UNIVERSITI PUTRA MALAYSIA

IMPROVED HANDOVER ROUTING SCHEME IN HIERARCHICAL MOBILE IPv6 NETWORKS

INDRA VIVALDI

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By

INDRA VIVALDI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Partial Fulfillment of the Requirement for the Degree of Master of Science

May 2003

Dedicated to

My Loving Parents, My dear siblings and my dear Puyi for their endless care and comfort,

Thank You

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in partial fulfillment of the requirement for the degree of Master of Science

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By

INDRA VIVALDI

May 2003

Chairman: Professor Borhanuddin Mohd Ali, Ph.D.

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Mobile Internet Protocol version 6 (MIPv6) has been proposed to solve the problem of mobility in the new era of Internet. MIPv6 is a proposal for handling routing of IPv6 packets to mobile nodes that have moved away from their home network. In the near future, with the simultaneous growth of the mobile user population and the Internet, users will move more frequently between networks as they stay connected to the Internet and access its resources. Thus, as mobility increases across networks, handovers will significantly give impact on the quality of the connection and on user application.

Previous research has shown that MIPv6 only defines a means of managing global mobility (macro-mobility) but does not address local mobility (micro-mobility) separately. Instead, it uses the same mechanism in both cases. This involves long handover delay and a lot of signaling. The extension of protocol of basic MIPv6 has been investigated. Internet Engineering Task Force (IETF) introduced Hierarchical Mobile IPv6 (HMIPv6). HMIPv6 is the proposed enhancement of MIPv6 that is

designed to reduce the amount of signaling required and to improve handover speed for mobile connections. New node in HMIPv6 called the mobility anchor point (MAP) serves as a local entity to aid in mobile handover. By separating global and local mobility, HMIPv6 makes it possible to deal with either situation of macro mobility and micro mobility appropriately. The MAP helps to decrease the delay and packet loss during handover.

HMIPv6's handover operation has been investigated. We have analyzed the handover routing scheme on Internet Protocol (IP) layer. The operation of this handover starts from the mobile node (MN) sends binding update (BU) to its new network until MN receives packet from the correspondent node (CN) or home agent (HA) through its new network.

The adoption of multicast scheme and the avoidance of redundancy in sending binding update scheme have been proposed and have been implemented to HMIPv6. Proposed multicast scheme may allow MN to receive packets during handover operation. The avoidance of redundancy in sending BU scheme may reduce the amount of signaling for the handover thus reduce the handover delay. We have tested the performance of HMIPv6 with the proposed schemes based on simulation study. The results show that our proposed schemes reduce the handover delay and the amount of packet loss in HMIPv6.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia untuk memenuhi sebahagian daripada keperluan Ijazah Master Sains

SKEMA PENGAMBILALIHAN PENGHALAAN PADA RANGKAIAN HIRARKI PROTOKOL INTERNET VERSI 6 BERGERAK

Oleh

INDRA VIVALDI

Mei 2003

Pengerusi : Profesor Borhanuddin Mohd. Ali, Ph.D.

Fakulti : Kejuruteraan

Protokol Internet bergerak versi ke-6 (MIPv6) telah dianjurkan untuk menyelesaikan masalah berhubung-kait dengan kebolehgerakan pada protocol Internet versi ke-6. MIPv6 adalah anjuran untuk memperlakukan penghalaan pada paket protokol Internet versi ke-6 (IPv6) kepada titik bergerak yang telah berpindah daripada rangkaian awalnya. Menjelang masa depan, dengan adanya pertumbuhan selari antara Internet dan pengguna rangkaian bergerak, para pengguna rangkaian bergerak akan bergerak lebih banyak dari satu rangkaian ke rangkaian yang lain seiring dengan mereka terhubung kepada Internet. Oleh karena itu, seiring dengan kobolehgerakan meningkat diantara rangkaian-rangkaian, proses pengambilalih sangat mempengaruhi kualiti sambungan dan aplikasi pengguna.

