UNIVERSITI PUTRA MALAYSIA

MULTICAST-BASED MOBILE IPv6 JOIN/LEAVE MECHANISM SOFTWARE

SAHAR A. M. ALI

MULTICAST-BASED MOBILE IPv6 JOIN/LEAVE MECHANISM SOFTWARE

By

SAHAR A. M. ALI

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

March 2003

Dedicated to

My husband and
my beloved children,
Shaymaa, Zainab, Rashad, Safa, and Abdullah

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

MULTICAST-BASED MOBILE IPv6 - JOIN/LEAVE MECHANISM SOFTWARE

By

SAHAR A. M. ALI

March 2003

Chairperson: **Borhanuddin Mohd. Ali, Prof.**

Faculty: **Engineering**

Increasing demand for mobility in the Internet has created the need for a routing protocol that allows a host to roam in the network. Mobile IP is a solution that enables an IP host to leave its home link while transparently maintaining all of its present connections and remaining reachable to the rest of the Internet.

The Internet Engineering Task Force (IETF) has standardized Mobile IPv4. Mobile IPv6 is a work in progress in the IETF, offering support for IPv6 mobile nodes. Although it is not yet standardized, every IPv6 node is required to implement Mobile IPv6, which means that mobility must be widely supported.

IP-multicast provides efficient algorithms for multiple packet delivery. It also provides location-independent group addressing. The receiver-initiated approach for IP-multicast enables new receivers to join to a nearby branch of an already established multicast tree. Hence, IP-multicast provides a scalable infrastructure for efficient, location-independent, packet delivery.

The recent advances in wireless communication technology and the growth of the Internet have paved the way for wireless networking and IP mobility. Unlike conventional wired networks, wireless networks possess different channel characteristics and mobility dynamics that render network design and analysis more challenging. Performance during handoff where the mobile moves from one cell, or coverage area, to another is a significant factor in evaluating wireless networks.

This thesis investigates how the advantages of using IP-multicast with IP mobility can be merged to improve the performance of the network. As the mobile node roams across the network, we want packets destined to it to follow it throughout its movement. This can be done through a dynamic distribution tree that has been constructed with branches reaching all locations visited by the mobile node during its journey. These branches constitute the shortest paths from the packet source to each of the visited locations. The tree is dynamic such that the branches grow and shrink to reach the mobile node as necessary, when necessary. This architecture is multicast-based, in which a mobile node is assigned a multicast address, and the correspondent nodes send packets to that multicast group. As the mobile node moves to a new location, it joins the multicast group through the new location and prunes through the old location. Dynamics of the multicast tree provide for smooth handoff, efficient routing, and conservation of network bandwidth.

To allow a smooth handoff, the mobile node should not prune the old location until/unless it starts getting packets from the new location.

This thesis describes also the mechanism developed for realizing such an architecture. Hash algorithm has been implemented as a mechanism for a mobile node to join and leave a multicast group. In addition to that, a software has been developed to implement

this algorithm for simulation purposes, to calculate the handoff latencies for the mobile node. The simulation results show that the dynamics of joining and leaving the group directly affect handoff latency and smoothness, as a result it conserve Radio Frequency (RF) bandwidth.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan ijazah Master Sains

PROTOKOL INTERNET MOBIL VERSI 6 BERASASKAN BERBILANG HEBAH - PERISIAN MEKANISMA MASUK/KELUAR

Oleh

SAHAR A. M. ALI

MAC 2003

Pengerusi : Profesor Borhanuddin Mohd. Ali

Fakulti : Kejuruteraan

Peningkatan permintaan mobiliti dalam Internet telah mewujudkan keperluan untuk protokol laluan yang membenarkan suatu tuan (host) untuk bergerak di dalam rangkaian. Protokol Internet Mobil (Mobile IP) adalah penyelesaian yang membolehkan suatu tuan protokol Internet untuk meninggalkan sambungan rumahnya sambil mengekalkan semua sambungan terkininya dan masih boleh dihubung oleh seluruh Internet.

Pasukan Petugas Kejuruteraan Internet (IETF) telah memiawaikan Protokol Internet Mobil versi 4 (Mobile IPv4). Protokol Internet Mobil versi 6 (Mobile IPv6) yang masih dimajukan dalam IETF, menawarkan sokongan kepada nod protokol Internet mobil versi 6. Walaupun ia belum dipiawaikan, setiap nod protokol Internet versi 6 dikehendaki melaksanakan Protokol Internet Mobil versi 6, ini bermakna bahawa ciri-ciri mobiliti perlu disokong.

Protokol Internet berbilang hebah memberi algoritma yang efisien untuk penghantaran banyak bungkusan. Ia juga memberi pengalamatan berkumpulan yang tidak bergantung kepada lokasi. Pendekatan yang dimulakan dari penerima untuk protokol Internet

berbilang hebah membolehkan penerima baru untuk memasuki cawangan baru daripada pokok berbilang hebah yang sudah dikukuhkan. Maka, protokol Internet berbilang hebah memberi infrastruktur berskala untuk penghantaran bungkusan yang efisien dan bebas lokasi.

