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Evaluation of Handover Latency in Intra-Domain Mobility

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***Abstract*—**Mobile IPv6 (MIPv6) describes how mobile node can change its point of attachment from one access router to another. As a demand for wireless mobile devices increases, many enhancements for macro-mobility (inter-domain) protocols have been proposed, designed and implemented in Mobile IPv6. Hierarchical Mobile IPv6 (HMIPv6) is one of them that is designed to reduce the amount of signaling required and to improve handover speed for mobile connections. This is achieved by introducing a new network entity called Mobility Anchor Point (MAP). This report presents a comparative study of the Hierarchical Mobility IPv6 and Mobile IPv6 protocols and we have narrowed down the scope to micro-mobility (intra-domain). The architecture and operation of each protocol is studied and they are evaluated based on the Quality of Service (QoS) parameter; handover latency. The simulation was carried out by using the Network Simulator-2. The outcome from this simulation has been discussed. From the results, it shows that, HMIPv6 performs best under intra-domain mobility compared to MIPv6. The MIPv6 suffers large handover latency. As enhancement we proposed to HMIPv6 to locate the MAP to be in the middle of the domain with respect to all Access Routers. That gives approximately same distance between MAP and Mobile Node (MN) regardless of the new location of MN, and possible shorter distance. This will reduce the delay since the distance is shorter. As a future work performance analysis is to be carried for the proposed HMIPv6 and compared to HMIPv6.

***Keywords*—**Intra-domain mobility, HMIPv6, Handover Latency, proposed HMIPv6.

I. Introduction

WIRELESS attachments to the Internet require mobility management for having the devices stay connected while moving between different points of attachment. Mobile IPv4 [1] is an Internet standards protocol, which enhances the existing Internet Protocol (IP) to accommodate mobility.

Over the Internet, when a MN moves and attaches itself to another domain, it needs a new IP address. With this all the existing connections with the home agent (HA) will be terminated. Mobile IP was introduced to overcome this problem. But later on, Mobile IPv4 itself experiences its own other discrepancies. This is when the packets destined for the mobile node (MN) are tunneled from the HA to the visited network. Correspondent nodes (CN) that want to send packets to the MN have to send them via the HA. This causes non optimal triangular routing.

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A route optimization option to Mobile IPv4 can eliminate this triangle routing by allowing CN to cache bindings of the MN current location. They can then tunnel the packets directly to the MN (to its care-of address) without going through the HA. Every new location has to be registered with HA that are actively communicating with the MN. However, route optimization option, may be difficult to run in practice. Thus, in MIPv6 [2], the support for route optimization is built in as a fundamental part of the protocol, rather than being added on as an optional set of extensions as in Mobile IPv4. However, MIPv6 is applicable only for the inter domain mobility, in case of intra-domain, it suffers large handover latency. Hence, HMIPv6 [3] was proposed as the enhancement of the MIPv6 to reduce the handover latencies. This is where the new entity, Mobility Anchor Point (MAP) has been introduced.

Mobility management refers to location and handover management. In this paper, we present performance analysis of the Hierarchical Mobile IPv6 and Mobile IPv6 protocols. It is organized as follows. Section 2 describes briefly the protocol overview. A simulative evaluation and the analysis of standard Mobile IPv6 in comparison with Hierarchical MIPv6 via *ns-2* are presented in section 3; section 4 contains results of the simulation. The proposed enhancement for HMIPv6 is point up in section 5, followed by the conclusion in section 6.

II. Protocol Overview

Intra-domain mobility means a Mobile Node (MN) moves within the domain. The MN gets a new Care of Address (CoA) on its new point-of attachment. HMIPv6 is considered as a proposed protocol for intra-domain mobility because it differentiates between intra-domain mobility management scheme and inter-domain mobility management scheme. The MN will have 2 CoAs which is Local Care of Address (LCoA) and Regional Care of Address (RCoA). The RCoA remains constant as long as the MN is roaming locally. Thus, MN mobility is completely hidden in intra-domain mobility. This is achieved by introducing the new entity, Mobility Anchor Point (MAP), which will improve the handover latency as well.

