UNIVERSITI PUTRA MALAYSIA

ROUTE OPTIMISATION FOR MOBILE IPv6

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By

COULIBALY YAHAYA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
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DEDICATION

I gratefully dedicate this humble work to my beloved mother **Maimouna TOURÉ** (TOUGOTIO), without whose prayers and, moral supports I would not have been able to attend this level in education.

Thank you very much mammy.

This thesis is also dedicated to my younger sisters: **Mariame COULIBALY, Safoura COULIBALY, Kardja COULIBALY, and Jalika COULIBALY** without whom my life would have little meaning.

I dedicate this work to my fiancée **Fatoumata MAIGA** whose patience, loyalty, and fidelity inspire me throughout this research.

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

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Chairman: Professor Borhanudin Mohd. Ali, Ph.D.

Faculty: Engineering

In the future it is expected that the number of terminals with wireless access to network resources will be more widespread, and it is therefore necessary to integrate mobility support into future generation networks so that users can be online, even while in motion. The increasing use of Internet suggests that the Internet technology can be the best candidate for effective realization of future generation mobile systems. Mobile IP can offer the possibility to use the mobile Internet in other ways than it is used in the standard wired environment,

Because of this, mobility in IPv6 (MIPv6) is designed to be scalable, stable, efficient and secure.

This thesis focuses on an important aspect of mobility, which is route optimisation. We investigate the existing route optimisation techniques, especially base MIPv6 route optimisation and propose an efficient route optimisation.

Our proposed solution, Mobile node Address Multicasting technique (MAM) is based on multicasting techniques different from base MIPv6 route optimisation, which is based on binding update technique.

the traversed route by packets between Mobile Node (MN) and Correspondent Node (CN).

Essentially, MAM makes current Point of Attachment (PoA) of MN known to the CN locally.

group of CNs. By doing so, we eliminate not only the triangular routing (as the CN already knows MN's current PoA), but MAM also eliminates the load imposed by base MIPv6 route optimisation on both MN and CN at any communication initialization manifested in binding update process.

This is true especially when the CN is in MN's visited networks, which may be very far from MN's home network. While Base MIPv6 route optimisation forces CN's packets to go through MN's Home Agent (HA) before MN can receive them, MAM only requires CN to join a multicast group either at MN's home network or MN's visited network the two cases studied in this thesis, However,

home network or the visited network, base MIPv6 route optimisation technique outperforms MAM because MAM does not handle such CNs.

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

PENGOPTIMUMAN LALUAN DALAM IPv6 BERGERAK

Oleh

COULIBALY YAHAYA

November 2002

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

Fakulti: **Kejuruteraan**

Di masa hadapan, diharapkan jumlah terminal dengan capaian wayarles ke jaringan komputer akan lebih luas, dan kerananya diperlukan integrasi daripada sokongan mobile ke dalam jaringan generasi masa hadapan sehingga user dapat on-line, termasuk saat mobile terminal dalam keadaan bergerak.

Pertambahan pengguna Internet mencadangkan bahawa teknologi Internet dapat digunakan untuk merealisasikan jaringan mobile generasi hadapan. mobile IP juga

menawarkan pemakaian mobile internet dalam aspek lain di luar system standar jaringan wayar saat ini, dimana ianya dapat menjadi solusi untuk tingginya permintaan dari pemakai mobile saat ini. Kerana itu, mobile Ipv6 dirancang untuk scalable, stabil, efisien dan aman.

Tesis ini mempunyai fokus penyeledikan pada aspek penting daripada mobility, iaitu optimisasi rute. Kami akan menyelidiki teknik optimisasi rute yang ada saat ini, khususnya Base MIPv6 route optimisation dan mencadangkan satu optimisasi rute yang efisien.

Solusi yang kami buat, iaitu Mobiele Node Address Multicasting Technique (MAM), adalah berlandaskan kepada teknik multicasting; berbeza dengan Base MIPv6 Route Optimisation, yang berlandaskan kepada teknik 'binding update', sistem yang kami buat mempunyai pendekatan yang berbeza, sebab ianya mencuba untuk meminimalkan rute yang dilalui oleh paket di antara Mobile Node (MN) dan Correspondent Node (CN).