Kemajuan terkini dalam teknologi komunikasi wayarles dan perkembangan Internet telah membuka jalan untuk perangkaian wayarles dan mobiliti protokol Internet. Berbeza daripada rangkaian berwayar biasa, rangkain wayarles mempunyai ciri-ciri saluran yang berlainan dan mobiliti berdinamik yang menjadikan reka bentuk dan analisa rangkaian lebih mencabar.

Kelakuan sistem semasa penyerahan (handoff) dimana mobil bergerak dari suatu sel, atau kawasan liputan, ke lain adalah faktor yang penting dalam penilaian rangkaian wayarles.

Tesis ini menyelidik bagaimana kegunaan protokol Internet berbilang hebah dengan mobility protokol Internet boleh digabungkan untuk meningkatkan kebolehan rangkaian. Semasa nod mobil bergerak dalam rangkaian, kita mahu bungkusan itu mengikuti pergerakannya. Ini boleh dilakukan melalui pokok pengedaran dinamik yang telah dibina dengan cabangan yang meliputi semua lokasi yang telah dilawati oleh nod mobil semasa perjalanannya. Cabangan ini merupakan jalan terpendek dari bungkusan sumber ke setiap lokasi yang dilawati. Pokok bersifat dinamik dimana cabangannya tumbuh dan mengecut untuk meliputi nod mobil sebagaimana yang diperlukan. Senibina ini adalah berasaskan berbilang hebah, dimana suatu nod mobil diberi suatu alamat berbilang hebah, dan nod-nod yang berhubung menghantar bungkusan kepada kumpulan berbilang hebah itu. Apabila nod mobile bergerak ke lokasi baru, ia akan menyertai kumpulan berbilang hebah baru itu dan akan meninggalkan lokasi lamanya. Sifat dinamik pokok berbilang

hebah membolehkan penyerahan lancar, laluan efisien, dan penjimatan lebar jalur rangkaian.

Untuk membenarkan penyerahan yang lancar, nod mobil tidak seharusnya meninggalkan lokasi lamanya sehingga/kecuali ia mula mendapat bungkusan daripada lokasi barunya.

Tesis ini menghuraikan mekanisma yang dibuat untuk merealisasikan seninbina sebegitu. Algoritma 'Hash' telah dilaksanakan sebagai mekanisma untuk suatu nod mobil memasuki dan keluar sebuah kumpulan berbilang hebah. Tambahan pula, perisian yang telah dibina melaksanakan algoritma ini untuk kepentingan simulasi, iaitu untuk mengira kelewatan penyerahan nod mobil. Hasil simulasi menunjukkan bahawa sifat dinamik masuk dan keluar kumpulan membawa kesan kepada kelewatan penyerahan dan kelancarannya, ini membolehkan lebar jalur frekuensi radio dijimatkan.

ACKNOWLEGEMENTS

In the name of Allah, the Most Beneficent, the Most Merciful

I would like to express my sincere gratitude to my thesis supervisor, prof. Borhanuddin Mohd Ali for his invaluable guidance, enthusiastic encourage and support in every stage of my thesis research. This thesis represents a great deal of time and effort not only on my part, but also on the part of my supervisor. He introduces me the field of mobile networking and provides me many opportunities for growth: from reading papers, writing a survey, turning ideas to implementation, to getting through the inevitable research setbacks, and finishing the thesis. He opens the door for me to enjoy a research work. What I learn from him will provide me with lifetime benefits. I consider myself luck to access his supervision.

I am grateful to Dr. V. Prakash for his invaluable guidance, comments and advices through the duration of this project. Without his help, I would never have finished my coding.

I extend my gratitude to Dr. Mohd Hadi Habaebi and Pn. Nor Kamariah Norddin for accepting to be on my committee, their comments and to sparing precious time for going through this work.

I am grateful to all the people at the wireless laboratory for creating the demanding and encouraging atmosphere.

Finally, I want to express my deepest feeling to my family for their constant support and encouragement during my study.

I certify that an Examination Committee met on 26 March 2003 to conduct the final examination of Sahar A. M. Ali on her Master of Science thesis entitled "Multicast-Based Mobile IPv6 Join/Leave Mechanism Software" 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 the relevant degree. Members of the Examination Committee are as follows:

ADZNAN JANTAN, Ph.D.
Associate Professor,
Department of Computer and Communication System
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

BORHANUDDIN MOHD ALI, Ph.D.
Professor,
Department of Computer and Communication System
Faculty of Engineering
Universiti Putra Malaysia
(Member)

VEERARAGHAVAN PRAKASH, Ph.D.,
Department of Computer and Communication System
Faculty of Engineering
Universiti Putra Malaysia
(Member)

MOHD HADI HABAEBI, Ph.D.,
Department of Computer and Communication System
Faculty of Engineering
Universiti Putra Malaysia
(Member)

GULAM RUSUL RAHMAT ALI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies,
Universiti Putra Malaysia

Date: 29 APR 2003

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

BORHANUDDIN MOHD ALI, Ph.D.,
Professor,
Department of Computer and Communication System Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

VEERARAGHAVAN PRAKASH, Ph.D.,
Faculty of Engineering
Universiti Putra Malaysia
(Member)

MOHD HADI HABAEBI, Ph.D.,
Faculty of Engineering
Universiti Putra Malaysia
(Member)

AINI IDERIS, Ph.D.,
Professor/Dean,
School of Graduate Studies,
Universiti Putra Malaysia

Date: 12 JUN 2003

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.

