Triangle Routing Problem in Mobile IP

Eng. Sherif Kamel Hussein
Ph.D. Student

A. Prof. Imane Aly Saroit Ismail
Information Technology Department
Faculty of Computers and Information
Cairo University

Prof. S. H. Ahmed
Vice Dean
Faculty of Computers and Information
Cairo University

Abstract

Mobile Internet Protocol is a recommended Internet protocol designed to support the mobility of a user (host). Host mobility is becoming important because of the recent blossoming of laptop computers and the high desire to have continuous network connectivity anywhere the host happens to be. The development of Mobile IP makes this possible. The traditional Mobile IP specification forces all packets forwarded to the Mobile Node, to be routed via Home Agent, which often leads to Triangular Routing, which in turn causes data transmission delay and wastes network resources. It discusses means of resolving the Triangle Routing Problem. It introduces some of the recent Route Optimization schemes that have been used to solve that problem.

Keywords: *Mobile IP, Triangle Routing Problem, Route Optimization, Home Agent, Foreign Agent, Mobile Node, Correspondent Node.*

1. Abbreviations

Mobile Node (MN), Home address (Ha), Home Agent (HA), Foreign Agent (FA), Care-of-Address (CoA), Correspondent Node (CN), Mobile Station (MS), Current Address (CA), Register Address (RA), Location Agent (LA), Mobile Agent (MA), Internet Service Provider (ISP), Point-of-Presence (PoP).

2. Introduction

Mobile IP is an open standard, defined by the Internet Engineering Task Force (IETF) RFC 2002, that allows users keep the same IP address, stay, connected, and maintain ongoing applications while roaming between networks, given that any media that can support IP can support Mobile IP. Efforts were made to enhance the standard protocol and to be able to achieve data transmission within the wireless infrastructure. However, in trying to achieve this goal many problems have emerged and still proposals to solve them are evolving [1].

The key feature of Mobile IP design is that all required functionalities for processing and managing mobility information are embedded in well-defined entities, the Home Agent (HA), Foreign Agent (FA), and Mobile Nodes (MN). The Mobile Node is a host or router that can change its location from one link to another without changing its IP address or interrupting existing services. The Home Agent is a router with an interface on a Mobile Node's home link that intercepts packets destined for the home address. It tunnels packets to the mobile nodes most recently reported Care-of-Address. The Foreign Agent is a router on a Mobile Node's visited network that provides routing services to the Mobile Node while it is registered [2,3,4].

Triangle Routing Problem is considered as one of the main problems facing the implementation of Mobile IP such as, when a Communicating Node (CN) sends traffic to the Mobile Node, packets first get to the Home Agent, which encapsulates these packets and tunnels them to the Foreign Agent. The Foreign Agent de-tunnels the packets and delivers them to the Mobile Node. The route taken by these packets is triangular in nature, and the most extreme case of routing can be observed when the Communicating Node and the Mobile Node are in the same subnet [5,6].

In recent literature many protocols have been invented to solve the Triangle Routing Problem. In this paper we introduce some of recent Route Optimization Schemes that are used in solving the conventional Triangle Routing Problem in Mobile IP [7,8,9,10,11,12,13,14]. The most common schemes that will be discussed in this paper are; Forward Tunneling and Binding Cache, Dynamic Address Allocation, Bidirectional Route Optimization, and finally the Internet Service Provider Points of Presence (ISP PoPs) [7,8,9,10].

The paper is divided into five sections. The second section; examines the modifications to IP protocol to accommodate wireless access to the internet (Mobile IP). The third section; introduces the concept of the Triangle Routing Problem in Mobile IP. The fourth section; details a survey for some previous recent protocols proposed for optimizing the Triangle Routing Problem plus their drawbacks. The fifth section; provides conclusion and future work.

3. Mobile IP

The main problem in the process of introducing mobility to the Internet is IP addressing. The IP address is a unique address for each network access point (e.g., in a router, a terminal, and so forth). Furthermore, the IP address is used for routing packets in the intermediate routers between the source and the destination, so the problem for mobility in the Internet is how to handle the mobile terminal's IP address and routing information when the mobile host makes handoff between two wireless access points (e.g., base stations) or when it roams between two network domains (i.e., between two network operators). A solution to this problem is provided through the Mobile IP protocol [15]. This protocol provides mobility also it is transparent to the transport and higher protocol layers. Its implementation does not require any changes in the existing nodes and hosts on the Internet.

3.1. Mobile IP Definition

Mobile IP is a modification to IP that allows nodes to continue to receive datagrams no matter where they happen to be attached to the Internet. It involves some additional control messages that allow the IP nodes involved to manage their IP routing tables reliably. Scalability has been a dominant design factor during the development of Mobile IP, because in the future a high percentage of the nodes attached to the Internet will be capable of mobility [5, 16].

