AN ALTERNATIVE ROUTE OPTIMIZATION HANDOFF SCHEME FOR MOBILE IPV6

HISHAM MOSTAFA ATTIR

A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computer Science and Information Systems
Universiti Teknologi Malaysia

NOVEMBER 2008

ABSTRACT

Mobile nodes using MIPv6 suffer long handoff delays due to the Route Optimization registration process. Route Optimization eliminates the triangular routing effect faced in MIPv4. The long handoff latencies may cause severe performance degradation of transmission protocols such as TCP and UDP. Such negative effect can be reduced by some enhancements to the handoff procedure. FastRA, RA Caching, Advanced DAD, Optimistic DAD and Optimistic Node are some of the handoff schemes proposed to reduce the handoff latencies. The aim of this project is to propose an alternative approach to reduce the handoff latencies in MIPv6. Early Handoff (EH) is a handoff scheme that takes advantage of the coverage overlapping areas to perform earlier and smoother handoffs. Simulations using NS-2 and Mobiwan had been carried out to evaluate the performances of EH, FastRA and Optimistic Node. The simulations were conducted within addressing and security issues free environments using 1, 10, 20 and 30 Mobile Nodes settings. The results show that EH has achieved good results in terms of low handoff latency, low packets loss rate, low signaling load and good bandwidth per station when implemented in environments with little number of nodes. On the other hand, FastRA outperformed Optimistic Nodes and EH respectively when the number of Mobile Nodes exceeded 20 nodes.

ABSTRAK

Nod bergerak yang menggunakan MIPv6 mempunyai kelemahan iaitu masa menunggu yang panjang ketika sambungan disebabkan oleh proses pendaftaran laluan optimum (Route Optimization). Route Optimization dapat mengatasi masalah laluan segitiga yang dihadapi dalam MIPv4. Masalah sambungan yang panjang boleh menyebabkan penurunan prestasi yang besar terhadap protokol transmisi seperti TCP dan UDP. Masalah ini boleh dikurangkan dengan melakukan beberapa pengubahsuaian pada prosidur sambungan. FastRA, RA Caching, Advanced DAD, Optimistic DAD dan Optimistic Node adalah antara beberapa skema sambungan yang telah dicadangkan untuk mengurangkan masalah yang dinyatakan di atas. Matlamat projek ini adalah untuk mencadangkan satu pendekatan alternatif untuk mengurangkan masalah tersembunyi sambungan MIPv6. Sambungan terawal (EH) ialah satu skema sambungan yang mengambil kelebihan daripada penguasaan kawasan-kawasan yang bertindih untuk melaksanakan sambungan dengan lebih awal dan lancar. Simulasi-simulasi menggunakan NS-2 dan Mobiwan telah dijalankan untuk menilai perestasi EH, FastRA dan Optimistic Node. Simulasi-simulasi tersebut telah dikendalikan dalam isu-isu keselamatan persekitaran bebas menggunakan 1, 10, 20 dan 30 set nod bergerak. Hasil dari simulasi menunjukkan bahawa EH telah mencapai hasil yang baik dalam terma masalah tersembunyi sambungan yang rendah, kadar kehilangan paket yang rendah, beban isyarat yang rendah dan jalur lebar yang baik bagi setiap perhentian apabila dilaksanakan di dalam persekitaran dengan jumlah nod yang sedikit. Di dalam situasi yang lain, FastRA menunjukkan prestasi yang lebih baik berbanding Optimistic Nodes dan EH apabila jumlah nod yang bergerak melebihi 20 nod.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Introduction

Computer networks have become a very important aspect in today's human world. Networking and Internetworking are now very well known terminologies among specialists in every field of knowledge. For instance, banks use computer networks to link their branches as well as to assist in doing businesses. In another scenario, libraries use networks to link and share their digital resources with the world. Nowadays Internet has become known to the entire world. The Internet is now been used to link countries, corporations, companies, banks, hospitals, customers and so on. The technologies used in the Internet are merely computer networking technologies. Since its first launch, the Internet is facing a rapid growth in user numbers as well as more sophisticated technologies are being implemented. Such advancements make the costs for users to connect to the Internet get lower each day. Services such as sending voice signals over Internet technology, which is known as Voice over Internet Protocol (VoIP) (Davidson et al., 2006), are cheaper compared to the Plain Old Telephone Service (POTS). Sending video signals over the Internet is also cheaper and more convenient for meetings and conferences compared to the traditional methods where one should travel for such meetings.