Kita telah mempelajari bahwa MIPv6 hanya mengerusi kobolehgerakan makro tetapi tidak mengerusi kobolehgerakan mikro secara terpisah. Ataupun MIPv6 menggunakan proses yang sama dalam dua kes tersebut. Ini mengakibatkan masa pengambilalih yang tinggi dan banyak proses pemberian isyarat. Angkatan Kejuruteraan Tugasan Internet (IETF) memperkenalkan Hirarki Protokol Internet

versi ke-6 bergerak (HMIPv6). HMIPv6 adalah peninggian yang dianjurkan daripada MIPv6 yang telah dibentuk untuk mengurangi jumlah dari proses pemberian isyarat yang diperlukan dan untuk meningkatkan kelajuan pengambilalihan untuk sambungan rangkaian bergerak. Satu unsur baru pada HMIPv6 iaitu Titik Jangkar Kobolehgerakan (MAP) melayani sebagai kesatuan tempatan untuk membantu proses pengambilalih rangkaian bergerak. Dengan memisahkan global dan tempatan kebolehgerakan, HMIPv6 memungkinkan mengerusi ke dua keadaan dengan tepat. MAP membantu mengurangi masa gangguan dan paket hilang selama masa pengambilalih.

Kita telah menganalisis skema penghalaan untuk proses pengambilalih pada lapisan protocol internet. Proses pada pengambilalihan ini dimulai pada saat titik bergerak (MN) menghantar pesan pembaharuan berjilid (BU) kepada unsur rangkaian yang baru sampai MN menerima paket dari titik pengirim (CN) atau dari rangkaian asal (HA) melalui rangkaian yang baru. Pemakaian skema multi penghantaran dan skema penghindaran daripada penghantaran berulang pesan pembaharuan berjilid telah dianjurkan. Kita telah melaksanakan skema-skema tersebut kepada HMIPv6. Skeme multi penghantaran membolehkan MN menerima paket selama proses pengambilalih. Skema penghindaran daripada penghantaran berulang pembaharuan berjilid dapat mengurangi jumlah proses pemberian isyarat demikian dapat mengurangi masa gangguan pada proses pengambilalih.

Kita telah menguji keupayaan daripada HMIPv6 dan skema yang kita anjurkan dengan berdasar pada simulasi. Hasil menunjukkan bahwa skema yang dianjurkan dapat mengurangi masa gangguan pada proses pengambilalih dan jumlah paket hilang daripada dasar HMIPv6

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I certify that an Examination Committee met on 7th May 2003 to conduct the final examination of Indra Vivaldi on his Master of Science thesis entitled "Improved Handover Routing Scheme in Hierarchical Mobile IPv6 Networks" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded a relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as partial fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.

INDRA VIVALDI

Date: 27 MAY 2003

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LIST OF ABBREVIATION

AR	Access Router
B_ack	Binding Acknowledgment
BU	Binding Update
CBR	Constant Bit Rate
CN	Correspondent Node
CoA	Care of Address
DAD	Duplicate Address Detection
FA	Foreign Agent
FTP	File Transfer Protocol
GPRS	Global Packet Radio Services
GSM	Global System for Mobile Communication
HA	Home Agent
HMIPv6	Hierarchical Mobile Internet Protocol version 6
HTTP	Hyper Text Transfer Protocol
ICMPv6	Internet Control Message Protocol version 6
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ITU	International Telecommunication Union
LAN	Local Area Network
LCoA	On Link care of address
MAP	Mobility Anchor Point
MIPv6	Mobile Internet Protocol version 6
MN	Mobile Node
NS-2	Network Simulator version 2
OSI	Open Source Institute
RCoA	Regional Care of Address
TcL	Tool Command Language
TCP	Transport Control Protocol
UMTS	Universal Mobile Telecommunication services

UDP	User Datagram Protocol
VOIP	Voice Over Internet Protocol
W-CDMA	Wide Code Division Multiple Access
3GPP2	The Third Generation Partnership Project version 2
CTP	Context Transfer Protocol

CHAPTER 1

INTRODUCTION

People's expectation for sophisticated communication system is getting higher all the time. People are becoming more critical for every technologies provided for them as they look for the most convenient one.

The most famous communication system that can support mobility is GSM (Global System for Mobile Communication). GSM is a wireless communication technology that have a lot of advantages such as the flexibility of providing integrated voice mail, high speed data, fax, SMS, additionally GSM supports full-featured, seamless roaming between GSM systems in the world. However GSM still has to be set with problems such as limited bandwidth and high cost. GSM is now almost saturated and are no longer able to fulfill users more sophisticated demand. People need communication systems that are cheap, flexible, scalable and more interactive than voice. GSM could not meet those demands due to the lack of bandwidth on the wireless interface, the form factor of wireless devices and the cost of wireless services.