3.2. Mobile IP Terminology

The Mobile IP terminology illustrates the following:

1. **Mobile Node (MN);** a host or router that changes its point of attachment from one network or subnetwork to another.
2. **Home address (Ha);** an IP address that is assigned for an extended period of time to a Mobile Node in the Home Network
3. **Home Agent (HA);** a router on a Mobile Node's Home Network which tunnels datagrams for delivery to the Mobile Node when it is away from home, and maintains current location information for the Mobile Node.
4. **Home Network;** a network, possibly virtual, having a network prefix matching that of a Mobile Node's Home Network.
5. **Foreign Agent (FA);** a router on a Mobile Node's Visited Network which provides routing services to the Mobile Node while registered. The Foreign Agent de-tunnels and delivers datagrams to the Mobile Node.
6. **Foreign Network;** any network other than the Mobile Node's Home Network.
7. **Care-of-Address (CoA);** the termination point of a tunnel toward a Mobile Node, for datagrams forwarded to the Mobile Node while it is away from home.
8. **Correspondent Node (CN);** a peer with which a Mobile Node is communicating, it may be either mobile or stationary.
9. **Link;** a facility or medium over which nodes can communicate at the link layer. A link underlies the network layer.
10. **Node;** a host or a router.
11. **Tunnel;** the path followed by a datagram while it is encapsulated.
12. **Virtual Network;** a network with no physical instantiation beyond its router (with a physical network interface on another network).
13. **Visited Network;** a network other than a Mobile Node's Home Network to which the Mobile Node is currently connected.
14. **Visitor List;** the list of Mobile Nodes visiting a Foreign Agent.
15. **Mobile Binding;** the association of Home Network with a Care-of-Address, along with the remaining lifetime of that association.

3.3. Operation of Mobile IP

Mobile IP is; in essence a way of doing the following three relatively separate functions; Agent Discovery, Registration and Tunneling [15,16].

3.3.1. Agent Discovery

The discovery process in Mobile IP is very similar to the router advertisement process defined in Internet Control Message Protocol (ICMP). For the purpose of discovery a router or other network node that can act as an agent periodically issues a router advertisement ICMP message with an advertisement extension. Figure 1 shows a general Abstract format for the Mobile IP Agent Advertisement Message. The router advertisement portion of the message includes the IP address of the router. The advertisement extension includes additional information about the router's role as an agent. A Mobile Node listens for these agent advertisement messages. The Mobile Node must compare the network portion of the router's IP address with the network portion of its own Home Network. If these network portions do not match, then the Mobile Node is on a Foreign Network [15,16].

ICMP router Advertisement	Agent advertisement extension	Optional prefix- length extension

Figure 1 General Mobile IP agent advertisement message

The prefix extension that follows the agent advertisement extension is used to indicate the number of bits of network prefix that apply to each router address listed in the ICMP router advertisement portion of the Agent advertisement

3.3.2. Registration

Once a Mobile Node has recognized that it has transferred on a Foreign Network and has acquired a Care-of-Address, it needs to alert a Home Agent on its Home Network and requests that the Home Agent forwards its IP traffics. The registration process involves four steps as shown in figure 2:

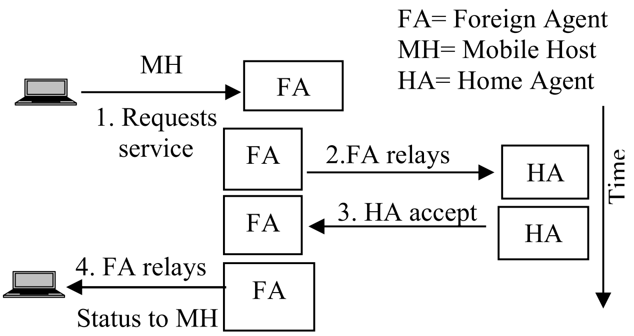


Figure 2 Mobile IP registration overview

1. The Mobile Node requests the forwarding service by sending a registration request to the Foreign Agent that the Mobile Node wants to use.
2. The Foreign Agent relays this request to the Mobile Node's Home Agent.
3. The Home Agent either accepts or denies the request and sends a registration reply to the Foreign Agent.
4. The Foreign Agent relays this reply to the Mobile Node.

If the Mobile Node uses a Co-located Care-of-Address; it registers directly with its Home Agent, rather than going through a Foreign Agent. The registration process involves two steps:

1. The Mobile Node sends a registration request to the Home Agent.
2. The Home Agent sends a registration reply to the Mobile Node that grants or denies the request.

Mobile IP registration messages use User Datagram Protocol (UDP). The overall data structure of the registration messages is shown in figure 3 [15-16].

IP Header fields	UDP header	Mobile IP message header	Extensions…

Figure 3 General Mobile IP registration message format

3.3.3. Tunneling

Once a Mobile Node is registered with a Home Agent, the Home Agent must be able, to intercept IP datagrams sent to the Mobile Node's Home Network so that these datagrams can be forwarded via tunneling.

