearest HA.

3.1 The Mobility Management Using GDMHA

HMIPv6 manages the MN's movement within the MAP administrative domain. Because of that, when MN moves to another MAP, it must carry out BU with its HA within HMIPv6 environment as shown in Fig. 5.

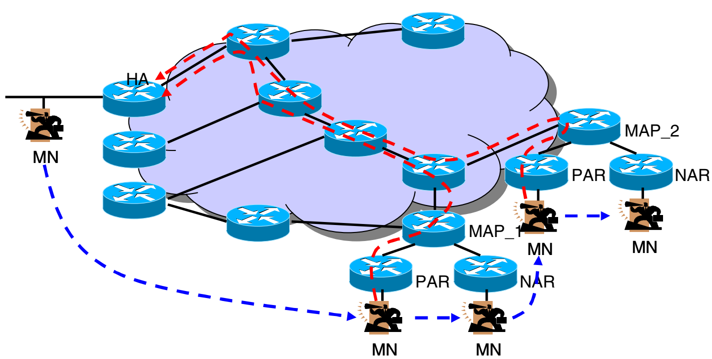

Fig. 5. BU operation within the HMIPv6 environment

At this time, if the distance of MN and HA is far away, the BU delay will be increased; this is the aspect of macro mobility that cannot be provided by HMIPv6's micro mobility utilizing the MAP. However, if we distribute through HAs belonging to an identical Anycast group, this problem should be manageable. Fig. 6 illustrates the geographically distributed HAs and MN's BU operation suggested by this research within the HMIPv6 environment. Geographically distributed multiple HAs will have the identical Anycast address.

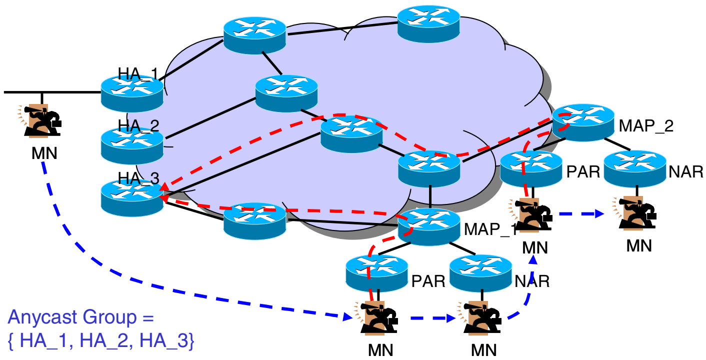

Fig. 6. BU operation within GDMHA environment

Fig. 6 illustrates the BU delay reduction when BU is carried out with a HA, which is the geographically closest one to the MN, provide that the MN moves to a different MAP for the HA belonging to the same Anycast routing group.

3.2 Binding Cache Router Advertisement

Since HA is geographically distributed, it is needed to synchronize the Binding Cache information that each HA. As shown in Fig. 7, for the purpose of synchronization, HA utilizes the BCRA (Binding Cache Router Advertisement) message, which is a modified RA message.

0		16	32
Type	Code		Checksum
Cur Hop Limit	M O H A	Reserved	Router Lifetime
Reachable Time			
Retrans Timer			
Options(Binding Cache Entry) ...			

Fig. 7. Binding Cache Router Advertisement message

The destination address of the new BCRA message becomes the HA's unicast address belonging to the HA group. The basic value of the current Hop Limit field is assigned to 255 and made to reach geographically distributed HAs. The newly added A bit signifies the BCRA message. For the Option section, the BCRA message conveying HA's binding cache information is sent with the HA's Binding Cache information. The BCRA message is transmitted only when HA receives BU from the MN and must not exceed the maximum IPv6 MTU.

The HA that receives the BCRA message instantly update the Binding cache information for addition of new MN.

3.3 BU Operation Procedure

Fig. 8 illustrates the HA's BU operation in the GDMHA environment, when MN moved to HMIPv6's MAP then moved again to another MAP.