The introduction of GPRS (General Packet Radio Service) in the wide area absolute based on IP (Internet Protocol) technology provides an extension to the GSM technology. Mobile users being permanently connected and expected to be able to support multimedia application and the usage of IP technologies at the backbone will be able to reduce the cost of wireless services. At the same time, another wireless technology has been introduced based on the IP technology, specifically in the local area. This wireless LAN allows the user to interconnect to the wide area networks, such as GPRS or UMTS. Both wide area wireless networks and local area wireless network have their own good feature and drawbacks; usually a trade-off between capacity and mobility. Pricing is another key factor that concern to users. Users need the cheapest and fastest connection. An operator that is able to offer a complete system that provides seamless roaming between different wireless systems will be the winning player for the next communication system provider. The trend for the next generation communication system focuses on real-time traffic and the mobility support between different communications systems. Several groups for standardization area in communication system such as 3GPP2, and ITU have defined that the core network of the next generation mobile network will be pure IP based.

Currently, we have to face several problems due to IP immobility. Problems occur when somebody disconnects his mobile device from the Internet in order to reconnect it elsewhere. Normally he would not be able to continue communication until he configures the system with a new IP address and new default routers.

The problem is based on the IP routing schemes. IP addresses define a kind of topological relation between the linked computers. Today's version of Internet protocols assumes implicitly that any node has always the same point of attachment to the Internet. Additionally the node's IP address identifies the link on which the nodes reside. If a node moves without changing its IP address, there is no information in the new network about the new point of attachment.

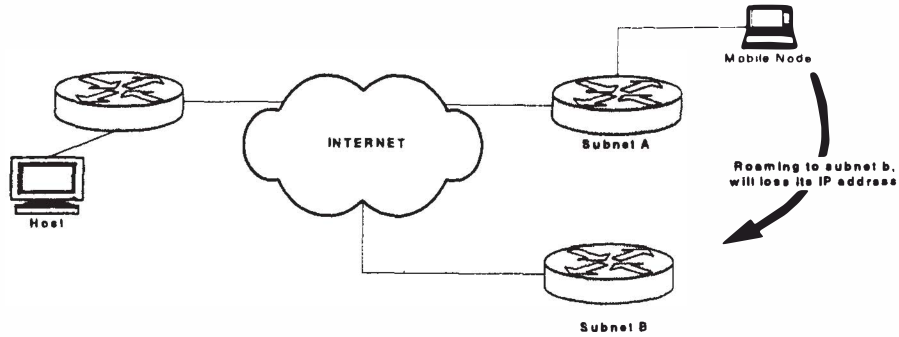

Figure 1.1: A node roams without changing its IP address

We can see from the figure 1.1, the packets are routed to subnet A and sent to mobile node. If this mobile node roams to another subnet, it will not receive the packets since the packets addressed to this mobile node are routed to subnet A.

IP mobility is specified for IPv4. Mobile IPv4 is not deployed widely enough to satisfy current mobile needs such as limited address space, triangle routing that cause long delays and overloaded network capacity especially in foreign network.

1.1. Problem Statements

The usage of IP as a transport technology solves several inter-working problems between different technologies. IP may become the core network for real time traffic, interactive services such as telephony, video conferencing and online games. Mobility support for Internet devices is becoming more important, since mobile computing is getting more pervasive. It is expected that in the near future, the number of mobile computers, including handheld devices will increase exponentially. However, IP technology is still far from the solution. IP was not developed to support each and every existing technology. In particular, IP protocol suffers from mobility restriction since IP was designed for a stationary environment that makes mobility difficult.

Several solutions have been introduced to support mobile devices, which dynamically changes the point of attachment to the Internet. The problems of mobility have been developed inside IETF (Internet Engineering Task Force) since 1996, with IPv4. The purpose is to enhance the conventional IP to support mobility called Mobile IPv4 associated with wireless technology; this allows movement from networks to networks. Mobile IPv4 handles mobility at the IP layer, which makes the mobility transparent to the application running over IP.

The next generation Internet called IPv6 has built in mobility support in the standard. This alleviates the drawback suffered in Mobile IPv4. Mobile IPv6 is designed to be efficient, robust and scalable. However the extensions to Mobile IPv6 are still necessary in order to provide higher grades services, such as real-time application support. The problem in Mobile IPv6 occurs when mobile users want to roam from one network to another network that need special handover operation. In order to support the applications, the handover operation must not significantly cause communications interruptions.