The Internet uses TCP/IP protocol suite for communication. Current Internet uses version 4 of the TCP/IP protocol suite which is also known as IPv4. The rapid growth of users and higher sophisticated services are forcing the Internet community to migrate to a more convenient TCP/IP protocol suite (IPv6) (Forouzan, 2006).

1.2 Networking Technologies

1.2.1 IPv4

IPv4 (Postel, 1981a) has been the most dominant protocol to be used and support connectivity for the Internet. Throughout the years IPv4 has seen many updates and changes to support the growth of the Internet. Technologies like Network Address Translation (NAT) (Egevang, 1994) have been introduced to support the reuse of IP addresses within private networks and corporations, which connect to the Internet through an Internet Server. Mobile IP has been introduced in order to support mobility and connectivity while roaming through different wireless networks routers without the need to reconfigure the mobile host (Perkins, 2002).

1.2.2 IPv6

IPv6 was first introduced to solve the problem of depleting IPv4 addresses, where IPv6 uses an astonishing 128-bits addressing space compared to just 32-bits used in IPv4. However, technologies like NAT have slowed down the real migration to IPv6. IPv6 also addresses some other problems currently faced in IPv4, For example, it provides a better support for multimedia sharing and better mobility support (Deering and Hinden, 1998; Johnson, Perkins and Arkko, 2004).

1.2.3 Wireless Technology

Wireless networking uses the technologies that help sending signals over transmission mediums without the needs of physical infrastructure. These technologies allows for a fair data rate to be sent and received through the wireless link. Wireless networking can be a better solution in situations where cabling is an option. Wireless LANs offer a combination of data connectivity with freedom of mobility (Wheat et al., 2001).

Wireless networks offer flexibility and reduce the cost and time needed to build up and break down a temporary network or groups of networks. This can be a big advantage for companies which hold up meetings and conferences frequently, where visitors can connect to the network using their own laptops.

Wireless networks also can be proven to be very convenient for old buildings where the costs of installing a WLAN can be very low compared to the costs of installing a wired LAN.

1.3 Problem Background

Since its first launch, the Internet faces an increasing number of challenges every day. Because of the rapid growth in the numbers of Internet users, the use of higher bandwidth and the introduction of more sophisticated technologies the cost to use the Internet these days is getting lower and lower. Handheld devices have become very small and capable of connecting to the Internet. Mobile IP (Postel, 1981a) was introduced to serve the demand of going mobile while being connected at the same time. It allows a moving node to stay connected while roaming across different sub-networks. The wireless network access offers some interesting advantages such as; it allows movements during communication and at a fair transfer rate (Montavont and Noël, 2002).

IPv6 (Deering and Hinden, 1998) was proposed to solve the problems currently faced in IPv4. One of the problems is the incapability of the IPv4 to support communications for huge numbers of mobile nodes. Figure 1.1, illustrates the wireless architecture in IPv6 (Montavont and Noël, 2002).

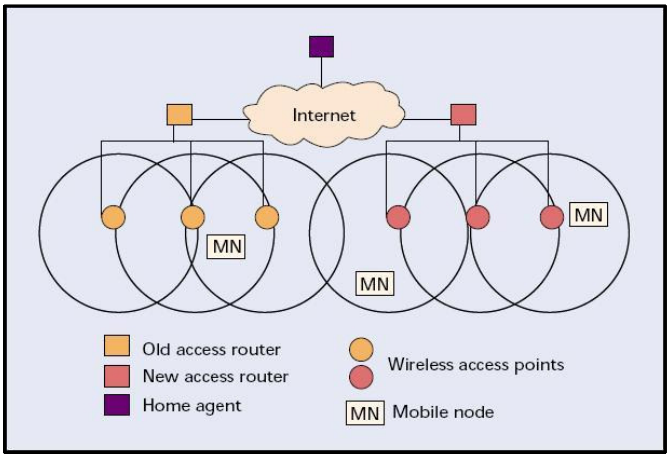

Figure 1.1: IPv6 Wireless Network Architecture (Montavont and Noël, 2002).