Pada dasarnya, MAM membuat Point of Attachement (PoA) daripada MN mengetahui lokasi tempatan CN. Hal ini dicapai dengan melakukan multicast daripada alamat MN kepada kumpulan multicast daripada CN. Dengan itu, kita menghilangkan tidak sahaja rute triangilar (sebab CN sudah mengetahu PoA daripada MN), akan tetapi juga menghilangkan beban yang dikenakan oleh Base MIPv6 route optimisation pada MN dan CN pada setiap permulaan komunikasi yang dilakukan pada proses binding update.

Pendekatan tersebut berlaku apabila CN berasal daripada jaringan yang dikunjungi oleh MN, yang boleh jadi berjarak sangat jauh daripada jaringan asal MN. Apabila Base MIPv6 Route Optimisation memaksa paket CN untuk melalui home agent daripada MN, maka sebailknya MAM hanya memerlukan CN untuk bergabung ke dalam kumpulan multicast dan dapat berkomunikasi secara langsung dengan MN yang menjadi tamu dalam jaringan CN.

Akan tetapi, sebagaimana kebanyakan solusi kejuruteraan lainnya, MAM tidak meng-claim efisiensi 100%. Ketika CN yang baru tidak berasal dari jaringan asal MN atau jaringan yang dikunjungi oleh MN, maka teknik Base MIPv6 Route Optimisation mengungguli MAM. Hal ini disebabkan MAM tidak menyediakan suatu mekanisme yang efisien untuk menangani CN seperti itu.

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LIST OF ABREVIATIONS

AAA	Authentication, Authorization and Accountability
ABRO	Agent-Base Route Optimisation
AH	Authentication Header
ARP	Address Resolution Protocol
BA	Binding Acceptance
BACK	Binding Acknowledgement
BC	Binding Cache
BR	Border Router
BS	Base Station
BU	Binding update
CCOA	Collocated Care Of address
CDPD	Cellular Digital Packet Data
CN	Correspondent Node
COA	Care Of Address
DAD	Duplicate Address Detection
DHCP	Dynamic Host Configuration Protocol
ESP	Encapsulating Security Payload
FIFO	First In First Out
HA	Home Agent
HIMPv6	Hierarchical Mobile IPv4/IPv6
ICMP	Internet Control message protocol
IEEE	Institute of Electrical and Electronic Engineers

IETF	Internet Engineering Task Force
IP	Internet Protocol
IPsec	Internet Protocol Security
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISP	Internet Service Provider
LAN	Local Area Network
LCoA	Link Care-of Address
MA	Mobility Agent
MAC	Media Access Control
MAM	Mobile node Address Multicast
MAP	Mobility Anchor Point
MBG	Mobile Border Gateway
MIP	Mobile IP
MIPv6	Mobile IPv6
MIPv4	Mobile IPv4
MN	Mobile Node
MNet	Mobility Network
MT	Mobile Terminal
NA	Neighbor advertisement
NAI	Network Access Identifier
ND	Neighbor discovery
NFS	Network File System
NS	Neighbor solicitation

NS-2	Network Simulator version 2
NUD	Neighbor Unreachability Detection
PDA	Personal Digital Assistant
PDL	Packet Delivery Latency
POA	Point Of Attachment
QoS	Quality of Service
RA	Router Advertisement
RFC	Request For Comment
RS	Router Solicitation
RSVP	Resource Reservation Protocol
SGM	Small Group Multicast
SIP	Session Initiation Protocol
MAM	Secure Multicasting Technique
SWT	Subhanahu Wa Taala[1]
TCoA	Temporary Care-of address
TCP	Transmission Control Protocol
THA	Temporary Home Agent.
UDP	User Datagram Protocol
UMA	User Mobility Agent
VoIP	Voice Over Internet Protocol
WLAN	Wireless Local Area Network
XCAST	Explicit Multicast

[1] Muslims' way of Glorifying God.