In the most general tunneling case; illustrated in figure 4; the source, the encapsulator, the decapsulator and the destination are separate nodes. The encapsulator node is considered the entry point of the tunnel, while the decapsulator node is considered the exit point of tunnel. Multiple source-destination pairs can use the same tunnel between the encapsulator and decapsulator [15-16].

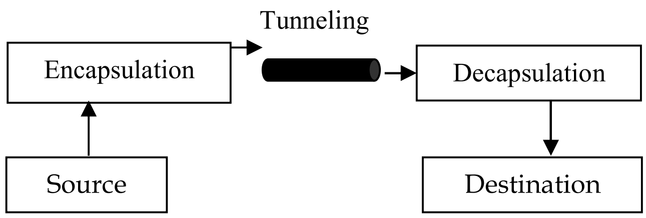


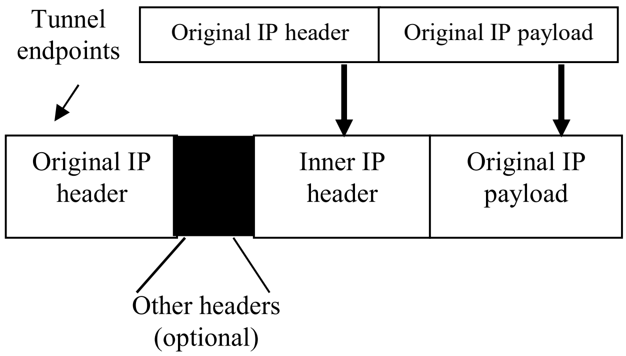
Figure 4 General tunneling

Three options for encapsulation (tunneling) are available for use by the Home Agent on behalf of the Mobile Node.

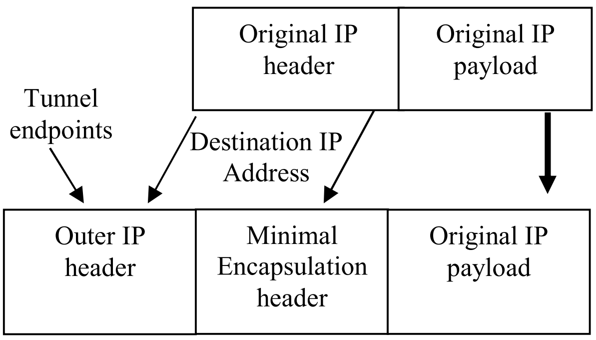
1. **IP-In-IP Encapsulation;** To encapsulate an IP datagram, an outer IP header is inserted before the datagram's existing IP header, as shown in figure 5.a. The outer IP header source address and destination address identify the endpoints of the tunnel. The inner IP header source address and destination address identify the original sender and recipient of the datagram respectively. The inner IP header is not changed by the encapsulator, and remains unchanged during its delivery to the tunnel exit point.
2. **Minimal Encapsulation;** To encapsulate an IP datagram using minimal encapsulation, the minimal forwarding header is inserted into the datagram, as shown in figure 5.b The IP header of the original datagram is modified and the minimal forwarding header is inserted into the datagram after the IP header,

followed by the unmodified IP payload of the original datagram (for example, transport header and transport data). No additional IP header is added to the datagram.

3. **General Routing Encapsulation (GRE);** GRE is more general than the other protocols described earlier. It can encapsulate numerous other protocols besides IP. The entire encapsulated packet has the form presented in figure 5.c.



(a) IP-In-IP Encapsulation



(b) Minimal Encapsulation

Delivery Header	GRE Header	Packet Payload

(c) General Routing Encapsulation

Figure 5 Types of encapsulation

3.4. Mobile IP Operation Sequence

With the three relatively separated functions, Agent Discovery, Registration and Tunneling, a rough outlines of the operation of Mobile IP Protocol is described as shown in figure 6 [5].