Mobile IPv6 (Johnson, Perkins and Arkko, 2004) was designed to manage mobile nodes movements across wireless IPv6 networks. However, during the movements, the active communication will be interrupted due to the changes of the network prefix of the new network. During this interruption, the mobile node cannot receive any IP packets on its new point of attachment until the handoff procedure ends. This interruption can take up to two seconds during a standard handoff procedure in MIPv6 (Vogt, 2006). This delay includes the time needed for new router discovery, movement detection, a new care-of-address establishment, and notifying the original router (Home Agent) and corresponding node of the new network attachment. Figure 1.2, shows the steps involve in the handoff procedure (Vogt, 2006).

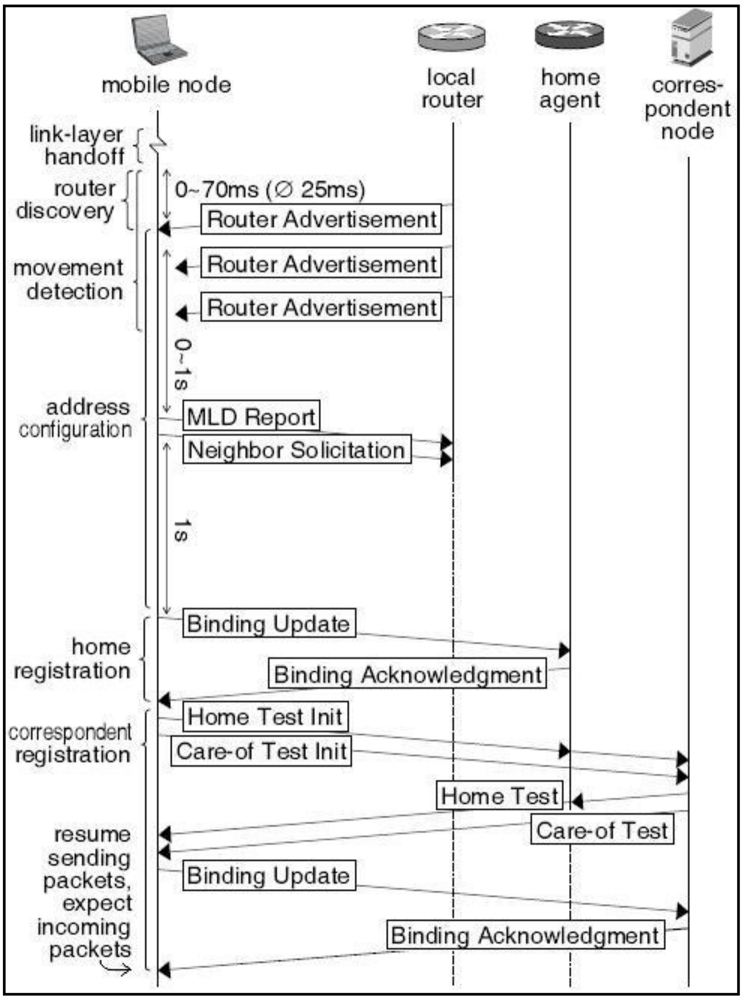

Figure 1.2: Standard MIPv6 Handoff Procedure (Vogt, 2006).

Route Optimization (Johnson, Perkins and Arkko, 2004; Vogt and Doll, 2006) was introduced in Mobile IPv6 (Johnson, Perkins and Arkko, 2004) to solve the problem of triangular routing (Forouzan, 2006) as faced in MIPv4, by creating a direct path between the two communicating nodes. It allows an end-to-end way of communication between peers. Such situation is illustrated in Figure 1.2.