CHAPTER 1

INTRODUCTION

1.1 Background

The exponential growth of global internetworking, widespread availability of highly mobile and small hosts in the form of notebook and laptop computers, and Personal Digital Assistants (PDAs) and rapid advancement made in the wireless telecommunication technologies have created a big demand for the concept of mobile IP.

Unfortunately, present day Internetworking protocols like TCP/IP, IPX and Appletalk do not provide support for re-directing packets when dealing with host mobility. The communication protocol used by the current Internet community is the Internet Protocol Version 4.0 (IPv4) suite of protocols, which was developed in the late 1970s (Solomon, 1998), (RFC 791). During that era, mobility of hosts was not a point of consideration as the hosts were usually bulky and physically too large to be moved around. IPv4 connects today's Internet network, routing packets to their destinations according to IP addresses. IPv4 assumes that the point at which a computer attaches to the Internet is fixed and the IP address (also called the home address) assigned to it identifies the network to which the computer belongs. With this approach, if a computer migrates to a different network, it will lose connection to the Internet. Thus, it became apparent to the Internet Engineering Task Force (IETF) that significant changes needed to be made to the IPv4 to support mobility. Many proposals were forwarded to the group, however mobile IP proposal retained to address the necessary changes in the summer of 1994 (Solomon, 1998), (Perkins, 1996).

Mobile IP was designed to allow a computer to roam freely to other networks and maintain connectivity to the Internet while still maintaining the same IP address throughout the movement. With mobile IP, a mobile host is able to send and receive packets over the Internet using its IP address regardless of its point-of-attachment. It allows hosts to be "connected" to their home networks when they are away and connected physically on another network. In essence, mobile IP extends the existing Internet Protocol to allow a portable host to be moved from one network to another without changing its IP address and without losing an existing connection. Remote printing, remote login, and file transfer are some examples of applications whose communications are undesirable to interrupt when a mobile host moves from one link to another. Mobile IP also helps to some extent to resolve address shortage problems and administrative workload, as each host that needs to attach to the network at different location requires only a single IP address, which is the home address.

Since IPv6 will ultimately replace IPv4, mobility support in IPv6 was addressed by IETF early 1998. The basic entities and operation of mobile IPv4 and mobile IPv6 are similar, in other words, mobile IPv6 inherits most of its techniques and entities from mobile IPv4.

The most obvious difference between the two protocols is the absence of foreign agent in mobile IPv6 due to the autoconfiguration feature of IPv6 protocol. Appendix A provides a comparison between MIPv4 and MIPv6.

1.2 Objective

The objective of this thesis is to study and investigate mobility issues in the existing mobile IPv6 protocol with focus on route optimisation, and to propose a complimentary solution that improves the existing mobile IPv6 route optimisation protocol.

1.3 Problem Statement and Scope of the Thesis

The fast growth of mobile nodes (Laptops, PDAs...) and the emerging technology of integrating wireless network and the Internet necessitate the need for mobile IP protocol, a protocol that permits nodes to be connected to their local networks regardless of their Point of Attachment (PoA).

Since the introduction of the protocol in 1996, there have been many researches around the globe by industries and academicians analyzing it for better implementation features. One of the issues addressed is the route optimisation, and that is the focus of this thesis. Packet latency between the Correspondent Node (CN) and the Mobile Node (MN) is a built in problem in the base Mobile IP protocol due to the triangular routing nature of the protocol.

The existing route optimisation proposal suffers from heavy traffic load and extra processing time for both CN and MN (Joe and Andrew, 2001) a feature that introduces delay in the network.

This thesis proposes a solution that avoids triangular routing with minimum process time for MN and CN in comparison to base Mobile IPv6 route optimisation.

1.3.1 Problems in Base MIPv6 Protocol

In this sub-section we list the shortcomings of the existing mobile IPv6 protocol with reference to (Joe, and Andrew 2001) in base IETF MIPv6 route optimisation for which a solution was proposed.

- **Inefficient Routing.**

  The protocol heavily depends on updating the binding list of correspondent nodes. The list can grow indefinitely. Always if a new correspondent is detected; the list has to be updated.

- **Network Congestion.**

  This is a direct result of the first problem (binding update). As the number of correspondents increases, the network load increases.