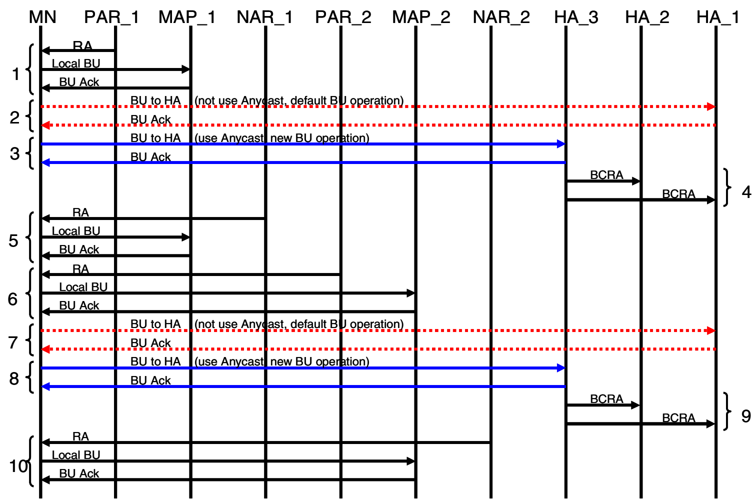

Fig. 8. MN's BU Operation Procedure

As illustrated in Fig. 9, the BU procedure that MN carries out to HA is as follows:
Procedures 2 and 7: Default BU operation
Procedures 3 and 8: New BU operation proposed by this paper

If we were to employ the method proposed by this paper, like the procedures 2 and 7, BU only carried out with the nearest HA. Therefore, BU delay can be extremely reduced.

4 Analysis of BU Delay

Like Fig. 2 during Location Update, proceeding after the Address Configuration, BU to HA and RR (Return Routability), and BU to CN process occur using a newly given CoA. All messages are not retransferred but obtained once; and when T_{work} represents work process being carried out, and $D_{x \cdot y}$ represents the message transfer delay between x and y, Location Update can be expressed by the following formula:

$$T_{LocationUpdate} = T_{BUtoHA} + T_{RR} + T_{BUtoCN} \tag{1}$$

Location Update process divided up in stages can be expressed as follows:

$$T_{BUtoHA} = D_{MN \cdot HA} + D_{HA \cdot MN} \tag{2}$$

$$T_{RR} = \max[(D_{MN \cdot HA} + D_{HA \cdot CN}), D_{MN \cdot CN}] + \max[(D_{CN \cdot HA} + D_{HA \cdot MN}), D_{CN \cdot MN}] \tag{3}$$

$$T_{BUtoCN} = D_{MN \cdot CN} + D_{CN \cdot MN} \tag{4}$$

Table 1. illustrates below, in hop units, BU operation between MN and HA_1, which is original HA of MN Fig. 5, BU operation between MN and the nearest HA_3 determined by using the geographically distributed multiple HA group's anycast operation.

Table 1. BU Delay Comparison in Existing BU and in Multiple HA Environment

	BU delay in current me thod		BU delay in proposed method	
	MAP_1	MAP_2	MAP_1	MAP_2
T_{BUtoHA}	14	14	8	10
$D_{MN \cdot HA}$	7	7	4	5
$D_{HA \cdot MN}$	7	7	4	5

As we see in Table 1, It is obvious that using GIA and carrying out BU with the nearest HA is more efficient then current way.

Fig. 9 and Fig. 10 show that there are noticeable decreases in delay with increase of the number of HAs.