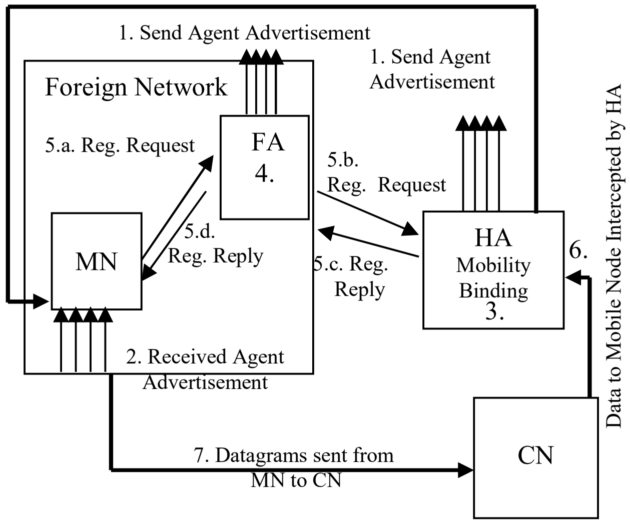


Figure 6 Mobile IP operation sequence

1. Mobility agents (Foreign Agents and Home Agents) advertise their presence via agent-advertisement messages. A Mobile Node may optionally solicit an agent advertisement message from any local mobility agents by using an agent solicitation message.
2. A Mobile Node receives an agent advertisement and determines whether it is on its Home Network or a Foreign Network.
3. When the Mobile Node detects that it is located on its Home Network, it operates without mobility services. If returning to its Home Network from being registered elsewhere, the Mobile Node deregisters with its Home Agent through a variation of the normal registration process.
4. When a Mobile Node detects that it has moved to a Foreign Network, it obtains a Care-of- Address on the Foreign Network. The Care-of-Address can either be a Foreign Agent Care-of- Address or a Co-located Care-of- Address.
5. The Mobile Node, operating away from home, then registers its new Care-of- Address with its Home Agent through the exchange of a registration request and registration reply message, possibly by way of a Foreign Agent.
6. Datagrams sent by the Correspondent Node to the Mobile Node's Home Network are intercepted by its Home Agent, tunneled by the Home Agent to the Mobile Node's Care-of- Address, received at the tunnel endpoint (either at a Foreign Agent or at the Mobile Node itself), and finally delivered to the Mobile Node.
7. In the reverse direction, datagrams sent by the Mobile Node may be delivered to their destination using standard IP routing mechanisms, without necessarily passing through the Home Agent.

3.5. Security in Mobile IP

Security is an increasing concern in the design of mobile networking protocols and systems [17,18,19]. Authentication is critical to authorizing operations indicating the Mobile Node's new point of attachment.

The three common security measures in today's Internet that affect the mobile networking are:

1. **Firewalls;** The existence of firewalls is an unfortunate reality in today's Internet. Firewalls perform the function of discriminating against IP datagrams transiting the enterprise's border routers to protect the computing assets of the enterprise against attack by the millions of Internet computers not associated with the enterprise [15,16].
2. **Border Routers;** Border routers can be configured to discard incoming datagrams that seem to emanate from internal computers. The philosophy is to prevent computers in the external Internet from spoofing (using the address of) internal computers [15,16].
3. **Ingress Filtering;** It has recently been proposed that border routers at the periphery of an administrative domain (for instance, supporting an Internet Service Provider) carefully discard datagrams that seem to emanate from an address external to the administrative domain. This feature is called ingress filtering [15,16].

4. Triangle Routing Problem

One of the basic problems facing the implementation of Mobile IP is the Triangle Routing Problem, since all the traffics between Correspondent Node and Mobile Node should have to pass through a longer path than the normal one. This section introduces the definition and the drawbacks for the Triangle Routing Problem, also it details some recent papers for Route Optimization scheme.

4.1. Triangle Routing Definition

Triangle Routing Problem is considered as one of the problems facing the implementation of Mobile IP. When a Correspondent Node sends traffics to Mobile Node, the following sequence must be done:

1. Packets first get the Home Agent.
2. Home Agent encapsulates these packets and tunnels them to the Foreign Agent.
3. The Foreign Agent de-tunnels the packets and delivers them to the Mobile Node.

As shown in figure 7, the route taken by these packets is triangle in nature, and the most extreme case of routing can be observed when the Correspondent Node and Mobile Node are in the same subnet [7, 16].

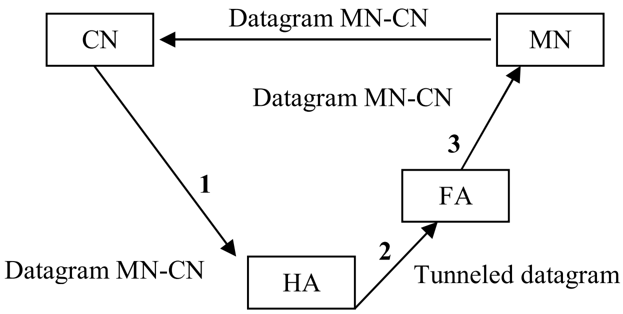


Figure 7 Illustration of the triangle routing problem in mobile IPv4

4.2. Triangle Routing Drawbacks

Conventional Mobile IP scheme allows transparent interoperation between Mobile Nodes and their Correspondent Nodes, but forces all datagrams for a Mobile Node to be routed through its Home Agent. Thus, datagrams to the Mobile Node are often routed along paths that are significantly longer that optimal. This indirect routing can significantly delay the delivery of the datagrams to Mobile Nodes, and it places an unnecessary burden on the networks and routers along its path through the internet. So we can summarize the Triangle Routing drawbacks as follow:

1. Increases the delays per packet in datagrams transferred to the Mobile Node.
2. Waste of network resources.
3. Home Agent bottle neck.
4. Delimits the scalability of Mobile IP protocol.

5. Triangle Problem's Previous Solutions

There have been attempts to eliminate or address the Triangle Routing Problem in Mobile IP [7,8,9,10,11,12,13,14]. This section introduces some of recent attempts dedicated for solving the Triangle Routing Problem [7,8,9,10].