Figure 1 briefly explains the intra-domain mobility in HMIPv6:

- MAP sends the advertisement (contains RCoA) to all Access Router (AR) within its region.
- A MN entering a MAP domain receives Router Advertisement (RA) from nearest AR that contains information (RCoA) on one or more local MAPs.
- Then, MN sends Local Binding Update (LBU) only which contains LCoA to MAP.

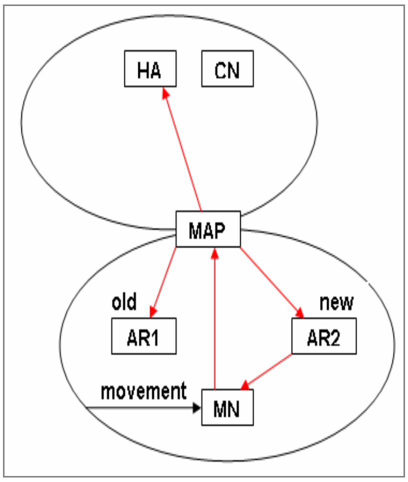

Fig. 1 HMIPv6

While in figure 2, it explains the intra-domain mobility in MIPv6:

- AR sends the advertisement (contains CoA) to MN.
- Then, MN will choose the nearest AR.
- Finally, it will send a Binding Update (BU) to CN and HA.

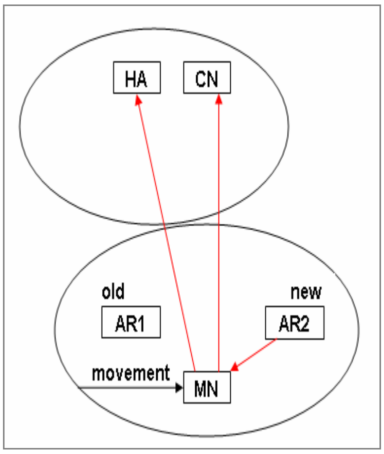

Fig. 2 MIPv6

From the above brief explanation, it could be clearly pointed out the involvement of the Home Agent (HA) in each MN's movement, in case of MIPv6. This causes considerable handover latency.

III. Simulation

A. *ns Simulator*

The Network Simulator, NS-2 [4] that supports for HMIPv6 which is *ns-2.1b7a* [5], was used for the evaluation of the protocols.

B. *Simulation Scenario*

The goal of this simulation is to examine and compare between HMIPv6 and MIPv6 in terms of handover latency. *Handover Latency* is defined for a receiving MN as the time that elapses between the last packets received via the old access router (oldAR) and the arrival of the first packet along the new access router (newAR) after a handover. Thus, this is the time during which the Mobile Node can neither receive, nor send IP traffic. Fig. 3 shows the network topology used for simulation experiment handover. The link characteristics namely the bandwidth (megabits/s) and the delay (milliseconds), are shown beside the link. The access routers are set to be 70 meters apart with free space in between. The wireless coverage area of the access router is approximately 40 meters. Finally, our model assumes a well-behaved mobile node movement pattern where the mobile node moves linearly from one access router to another at a constant speed of 1m/s.

Table 1 explains the nodes topology for both protocols.

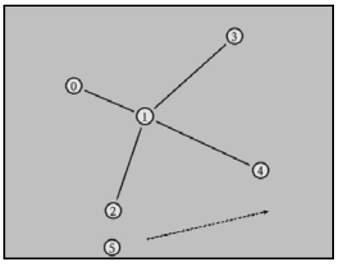

Fig. 3 Simulation network topology

TABLE I
NODE DESCRIPTION

	HMIPv6	MIPv6
Node 0	Corresponding Node	Corresponding Node
Node 1	Mobility Anchor Point	-
Node 2	Old Access Router	Old Access Router
Node 3	Home Agent	Home Agent
Node 4	New Access Router	New Access Router
Node 5	Mobile Node	Mobile Node

IV. Results and Discussion

A. *Handover Latency*

Figure 4 shows the handover effect where it is evaluated based on the graph of cumulative sum of the packets sent from CN to MN versus time in seconds.