1.4 Problem Statement

In this project, several existing Route Optimization handoff techniques will be analyzed and simulated to study the efficiency of each technique. The standard Route Optimization approach in Mobile IPv6 shows a delay of up to 2 seconds before resume communication between two peers (Vogt, 2006). The performance of the Real-time applications streaming will be the focus of the study. In Real-time streaming (e.g. VoIP or video conferencing), the delay during the handoff can become a huge setback in implementing MIPv6 (Johnson, Perkins and Arkko, 2004).

A new approach will be proposed to reduce the time gap between link-layer handoff and resuming routability. A simulation then will be carried out to examine the effectiveness of the new approach against the existing schemes.

1.5 Project Objectives

With reference to the problem stated above, this study is attempting to achieve the following objectives:

1. To study the existing handoff schemes of Route Optimization in Mobile IPv6.
2. To propose an alternative approach to reduce the latencies and packets loss for real-time communication streaming caused by the current Route Optimization techniques.
3. To analyze the performance of the proposed technique.

1.6 Project Scope

1. The study of the existing handoff schemes of Route Optimization in MIPv6 will focus upon five of the most popular techniques.
2. The performance analysis of the proposed technique will be carried out by using ns-2 simulation tools.
3. TCP and UDP Packets of real-time streaming communication will be used as comparison metrics in the performance analysis between the proposed technique and the existing ones.
4. Security issues during handoff will not be addressed. This study will consider that there are neither security issues nor any kind of authentication or network keys for the Access Routers during the handoffs.
5. The simulation topology and model described in chapter 3 will not be changed for any of the handoff schemes.

1.7 Importance of Study

This study gives an insight on the issues of handoff latencies in MIPv6. By studying and comparing several existing techniques proposed to solve the handoff latencies and optimize Route Optimization in MIPv6, this projects aims to propose a new approach to solve the issues regarding real-time multimedia streaming in order to improve the performance of the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) during the handoffs.

1.8 Organization of the Report

The report is organized as follows:

Chapter (1) introduces the general idea of wireless network and the protocols that help achieve node mobility. This chapter also briefly discussed the Route Optimization handoff procedure and its issues faced in mobile IPv6. The project objectives and scope are mentioned in this chapter.

Chapter (2) discusses the literature reviews, where the background details and concepts of Transport Control Protocol (TCP), User Datagram Protocol (UDP) and Mobile IP were explained. The chapter also explains the Mobile IPv6 handoff procedure. The chapter also discusses some existing related works that concern with improving the performance of handoff and Mobile IPv6. The end of chapter two discusses some of the handoff schemes which will be simulated. A brief comparison in the chapter illustrates the advantages and limitations of each scheme.

Chapter (3) discusses the methodology used in this study. In this chapter the operational framework is presented to show the steps that are needed to be followed to achieve the objectives of this project. The Network Model will also be described in this chapter. The Network Model is designed as simple as possible to avoid unnecessary drawbacks, whether they are caused by the complexity of the design or the infrastructure of the network model. The Simulation Model that shows the parameters and metrics of the simulation is also described in this chapter.

Chapter (4) discusses the proposed scheme along with the algorithm and coding of the scheme. The simulation coding will be illustrated here as well.

Chapter (5) discusses the simulation model and the simulation metrics that are going to be studied for each chosen scheme. These metrics represents the times needed to be reduced in order for the scheme to perform better. The chapter also illustrates the results of the conducted simulations. Different existing MIPv6 handoff schemes along with the proposed alternative are simulated using the same network model. A comparison is carried out to compare the performance of each scheme.

Chapter (6) discusses the findings of the simulations and the study. The achievements of the study are discussed in this chapter as well. Some future works is proposed that can tune the proposed scheme and help implementing it in real MIPv6 networks.