5.1. Route Optimization by Forward Tunneling and Binding Cache

Route Optimization Protocol in figure 8 was developed to solve the Triangular Routing Problem, by allowing each host to maintain a binding cache for a mobile host wherever it is. When sending a packet to a Mobile Node, the following sequence must be taken:

1. If the sender has a binding cache containing the Care-of-Address of the Mobile Node, it will deliver the packets directly towards the Mobile Node.
2. If the sender has no binding information the first packets should be destined at first to the Home Agent.

3. Home Agent encapsulates the packets and send them to the Foreign Agent.
4. Foreign Agent decapsulates the packets and send them to the Mobile Node.
5. Binding information is transferred from the Home Agent to the source node for the further correspondences in the future, such that the next packets should be routed directly to the Foreign Network.
6. If Mobile Node sends packets to the source node, the packets will be transferred directly form the Mobile Node to the source node.

This Route Optimization scheme provides a smooth handoff when the Mobile Node moves and registers with a new Foreign Agent [20,21]. It provides a means for the previous Foreign Agent to be notified of the Mobile Node's new mobility binding allowing data grams in flight to the Mobile Node's Foreign Agent to be forwarded to its new Care-of-Address as shown in figure 9.

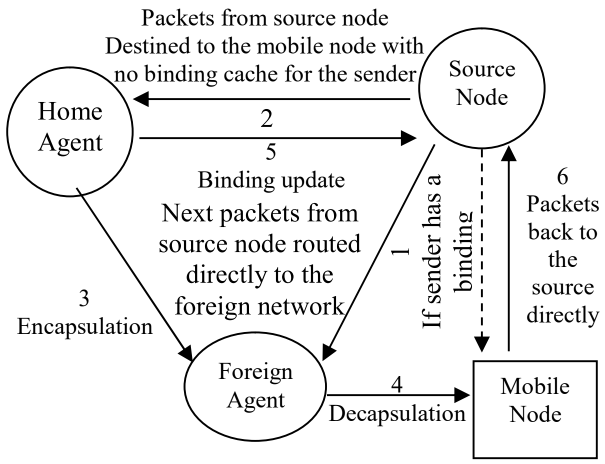


Figure 8 Route optimization

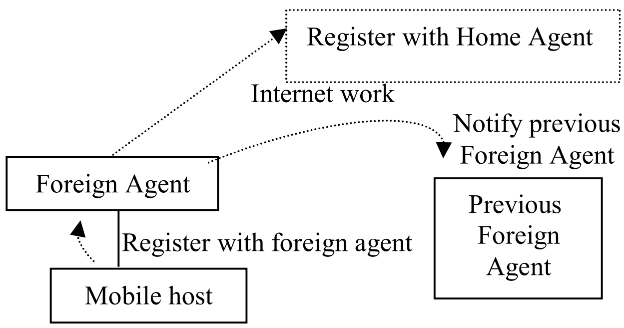


Figure 9 Smooth handoff during registration

As a result of simulation comparison between the original Mobile IP scheme and the improved scheme using Forward Tunneling and Binding Cache. It has been proved that, the transmission time (delay) between the Correspondent Node and the Mobile Node is reduced because of the shortest path to reach the Mobile Node. The traffic and control signals over the network have been decreased [7].

5.2. Route Optimization Using Dynamic Address Allocation in Mobile IP

This technique proposes an extension to the Mobile IP architecture. In this scheme one Mobile Station is to handle two IP addresses between internet and intra-domain, one is called Current Address and another one is called Register Address. Location Agent is a router responsible for translating both addresses between internet and intra-domain. Register Address is used for packets routing in internet; Current Address is used for packets in intra-domain. Mobile Agent is router on a Mobile Station's current network which delivers packets to Mobile Station, it has a functionality similar to FA and HA.

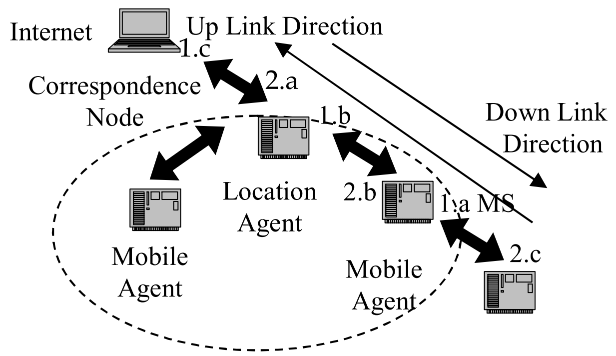


Figure 10 Dynamic allocation mobile IP architecture

Considering a packets routing scheme between MS and CN, the packets downlink and uplink of the proposed architecture are described in figure 10 as following:

1. When a MS sends a packet to CN, the packet routed first to LA by using Current Address. When LA receives packet, it will use the Current Address of MS to check relative address of MS. LA uses the Register Address instead of Current Address and retransmits the packet to CN. This sequence is called packet Up Link sequence.
2. In case of packet Down Link, when a CN sends a packet to MS, the packet is routed to LA by using Register Address first. When LA receives the packet, it will use the Register Address of MS to check the relative Current Address of MS. LA uses the Current

Address instead of Register Address and retransmits the packet to MS.