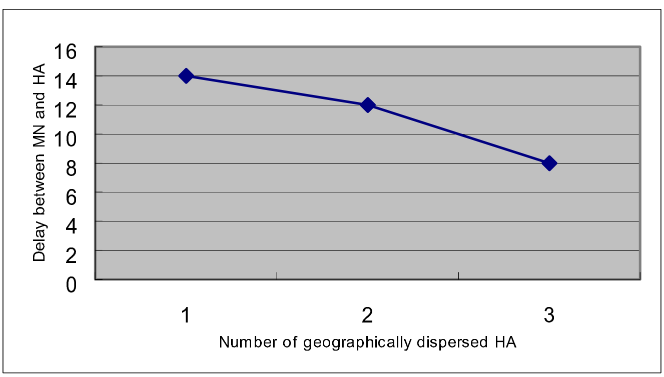

Fig. 9. $D_{MN \cdot HA}$ in MAP_1

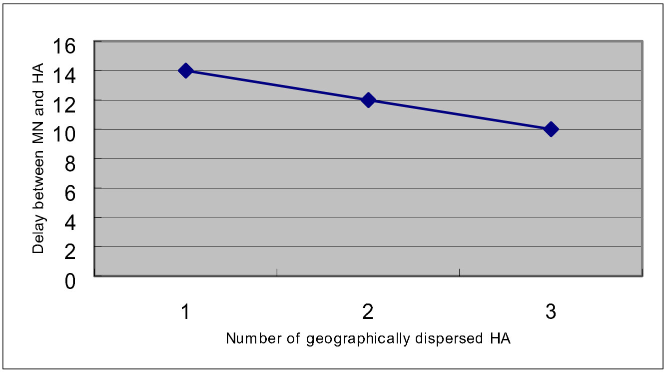

Fig. 10. $D_{MN \cdot HA}$ in MAP_2

5 Conclusions and Further Work

In order to reduce the MN's BU delay regarding HA, this paper has proposed the GDMHA (Geographically Distributed Multiple HAs). This mechanism resolved the BU delay problem of the existing HMIPv6's problem of BU delay between MAPs transfer. It is also effective when MN moves far away from the home network because BU delay can be reduced as HA is widely distributed over a large geographical area. Moreover, it would be a good example of and function well in anycast mobile environment, one of IPv6's address modes.

This mechanism can be effectively utilized within a single administrative domain, such as an ISP or a university campus. However, HA administrative information must be maintained and HA function needs to be augmented in order to manage the BCRA message for the purpose of Binding Cache entry exchange between HAs.

Further research activities proposed by this paper is research into the administrative information that HA, within GIA, needs to maintain and reducing the load generated during the Binding Cache entry exchange.

Acknowledgements

This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare, and Republic of Korea (02-PJ3-PG6-EV08-0001).

References

1. D. Johnson, C. Perkins, J. Arkko: Mobility Support in IPv6, RFC 3775, June 2004.
2. C. Perkins: Mobility Support in IPv4, RFC 3344, August 2002.
3. R. Koodli: Fast Handovers for Mobile IPv6, draft-ietf-mobileip-fast-mipv6-08.txt, October 2003.

4. H. Soliman, C. Castelluccia, K. El-Malki, and L. Bellier: Hierarchical Mobile IPv6 mobility management (HMIPv6), draft-ietf-mobileip-hmipv6-08.txt, Jun 2003.
5. R. Hsieh, Z.G. Zhou, A. Seneviratne: S-MIP: a seamless handoff architecture for mobile IP, INFOCOM 2003, Vol. 3, pp. 1173 - 1185, April 2003.
6. S. Sharma, Ningning Zhu, Tzi-cker Chiueh: Low-latency mobile IP handoff for infrastructure-mode wireless LANs, Selected Areas in Communications, IEEE Journal, Vol. 22, Issue 4, pp. 643 - 652, May 2004.
7. I. Vivaldi, M.H. Habaebi, B.M. Ali, V. Prakesh:Fast handover algorithm for hierarchical mobile IPv6 macro-mobility management, APCC 2003, Vol. 2, pp. 630 - 634, Sept. 2003.
8. I. Vivaldi, B.M. Ali, H. Habaebi, V. Prakash, A. Sali: Routing scheme for macro mobility handover in hierarchical mobile IPv6 network, Telecommunication Technology, 2003. NCTT 2003 Proceedings. 4th National Conference on , pp. 88 - 92, Jan. 2003.
9. S. Weber, Liang Cheng: A survey of anycast in IPv6 networks, IEEE Communications Magazine, Vol. 42, Issue 1, pp. 127 - 132, Jan. 2004.
10. D. Katabi, J. Wroclawski: A Framework for Scalable Global IP-Anycast (GIA), ACM SIGCOMM Computer Communication Review, Vol. 30, Issue 4, pp. 315, Oct 2000.