The Implementation of Mobile Internet Protocol in Local Area Network

Dr. Norsheila Fisal, Lee Soon Ho, Yazid Mohamed
Telecom Laboratory
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
81300 Sekudai, Johor, Malaysia.
Lee@telekomlab.fke.utm.my

Abstract- **Mobile Internet Protocol (IP) is a new recommended Internet protocol designed to support the mobility of a user. 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. This paper is concerning the implementation of Mobile IP in local area network (LAN).**

I. INTRODUCTION

In telecommunications, it is now possible to stay connected to the existing telephone network while on the move. We can use hand-phone to communicate with others no matter where we are. We would like to have similar mobility support for the Internet as well using laptop computer. That is, we would travel with laptop computers on planes, trains and ships and yet still remain connected to the Internet. Cellular telephone technology (which is also a radio frequency technology) is also of interest to mobile computer users. That is, now we can use cellular phone to call Internet Service Provider (ISP) to provide mobile Internet to laptop computer, but it is unacceptable and too costly for LAN user. It is because the mobility services rely on the Telephone Company to maintain connectivity and usually we have to pay a substantial premium for that service. In contrast, if we can use radio or infrared that attach to our LAN, they are typically made without charge, as long as the LAN administrator is willing to accommodate the user's wireless link [1]. But, there are still some problems with the existing Internet to support mobility host. Fortunately, over the past few years, the problems have been significantly reduced, both theoretically and practically. A new protocol called Mobile IP is recommended by IETF (Internet Engineering Task Force) in order to provide mobility in LAN using existing Internet Protocol. This paper is concerning the mechanism and also the implementation of Mobile Internet Protocol [2] in LAN.

II. EXISTING IP

In order to allow mobility in Local Area Network, we have to analyze the existing Internet Protocol in order to overcome the problem thereafter cause by the implementation of mobility host, as the existing IP does not support mobility. The detail is discussed below.

The Internet Protocol that is currently used is called IP version 4 (IPv4). IPv4 assumes that a node's IP address uniquely identifies the node's point of attachment to the Internet. Therefore, a node must be indicated by its IP address in order to receive packets destined to it; otherwise, packets destined to the node would be undeliverable. Packets destined to the unique IP address is routed based on the network-prefix. Network-prefix routing requires all nodes on the same link to have the same network-prefix portion of their IP addresses. For example, IP addresses from 1.0.0.1 to 1.0.0.254 are allowed to attach to 1.0.0 network prefix (length 24 bits), but not other network-prefix like 2.0.0.

Thus, when a node moves from one link to another, minimally the network-prefix portion of its IP address must be changed to reflect the network-prefix that has been assigned to the new link. That is, a node has to change its IP address whenever it changes its point of attachment in order to maintain the connectivity. For example, IP address 1.0.0.1 has to change to 2.0.0.1 when it changes its attachment to (or move to) 2.0.0 network-prefix. But this will make the connection lost as IPv4 transport-layer protocols, TCP and UDP require constant IP address to maintain connectivity. Thus we unable to implement mobility to our existing IP by changing node IP address.

Although host-specific routes can be consider as a possible solution to enable host mobility, but we are not going to discuss selecting hosts-specific routes as one of the possible solution here. It is because the hosts-specific routing has severe scaling, robustness, and security problems, which make it an unacceptable solution to node mobility in the global Internet [3].

Thus it is clear that our current Internet protocol versions 4 do not support host mobility. IPv4 is designed such that moving hosts were not considered, that is, it assumes that a node's point of attachment to the network remains unchanged at all times. In order to make the existing IP to support host mobility, we need to implement Mobile IP.

III. MOBILE IP

Mobile IP is an Internet protocol designed to support host mobility. Mobile IP is a solution for mobility on the global Internet, which is scalable, robust, secured and allows nodes to maintain all ongoing communications while changing links. Specifically, Mobile IP provides a mechanism for routing IP packets to mobile nodes, which may be connected to any link while using their permanent IP. Mobile IP solves the primary problem of routing IP packets to mobile nodes in network-layer, which is enormous first step in providing mobility on the Internet. However, a complete mobility solution would involve enhancements to other layers of the protocol stack as well.