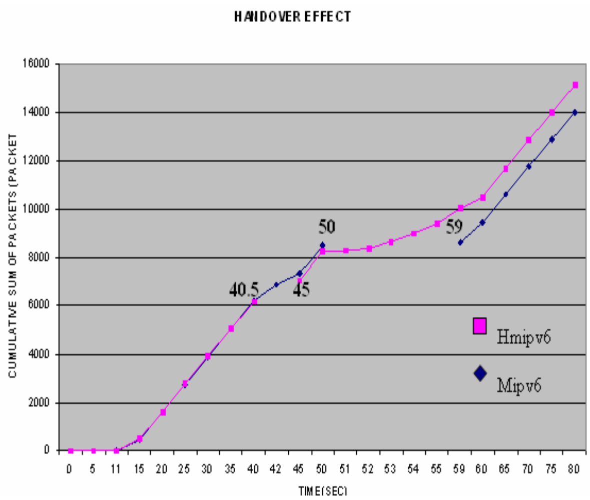

Fig. 4 Handover effect

The following observations can be made about figure 4:

i. CN starts to communicate with MN by sending packets at 11s after it finishes its registration and all the setup links with HA and MN.

ii. Then, at around 40s, packets lost/reordering begin to occur where at this moment, MN has moved to a new AR. However, this situation only happened in HMIPv6. In MIPv6, even though it suppose to start at the same time but due to the location of HA is quite further away from MN, thus, the delay will be increased. Since MN is always contact to HA in order to tunnel the packet from/to CN, then, it affects the movement of MN to the new AR. As a result of the packets lost/reordering, slow start activity can be observed thereafter.

iii. After around t =45s for HMIPv6 and 49s for MIPv6, eventually, the transmission returns to normal. The overall handover latency, defined as the time when the MN detaches from the network at layer-2 till the disrupted communication session is returned to full operational state, is approximately 4500ms for HMIPv6 and 9000ms for MIPv6.

From the figure, we found that the time in HMIPv6 protocols between the last moment where the MN can receive and send packets through the old Access Router and the first moment where it can receive and send packets through the new Access Router is shorter compared to MIPv6.

V. Proposed Enhancement

In this paper, we proposed a new enhancement in our current HMIPv6 protocol. We emphasized more into MAP location issues.

In the current protocol MAP is located mostly at the edge of the network. The reason is to be closed to CN and HA. Normally, the researchers did not specify the exact location of the MAP. It can reside anywhere within the domain. Therefore, the distance between MAP and MN is longer and results in longer delay or latency. Due to the problem or limitation that we faced, we come out with a new proposed enhancement in terms of MAP location.

We proposed MAP to be located in the middle of the domain with respect to all ARs. That gives approximately same distance between MAP and MN regardless of the new location of MN, and possible shorter distance. This will reduce the delay since the distance is shorter. We also have to take note that the proposed enhancement that we made does not affect other Quality of Service such as signaling and packet loss except for delay only. Once again, this is due to the MAP location that only involved with distance.

VI. Conclusion

This paper presents a comparative study of intra domain mobility between HMIPv6 and MIPv6. We have shown through the simulation that HMIPv6 perform best in terms handover latency compared to MIPv6. MIPv6 suffers longer handover latency because the time to send back the BU at new AR to the CN takes longer time. However, the handover latency for HMIPv6 is still quite large, thus as enhancement we proposed to HMIPv6 to locate the MAP to be in the middle of the domain with respect to all ARs. That gives approximately same distance between MAP and MN regardless of the new location of MN, and possible shorter distance. This will reduce the delay since the distance is shorter.

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