As noted in (Nokia, 2001), Mobile IPv6 is designed to address the macro-mobility management problem, such as supporting host mobility over wide area network. Mobile IPv6 does not address micro-level mobility issues. Studies and investigations to solve the drawbacks in Mobile IPv6 should be considered especially in handover operation.

1.4

Hierarchical Mobile IPv6 (HMIPv6) is an extension to Mobile IPv6 that is designed to reduce the signaling load and improve handover speed for mobile connections by introducing new protocol agents called mobility anchor point (MAP). This network element splits the mobility management into macro mobility and micro mobility schemes. However HMIPv6 only improves the micro mobility problem. Significant delays still occur in the HMIPv6 macro mobility management because the handover algorithm is similar with the Mobile IPv6 in this environment. However, there are still long interruptions in handover in micro-mobility, which can still be reduced.

In this thesis, we propose a new handover algorithm that overcomes the limitations in Mobile IPv6 and its extension HMIPv6. Our objective is to re-establish the communication traffic flow quickly and to minimize the service disruption delay that occurs during handover process in a macro and micro mobility environment. This handover algorithm is based on the modification of the HMIPv6 protocol using the multicast technique concept. Basically, we implement the multicast technique on the MAP, which allows the MAP to multicast the packets to the same single mobile user. However, our proposed algorithm is not strictly the same as the base multicast technique, thus we define our proposed technique as a multicast-like algorithm, since it only resembles multicasting during handover rather than multicasting for distribution. This multicast-like algorithm will enable the mobile node to receive packets faster than HMIPv6 protocol during handover, seamlessly and transparently.

1.2. Scope of Works

Mobile IPv6 mechanism requires some handover algorithm when it changes its point of attachment in the Internet. This causes Mobile IPv6 to incur long delays and signaling load to the backbone networks. This limitation is due to the lack of hierarchy in the Mobile IPv6 mobility management that it uses the same mechanisms for macro mobility and micro mobility. This is an inefficient use of resources in the case of local mobility.

This thesis tries to examine the problem that causes delays during handover operation in Mobile IPv6 and its extension, the HMIPv6. Registration operation is part of the handover operation in Mobile IPv6 protocol that can cause communications interruptions and this thesis will analyze and consider the registration operation. Since this operation is on the network layer, we can model for this operation based on the routing scheme from the related protocol agents, such as mobile node, access router, and the correspondent node. However, the handover on the lower layer e.g., physical layer and link layer are out of the scope of this thesis.

1.3. Research Objectives

The aim of this thesis are defined as follows:

1. To investigate the design issues for supporting mobility in Internet Protocols,
2. To study several handover routing schemes for Mobile IPv6,
3. To examine the problem of performing handover routing scheme in Mobile IPv6,

4. To analyze the drawback of handover routing scheme in Mobile IPv6.
5. To propose routing schemes for handover operation in Mobile IPv6.
6. To evaluate the performance of the routing scheme based on the delay and packet loss.

1.4. Thesis Organization

The remainder of this thesis is organized as follows: Chapter 2 starts with a brief discussion of the concept of internet reference model, then a discussion of the proposal of the Mobile IPv4 by IETF. This includes the advantages of Mobile IPv4, Mobile IPv4 overview, the terminology of Mobile IPv4 followed by Mobile IPv4's drawbacks. Secondly we discuss the enhancement of Mobile IPv4 and the next IP next generation that is Mobile IPv6 and IPv6 respectively. This chapter describes the terminology of Mobile IPv6, the handover operation of Mobile IPv6, the advantages of Mobile IPv6 compared to Mobile IPv4 and we also discuss the handover management issues in mobile IPv6 network and the problem occurs due to the handover operation. This chapter also concerns with the discussion of HMIPv6 as the extension of basic Mobile IPv6 that is able to solve some problem due to handover operation. Chapter 3 describes the scope of the research and the proposal for HMIPv6 and the detailed description of the handover routing scheme on IP layer for HMIPv6 and our proposal routing scheme and also this chapter presents a performance testing for HMIPv6 handover routing scheme and our proposal handover routing scheme using simulation tools. Then a comparison of them is made. In chapter 4 we show our results and finally in chapter 5 we conclude our work with a brief summary of the overall work.