As a network-layer protocol, Mobile IP is completely independent from the support of any media. That is, it does not matter whether the computer is connected via radio LAN, infrared, wireless telephone or indeed whether the computer is hooked up directly to an Ethernet or token ring network [1]. A mobile node employing Mobile IP can move from one type of medium to another without losing connectivity.

In the design and implementation of Mobile IP, the mobile node, must be able to communicate with other nodes after changing its link-layer point of attachment to the Internet, without changing its IP address. It also must be able to communicate using only its home (permanent) IP address, regardless of its current link-layer point of attachment to the Internet. Most important here is.mobile node must be able to communicate with other computers that do not implement the Mobile IP mobility functions. This is to make sure Mobile IP can be implement without affecting the existing network and can be implement everywhere.

IV. THE ENTITIES AND OPERATIONS OF MOBILE IP

Mobile IP defines three functional entities where its mobility protocols must be implemented:

1. Mobile Node (MN) – a node which can change its point-of-attachment to the Internet from one link to another while maintaining any ongoing communications and using only its permanent IP home address.
2. Home Agent (HA) – a router with an interface on the MN home link which the MN keeps informed of its current location when MN moves from link to link. It intercepts packets destined to the MN home address and tunnels them to the MN current location.
3. Foreign Agent (FA) – a router on a MN foreign link, which assists a locally reachable MN that, is away from its home network. It delivers packets between the MN and HA.

Below is a simple diagram illustrates these entities and shows their relationship [3].

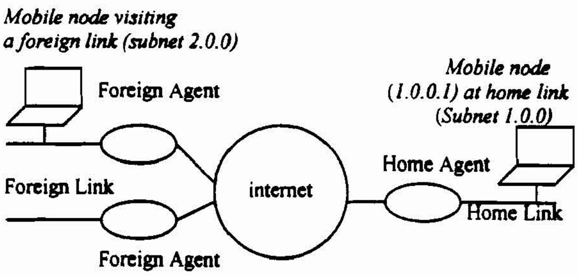

Figure 1: Mobile IP entities and relationships

Now we are going to discuss briefly on the operation of Mobile IP. From figure 1, while MN at home, it is on its home link. Therefore, MN can easily receive or send packets on this location, since all the packet that is destined to MN will directly reach MN through its home link.

When MN (with permanent IP) moves to foreign link as shown in figure 1 (location 2), MN is connected to wrong subnet prefix for the destined subnet. This is because MN with IP 1.0.0.1 from subnet 1.0.0 is actually attached to a subnet with routing-prefix 2.0.0, which do not comply with the requirement. Hence, no packet will reach MN through the foreign link. Here is where the Mobile IP is going to function and maintain MN communication to the Internet as discussed below.

First of all, mobility agents (HA and FA) will advertise their presence via Agent Advertisement. The advertisements are to inform MN which HA and FA is available in the network. If no advertisement is received, our MN will send Agent Solicitation to ask Agent Advertisement from FA through the network. After MN receives these advertisements and it will determine whether it is on its home subnet (161.139.118) or foreign subnet (192.168.100).

The MN, in figure 1, which detects it has moved to a foreign subnet, will obtain a care-of-address of the foreign subnet from FA advertisements. From the care-of-address, the current location of MN can be determined. After that, the MN will send Registration Request through port 434 (default port for Mobile IP) in UDP format, to register its care-of-address with its HA, via FA. HA will send Registration Reply to MN too via FA. The whole signaling process is shown in figure 2. If there are no error for the whole process, then we can say that the connection for Mobile IP now is successfully setup. HA knows where the MN is located and FA knows the MN is connected to its subnet.