Hard handoff scheme is proposed to be used with this technique. Also a "packet retransmission" scheme is used to avoid packet loss while hard handoff, in which every MA should have a buffer to store the downlink packets transmitted to MS. After MS handoff, old MA would retransmit packets which are stored in its buffer to new MA which delivers them to MS.

By evaluating the performance comparison between the Mobile IP scheme and the dynamic address allocation scheme, it has been found that the transmission time taken between the CN and MS takes a longer Downlink path in case of Mobile IP scheme than the dynamic allocation scheme in which the transmission time equal to the time taken between the CN and MA plus the time taken between MA and MS. Also the traffic would increase obviously in the Mobile IP scheme. Comparatively, Dynamic Allocation Scheme would not increase any extra traffic [8].

5.3. Bi-directional Route Optimization in Mobile IP over Wireless LAN

This technique is proposed to support symmetric bidirectional route optimization in Mobile IP considering ingress-filtering routers [22]. Subnet-based direct tunneling techniques are proposed to improve the routing efficiency for Mobile IP and a binding optimization technique to reduce the handoff latency for Mobile Nodes. An enhanced correspondent agent was introduced to collaborate with the Home Agent and the Foreign Agent to support these techniques. Figure 11 presents the overall design of the bidirectional route optimization. It is used to address the issues of Triangle Routing and ingress filtering in Mobile IP.

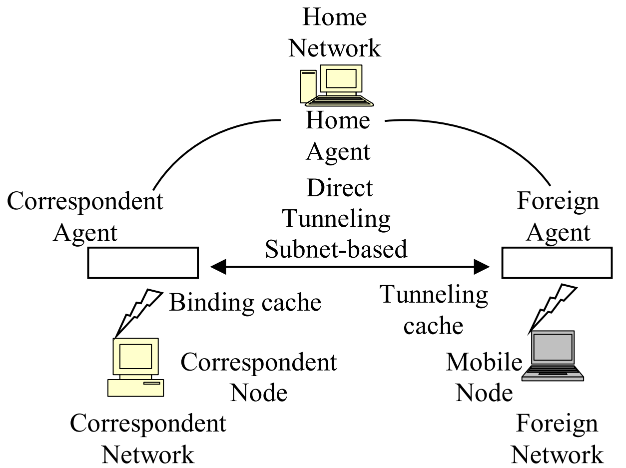


Figure 11 Architecture of bi-direction route optimization

The design introduces a Correspondent Agent which maintains the binding cache and intercepts all packets sent to and from the Correspondent Nodes.

Symmetrically, a Foreign Agent, at the other end of the optimized route or tunnel, maintains a tunneling cache for bidirectional route optimization. An entry of the tunneling cache indicates that a Correspondent Node or Correspondent Network supports Route Optimization and direct tunneling, so a Foreign Agent can directly tunnel a packet received from a Mobile Node to the Correspondent Node that matches a tunneling cache entry. So a Home Agent or a Foreign Agent must be able to distinguish the traditional Correspondent Node from the enhanced Correspondent Agent, and the enhanced Correspondent Agent must also be able to distinguish a Mobile Node from a usual Stationary Node.

From the preliminary results of the simulation over a Wireless Local Area Network (WLAN) it has been found that; using Bi-directional route optimization not only improves the routing efficiency but also reduces the handoff latency for Mobile Node. Also the packet transmission time and the traffic can also be reduced through direct tunneling. Further simulation is under development [9].

5.4. Route Optimization Using Internet Service Provider Points of Presence ISP PoPs

The basic idea in optimizing Triangle Routing is to get the HA as close as possible to the MN, when the MN no longer in its Home Network. This is achieved by shifting the Home Agent into the ISP's Domain. The ISP's network can be made Mobile IP "aware" by enhancing ISP Points of presence (PoPs) and by creating a virtual network composed of PoPs to distribute the state information about the MN at the original HA to all PoPs. This ensures that no matter where the MN is, the HA is just a PoP away [10]. Figure 12 offers a simplistic view of a global network showing the position of CN, MN, PoP1. PoP2, PoP3 and ISP.

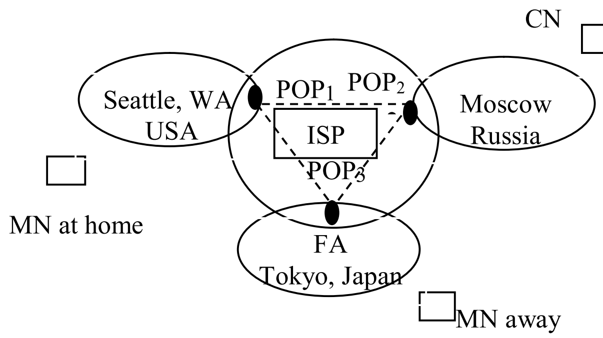


Figure 12 Simplistic view of a global network

The following paragraphs describe events that occur in order to set up the stage for successful CN to MN communication.