1.9 Summary

The ease of use, low cost and the vast variety of information made the Internet a necessity in the modern world. Users want to access information, their emails or even make businesses while they drive their cars or commute to work. Mobile IP was introduced to solve the problem of changing network attachments while keep communication available. The issues of handoff procedures (the process of changing network prefixes) delay the full implementation of Mobile IP over mobile networks. This report discusses some of these issues and proposes an alternative approach to help reduce the handoff latency of Mobile IPv6.

REFERENCES

Altman, E., and Jimenez, T. (2003), “NS Simulator for Beginners”, University De Los Andes, France, Lecture Notes (2003/2004).

Aura, T. (2005), “Cryptographically Generated Addresses (CGA)”, RFC 3972, http://www.ietf.org/rfc/rfc3972.txt.

Choi, J., and Shin, D. (2002), “Fast Router Discovery with AP Notification”, http://www.ietf.org/internet-drafts/draft-jinchoi-l2trigger-fastrd-01.txt. (Work in Progress).

Clark, D. (1982), “Window and Acknowledgement Strategy in TCP”, RFC 813, http:// www.ietf.org/rfc/rfc813.txt.

Daley, G., and Nelson, R. (2003), “Duplicate Address Detection Optimization using IPv6 Multicast Listener Discovery”, http://tools.ietf.org/html/draft-daley-ipv6-mcast-dad-02. (Work in Progress).

Daley, G., Pentland, B., and Nelson, R. (2003), “Movement detection optimizations in mobile IPv6”. The 11th IEEE International Conference on Networks. 28 SEP. – 1 OCT. 2003. 687-692.

Daley, G., Pentland, B., and Nelson, R. (2006), “Effects of Fast Router Advertisement on Mobile IPv6 Handovers”. Proceedings of the Eighth IEEE *International Symposium on Computers and Communication ISCC’03*. 30 June – 3 July. Kemer - Antalya, Turkey. 1, 557-562.

Davidson, J., Peters, J., Bhatia, M., Kalidindi, S., and Mukherjee, S. (2006). Voice over IP Fundamentals (2nd ed.): CiscoPress.

Deering, S., and Hinden, R. (1998)” Internet Protocol, Version 6 (IPv6) Specification”, RFC 2460, http://www.ietf.org/rfc/rfc2460.txt

Droms, R., Bound, J., Volz, B., Lemon, T., Perkins, C., and Carney, M. (2002), "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", http://www.tools.ietf.org/html/draft-ietf-dhc-dhcpv6-28.

Egevang, K. (1994) "The IP Network Address Translator (NAT)", RFC 1631, http://www.ietf.org/rfc/rfc1631.txt.

Ernest, T. (2001), "MobiWan A NS-2.1b6 Simulation Platform for Mobile IPv6 in Wide Area Networks", MobiWan Official Manual.

Ernest, T. (2002), "MobiWan: ns2 extensions to study mobility in Wide-Area IPv6 Networks". http://www.inrialpes.fr/planete/mobiwan.

Fall, K., and Varadhan, K. (Eds.) (2008), "The ns Manual".

Fikouras, A., El Malki, K., Cvetkovic, S., and Smythe, C. (1999), "Performance of TCP and UDP during Mobile IP Handoffs in Single-Agent Subnetworks". Wireless Communications and Networking Conference, WCNC 1999. 21-24 September. New Orleans: IEEE, 3, 1258-1262.

Forouzan, B. (2006), TCP/IP Protocol Suite, (3rd ed.): McGraw-Hill.

Han, Y., Choi, J., Jang, H., and Park, P. (2003), "Advance Duplicate Address Detection", https://datatracker.ietf.org/drafts/draft-jinchoi-l2trigger-fastrd. (Work in Progress).

Heidemann, J., and Huang, P. (2002), "IPAM Tutorial: Network Modeling and Traffic Analysis with ns-2"

Johnson, D., Perkins, C., and Arkko, J. (2004), "Mobility Support in IPv6", RFC 3775, http://www.ietf.org/rfc/rfc3775.txt

Jung, J., Montgomery, D., Cheon, J., and Kahng, H. (2003), "Mobility Agent with SIP Registrar for VoIP Services", International Conference on Human.Society@Internet No2, 18-20 June 2003, Seoul, South Korea. 2713, 454-464

Kempf, J., Khalil, M., and Pentland, B. (2005), "IPv6 Fast Router Advertisement", http://tools.ietf.org/html/draft-mkhalil-ipv6-fastra-05. (Work in Progress).

