Chapter 7.29
A Study on the Performance of IPv6-Based Mobility Protocols:
Mobile IPv6 vs. Hierarchical Mobile IPv6

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ABSTRACT

The performance of IP mobility protocols is highly dependent on the change of mobile nodes' (MNs') mobility and traffic-related characteristics. Therefore, it is essential to investigate the effects of these characteristics and to conduct an in-depth performance study of these protocols. In this paper, we introduce a novel analytical approach using a continuous-time Markov chain model and hierarchical network model for the performance analysis of IPv6 mobility protocols: Mobile IPv6 (MIPv6) and Hierarchical Mobile IPv6 (HMIPv6). According to these analytical models, we derive the location update costs (i.e., binding update costs plus binding renewal costs), packet tunneling costs, and total signaling costs, which are generated by an MN during its aver-

age domain residence time, when MIPv6 or HMIPv6 is deployed under the same network architecture, respectively. In addition, based on these derived costs, we investigate the effects of various parameters, such as the average speed of an MN, binding lifetime period, the ratio of the network scale, and packet arrival rate, on the signaling costs generated by an MN under MIPv6 and HMIPv6. Moreover, we conduct the performance comparison between these two protocols by showing the relative total signaling costs under the various conditions. The analytical results show that as the average speed of an MN gets higher and the binding lifetime period is set to the larger value or as its packet arrival rate gets lower, the total signaling cost generated by an MN during its average domain residence time under HMIPv6 will get relatively lower than that under

MIPv6, and that under the reverse conditions, the total signaling cost under MIPv6 will get relatively lower than that under HMIPv6.

INTRODUCTION

The demand for anywhere, anytime high-speed Internet access has been a driving force for the increasing growth and advances in wireless/ mobile communication and portable devices. As a consequence, these trends have prompted research into mobility support in networking protocols. The IETF Mobile IP working group has proposed Mobile IPv4 (MIPv4) (Perkins, 1997, 2002) as a main protocol for supporting IP mobility. However, MIPv4 has some problems, such as triangle routing, security, and limited IP address space. Thus, based on the next generation Internet protocol, IPv6, Mobile IPv6 (MIPv6) (Johnson, 2004) has been developed by the IETF with new functionalities. In MIPv6, when a mobile node (MN) moves from one subnet to another, it acquires a care-of-address (CoA) by stateless address autoconfiguration (Johnson, 2004). After configuring the CoA, the MN registers the association between the CoA and its home address (HoA) by sending a binding update (BU) message to its home agent (HA) or correspondent node (CN). Although MIPv6 solves some drawbacks addressed in MIPv4, it still has a problem, nevertheless. That is, MIPv6 handles local mobility of an MN in the same way as it handles global mobility. As a result, an MN sends the BU message to its HA and its CN each time it changes its point of attachment, regardless of locality. Such an approach may cause excessive signaling traffic, especially for MNs with relatively high mobility or long distance to their HAs or CNs. In addition, this approach is not scalable, since the signaling traffic generated by the MNs can become quite overwhelming as the number of the MNs increases. In order to overcome these drawbacks, Hierarchical Mobile IPv6 (HMIPv6) (Castelluc-

cia, 2000; Soliman, 2004) has been proposed to accommodate frequent mobility of the MNs and to reduce the signaling load in the backbone networks. In addition, handoff performance may be improved by reducing handoff latency. HMIPv6 introduces a new entity, the mobility anchor point (MAP), which works as a proxy for the HA in a foreign network. When an MN moves into a network controlled by a new MAP, it configures two CoAs: a regional care-of-address (RCoA) and an on-link care-of-address (LCoA). The RCoA is an address on the MAP's subnet, whereas the LCoA is an address configured to the MN's current point of attachment. Figure 1 shows the basic operation of HMIPv6. When the MN first enters a MAP domain, it sends the BU message to the MAP, the HA, and, potentially, to the CNs. When an MN changes the subnets within a same MAP domain, it only sends the BU message to the MAP. In other words, if the MN changes its current LCoA within a MAP domain, it only needs to register its LCoA with the MAP. The RCoA does not change, as long as the MN moves within the same MAP domain. This makes the MN's mobility transparent to the HA and the CNs. However, this does not imply any change to the periodic binding renewal (BR) message that an MN has to send to the HA and the CN, and now an MN additionally should send it to the MAP. In addition, since the MAP acts as a local HA, it receives all packets on behalf of the MNs that it is serving and tunnels the received packets to the MN's current LcoA.

Generally, the performance of IP mobility protocols may vary widely, depending on the change of MNs' mobility and traffic-related characteristics (Campbell, 2002). Our previous work on HMIPv6 (Kong, 2004) also revealed that such characteristics are the crucial factors that significantly may affect the signaling load on the Internet. Therefore, it is essential to analyze and evaluate the IP mobility protocols under various conditions, and more in-depth study on these protocols should be considered as the first step

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