1. Registration with the HA

- The MN registers with the closest HA, in this case, PoP_1
- PoP_1 informs PoP_2 and PoP_3 about MNs intent to be mobile through the PoPs Virtual Network (PVN) as shown in figure 13.a (based on figure 12).

2. Registration with the FA

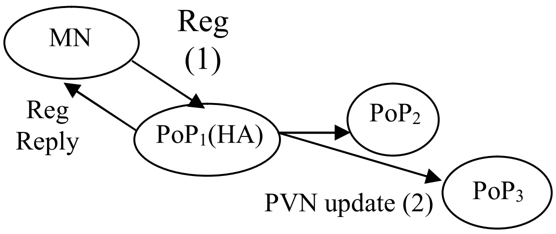
- The MN registers with the FA, seeking mobile services in the new network.
- The FA gets in touch with the nearest HA, in this case PoP_3 in order to authenticate the MN.
- PoP_3 now knows that to reach the MN, it only needs to reach the FA. So it creates an explicit routing entry mapping the MN address with the FA address. PoP_3 broadcasts this information to all other PoPs, so that they may also do the same as shown in figure 13.b (based on figure 12).
- On receiving a successful reply for the MN authentication message, the FA creates an association between the original MN address and its current point of attachment in the subnet. It uses this association to replace the destination IP address in incoming packets with the current point of attachment address. Similarly, the source address in outgoing packets from the MN is replaced with the original MN address.

3. CN needs to communicate with MN;

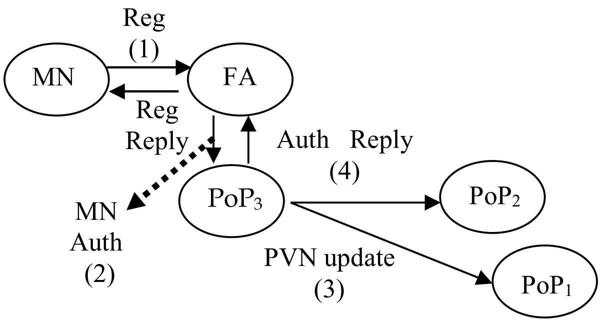
- Packets addressed to the MN's address can be routed by PoP_3, since it has an explicit routing destination (FA) for such packets.
- Normal Internet routing gets these packets to the FA, where a destination address swapping occurs, in which the original MN address is swapped with its Current Address.
- The IP protocol stack at the MN can now receive the packets originally destined for the MN address.

4. MN gets back to its Home Network;

- The MN de-registers with the closest HA, in this case PoP_1.
- PoP_1 informs its peers, and all state information regarding the MN is purged.
- FAs purge their associations based on the lifetime of the association.



(a) HA registration



(b) FA registration

Figure 13 HA and FA registration with PVN update messages

As the result of simulation comparison applied between the two approaches, the Conventional Mobile IP framework and the new proposed Mobile IP framework. It has been found that applying the new framework for Mobile IP is best suited to large ISPs with a large topological reach. It increases the TCP throughput to MN by almost double that in that traditional Triangle Routing case. Also the transmission time (delay) has been reduced through the new framework.

5.5. Previous Route Optimization Schemes Drawbacks in Mobile IP

The great effect of using the Route Optimization schemes is to minimize the transmission time (delay) between Correspondent Node and Mobile Node because of the shortest path to reach Mobile Node and also to reduce the traffic and control signals over the network. The drawbacks of the most Route Optimization techniques are classified as follows:

1. Rigid requirements for an authentication of the clamed Care-of-Address especially when both of Mobile Node and Correspondent Node are in a different IP networks.
2. Expensive hardware devices needed for the Route Optimization functions.

3. Increase the amount of traffics over the network.
4. Increase the rate of buffering and storage buffers.
5. Increase the rate of blocking especially when the number of connections to Mobile Nodes is increased which results in increasing in the transmission time between Correspondent Node (CN) and Mobile Node (MN).

6. Conclusions and Future Work

In this paper we introduced the definition, the operation and the security in Mobile IP Protocol. The discussion includes the three main functions for the Mobile IP operation; Agent Discovery, Advertisement and the Tunneling Procedures. A description for the Triangle Routing Problem in Mobile IP plus some recent researches with their drawbacks has been discussed. Forward Tunneling, Dynamic Agent Allocation, Bidirectional Route Optimization and the Internet Service Providers Points-of-Presence (ISP PoPs) were proposed as recent researches that provide a solution for the Triangle Routing Problem in conventional Mobile IP Protocol.