Liu Y., Ye, M., and Zhang, H. (2003), "The Handoff Schemes in Mobile IP". Vehicular Technology Conference, VTC 2003. 4-9 October. Orlando, Florida: The 57th IEEE Semiannual, 1, 485-489.

McCanne, S., and Floyd, S. "ns Network Simulator". http://www.isi.edu/nsnam/ns/

Montavont, N., and Noël, T. (2002), “Handover Management for Mobile Nodes in IPv6 Networks”, Communications Magazine, IEEE, 40(8), 38-43.

Moore, N. (2006), “Optimistic Duplicate Address Detection (DAD) for IPv6”, RFC 4429, http://www.ietf.org/rfc/rfc4429.txt.

Narten, T., and Draves, R. (2001), “Privacy Extensions for Stateless Address Autoconfiguration in IPv6”, RFC 3041, http://www.ietf.org/rfc/rfc3041.txt.

Narten, T., Nordmark, E., and Simpson, W. (1998), “Neighbor Discovery for IPv6”, RFC 2461, http://www.ietf.org/rfc/rfc2461.txt.

Naugle, M. (1998), Illustrated TCP/IP, (1st ed): Wiley Computer Publishing, John Wiley & Sons, Inc.

P´erez-Costa, X., Torrent-Moreno, M., and Hartenstein, H. (2003a), “A Performance Comparison of Mobile IPv6, Hierarchical Mobile IPv6, Fast Handovers for Mobile IPv6 and Their Combination”. Mobile Computingand Communications Review, 7(3), 5-19.

P´erez-Costa, X., Torrent-Moreno, M., and Hartenstein, H. (2003b), "A Simulation Study on the Performance of Hierarchical Mobile IPv6". ACM SIGMOBILE Mobile Computing and Communications Review, 7(4), 5-19.

Perkins, C. (2002), “IP Mobility Support for IPv4”, RFC 3344, http://www.ietf.org/rfc/rfc3344.txt.

Postel, J. (1980), “User Datagram Protocol”, RFC 768, http://www.ietf.org/rfc/rfc768.txt.

Postel, J. (1981a), “Internet Protocol”, RFC 791, http://www.ietf.org/rfc/rfc791.txt.

Postel, J. (1981b), “Transmission Control Protocol”, RFC 793, http://www.ietf.org/rfc/rfc793.txt.

Stevens, W. (1997), “TCP Slow Start, Congestion Avoidance, Fast Retransmit, and Fast Recovery Algorithms”, RFC 2001, http://www.ietf.org/rfc/rfc2001.txt.

Thomson, S. and Narten, T. (1998), “IPv6 Stateless Address Autoconfiguration”, RFC 2462, http://www.ietf.org/rfc/rfc2462.txt.

Vogt, C. (2006), “A comprehensive and efficient handoff procedure for IPv6 mobility support”. Proceedings of the 2006 International Symposium on a World of Wireless, Mobile and Multimedia Networks WoWMoM'06. 26- 29 June. Niagara Falls, Buffalo-NY: IEEE, 212-218.

Vogt, C., and Doll, M. (2006), "Efficient End-to-End Mobility Support in IPv6". Wireless Communications and Networking Conference, WCNC 2006. 3-6 April. Las Vegas, NV: IEEE, 1, 575-580.

Wheat, J., Hiser, R., Tucker, J., Neely, A., and Mccullougy, A. (2001), Designing a Wireless Network: Understand How Wireless Communication Works, (1st ed.): Syngress Publishing, Inc.

Willig, A., Kubisch, M., and Wolisz, A. (2001), "Measurements and Stochastic Modeling of Wireless Link in an Industrial Environment", Technical University Berlin, Telecommunication Networks Group, TKN Technical Report TKN-01-001.