SAHAR A. M. ALI

Date: 24 April 2003

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE **page**

LIST OF ABBREVIATIONS

3GPP	Third Generation Partnership Project
AH	Authentication Header
CN	Correspondent Node
DAD	Duplicate Address Detection
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
ESP	Encrypted Security Payload
FA	Foreign Agent
FDDI	Fiber Distributed Data Interface
FTP	File Transfer Protocol
HA	Home Agent
ICMP	Internet Control Message Protocol
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPng	Internet Protocol Next Generation
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISP	Internet Service Provider
L2TP	Layer Two Tunneling Protocol
LAN	Local Area Network
MAC	Medium Access Control
MLD	Multicast Listener Discovery
MN	Mobile Node
MTU	Maximum Transfer Unit
MWIF	Mobile Wireless Internet Forum
NAT	Network Address Translation
NUD	Neighbor Unreachable Detection
OUI	Organization Unique Identifier

PDA	Personal Digital assistant
PPP	Point-to-Point Protocol
PPTP	Point to Point Tunneling Protocol
QoS	Quality Of Service
RF	Radio Frequency
TCP	Transmission Control Protocol
TTL	Time To Leave
UDP	User Datagram Protocol
UMA	User Mobility Agent
W-CDMA	Wireless-Code Division Multiple Access
WWW	World Wide Web

CHAPTER 1

INTRODUCTION

This chapter introduces background information on Mobile IPv6 and the key elements of IP multicasting that are relevant to the support of mobility. This can be useful to provide smooth subnet handoffs.

1.1 Background

Mobile IPv6 is designed for the mobility support in IPv6 [1]. It is derived from mobility support for IPv4 [2]. However, some of the new mechanisms designed in IPv6 are adapted. It defines three functional entities: the mobile node, the home agent, and the correspondent node. Foreign agent does not exist any more.

Wireless networks posses different channel characteristics and mobility dynamics that render network design and analysis more challenging. Performance during handoff where the mobile moves from one cell, or coverage area, to another is a significant factor in evaluating wireless networks. In addition, route efficiency is a measure to evaluate the impact of the mobility architecture on the network [3].

Multicast is a mechanism for efficient one-to-many communication in which the source transmits a single packet, and the network performs the task of delivering the packet to

multiple destinations. For fixed host networks, multicast is achieved by constructing a delivering tree. Multicast applications such as weather reports, travel information and stock market reports may become widely used by mobile users. Multicast addresses are defined independent of location and separate from the normal unicast addresses. According to this characteristic, mobility should not be a problem for multicast.

Earlier and recent studies [3-9] have suggested that using multicast principles may improve performance of IP mobility.

This chapter presents some basic concepts and issues pertaining to network mobility, next generation mobile networking, motivation for mobility, mobility problem in IP networks, mobility solutions, research objectives and thesis organization.

1.2 Network Mobility

Mobile computing enjoys more popularity with the convergence of two technological developments, portable computer or information access devices, and wireless communication as well as the people's dependency on the Internet day by day. Mobile computing is also called mobile networking, which means that a user does not notice the change of the host's point of attachment, that is, the movement is transparent to applications. The fact that mobile computing is more desirable than ever can be attributed to two technology enhancements. Hardware research results in affordable, portable, lower-power wireless computers such as laptops or personal digital assistants (PDAs).

Wireless technology improvements address some constrains such as lower bandwidth, higher noise level and expensive access equipment in the wireless communication environment. Besides the technology development, the demand from people is also an important reason to mobility support in the Internet. Users who get used to the services received from a stationary host expect to receive the same or even more fascinating services while they travel with their wireless information access device anywhere and anytime. For example, an automatic piloting system can utilize the wireless access and mobility support to plan a route and indicate traffic congestion dynamically during a trip.

However, mobility support is a non-trivial task because location tracking and routing system reaction to the movement are two challenges in networking, especially in the Internet's TCP/IP suite. In order to provide an IP mobility solution, many research groups and industrial partners are involved, such as the Internet Engineering Task Force (IETF), the Third Generation Partnership Project (3GPP), and the Mobile Wireless Internet Forum (MWIF). A general architecture for Third Generation Wireless Networking was introduced by these efforts.

1.3 Third Generation Mobile Networking

3G is the generic term used for the next generation of mobile communication systems. A 3G-IP network comprises all-IP wireless access networks and a wired IP backbone network. The IP backbone network is an end-to-end wired infrastructure that consists of regional wired IP networks and the IP Internet that connects all the regional wired IP