In future work, we shall introduce a new route optimization scheme for solving the triangle routing problem in conventional Mobile IP protocol. This scheme will be proposed to recover most of the drawbacks for the previous route optimization schemes. The design of this scheme is based on using a number of Internet Service Providers separated by a multiple Mobile IP Border Gateways (MBGs) which are used to keep the binding information or the home information for the transferred Mobile Nodes between Internet service Providers (ISPs). Each ISP is composed of an approximately a number of an equal areas and each area is served by an agent and composed of a multiple equal zones, each zone is served by a definite number of Points-of-Presence (PoPs). Each PoP serving a number of nodes with a range of address. A Virtual Networks are used to connect the PoPs in such a way the redundancy in keeping the nodes information will be minimized or almost cancelled. The main objectives of the newly proposed scheme is to get the shortest routing path for the packet transferred between the Correspondent Nodes and Mobile Nodes, increase the level of authentication, decrease the hardware devices needed, decrease the amount of traffic over the network and finally decreasing the rate of buffering and blocking especially when the number of connections to Mobile Nodes are increased.

7. References

1. Clint Smith and Daniel Collins, "*3G Wireless Networks*", "McGraw-Hill, United States, 2002.
2. Abbas Jamalipour, "*The Wireless Mobile Internet*", John Wiley & Sons Ltd., England, 2003.
3. Philip J. and Nesser II, "S*urvey of IPV4 Addresses in Currently Deployed IETF standards*", Internet-drafts, draft-ietf-ngtrans-ipv4 survey-01.text, work on progress, August 2001.
4. Seong Gon Choi, Rami Mukhtar, Jun Kyun Choi, and Moshe Zukerman, "*Efficient Marcro Mobility Management for GPRS IP Networks*", Optical Internet research center (OIRC), Korea, May 2002.
5. William Stallings, "*Wireless Communications and Networks*", prentice Hall, New Jersey, United States, 2002.
6. Toni Janevski, "*Traffic Analysis and Design of Wirless IP Netowrks*", Artech House Inc., Boston, London, 2003.
7. C. Perkins, "*IP Mobility Support for IPV4*", RFC 3344, work on progress, August 2002.
8. Wei Wu, Wen-Shiung Chen, Fong-Rey Young and Ho-En Liao, "*Dynamic Address Allocation in Mobile IP*", Nov. 1999.
9. Chun- Hsin Wu, Ann – Tzung Cheng, Shao – Ting Lee, Jan-Ming Ho and Der – Tsai Lee, "*Bi-directional Route Optimization in Mobile IP Over Wireless LAN*", Institute of Information Science, Academia Sinica, Taiper, Taiwan, 2002.
10. "*An Efficient, Global Mobile IPV4 Routing Frame Work using Internet Service provider, Point of Presence ISP, PoP*, http:\\networks.ecse.rpi.edu/papers/mip.pdf.
11. Kumar C., Tyagi N., Tripathi R., "*Performance of Mobile IP with new Route Optimization Technique*", IEEE International Conference, PP. 522-526, 23-25 Jan. 2005.
12. Badami D., Thanthry N., Best T., Bhagavathula R., Pendse R., "*Port Address Translation based Route Optimization For Mobile IP*", Vehicular Technology Conference, IEEE 60th, Vol. 5, PP. 3110-3114, 26-29 Sept. 2004.
13. Vadali R., Jianhui Li, Yiqiong Wu, Guohong Cao, "*Agent based Route Optimization For Mobile IP*", Vehicular Technology Conference, IEEE VTS 54th,Vol. 4, PP. 2731-2735, 7-11 Oct. 2001.
14. Qiang Gao, Acampora A., "*A Virtual Home Agent based Route Optimization for Mobile IP*", Wireless Communication and Networking Conference, IEEE, Vol. 2, PP. 592-596, 23-28 Sept. 2000.
15. Charles E. Perkins "*Mobile IP*", IEEE, 50th Anniversary Communicative Issue, PP. 66-82. May 2002.
16. Charels E. Perkins, "*Mobile IP: Design Principles and Practices*", Addison-Wesley, United States, 1998.
17. S. Vaarala, "*Mobile IPV4 Traversal Across. IPSec Based VPN Gateways*", Internet- drafts, ietf-mobile ip-vpn-problem-solution-02, work on progress, June 2003.
18. Horri Hansen, "*IPSec and Mobile IP in Mobile Ad-Hoc Networking*", Department of Computer Science and Engineering, Helsinki University of Technology, April 2000.
19. J. Arkko, V. Devarapali and F. Dupont, "*Using IPSec to Protect Mobile IPV6 Signaling between Mobile Node and Home Agents*", Internet- drafts, ietf-mobile ip-mipv6-ha-ipsec-03.txt, work on progress, February. 2003.
20. Babak Ayani, "*Smooth Handoff in Mobile IP*", Master Thesis, University of California in Berkeley, May 2005.

21. Tom Hiller, James Kempt, Peter J. Mccann, Ajoy Singh, Hesham Soliman, and Sebstian thalanany, "*Low Latency Handoffs in Mobile IPV4*", Internet-drafts, ietf-mobileip-low laterncy-handoffs-v4-05. txt, work on progress, December 2003.
22. G. Montenegro, "*Reverse Tunneleng for Mobile IP*", RFC 3024, work on progress, January 2001.