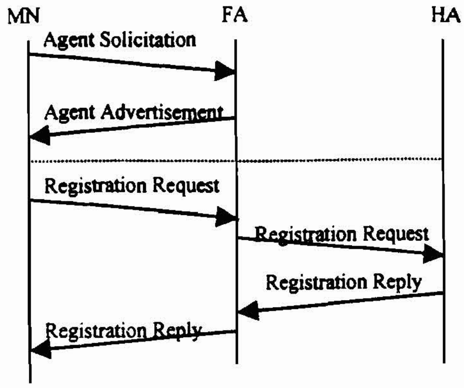

Figure 2: Mobile IP signaling

If someone is sending packets to MN (1.0.0.1), the packets will go to 1.0.0 subnet. HA will intercept the packets, as it knows MN now is away and located in foreign subnet (2.0.0). HA will tunnel (IP in IP encapsulation) the packets to the FA by using the care-of-address as shown in figure 3. When the packets reached FA, FA will remove the original packets from the tunnel (decapsulation) and deliver the original packet to the MN over the foreign link.

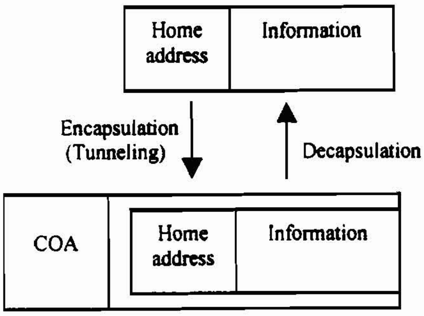

Figure 3: Encapsulation and Decapsulation

V. THE HARDWARE AND SOFTWARE

In order to implement and test Mobile IP in LAN, we setup HA, FA, MN and a router. The router is to setup 2 different subnet (home link and foreign link) for our configuration. The hardware we used here is 3 PCs with 166Mhz Intel Pentium Processor and 32M Ram. This 3 PCs are used to setup router, HA and FA. PC with 200Mhz Intel Pentium Processor and 64M Ram is used for MN. 5 Ethernet cards is used here, 2 Ethernet cards for router, and each HA, FA, and MN takes 1 Ethernet card. We initially use PC instead of laptop computer for MN. Laptop computer with WaveLAN card that supports mobility (in radio frequency) will be implemented in our system later.

The Operating System (OS) chosen here is Linux - Red Hat version 6.1. We installed the Linux OS in all the 4 PCs mentioned above. The kernel for Red Hat 6.1 is 2.2.12-20. We faced some problems here as 2 of our PCs that using Alliance Promotion VGA card is not fully supported in Linux OS. We have problem running the X windows in the PCs.

After that, we configure the Router for 2 different subnet, that is 161.139.118 (prefix 24) and 192.168.100 (prefix 24). We configure the IP for the Ethernet card 0 (eth0) as 161.139.118.164 for 161.139.118 network; and Ethernet card 1 (eth1) as 192.168.10.1 for 192.168.100 network. Subnet 161.139.118 is connected to UTM LAN, but subnet 192.168.100 is an isolated network. It is shown in figure 4.

Then we used the Dynamics Mobile IP (version 6.1) software [4] from Helsinki University of Technology to implement the Mobile IP. The Dynamics Mobile IP solution is chosen because it runs entirely on user space, so no implementation specific kernel patches are needed. We compiled and installed the software in HA, FA and MN. We also enabled IP forwarding in FA and HA. We added kernel options (advanced router and policy routing) for FA. Then we configure IP address for both kernel and Dynamics program. The IP for both kernel and program must be equal. That is HA as 161.139.118.170, FA as 192.168.100.2 and MN as 161.139.118.156. IP for the kernel is set through command "linuxconf". The IP for the program is set through editing the dynhad.conf configuration file for HA, dynfad.conf configuration file for FA, and dynmnd.conf configuration file for MN. We enable Triangle Tunneling and Reverse Tunneling.

MN, HA and FA only has 1 interface. Although we tried to make the Router and HA in the same PC, but it does not work. It is because the IP address for the kernel unable to match the IP for the Dynamics Mobile IP. The IP for both kernel and program must be equal.

Our testbed configuration is shown below:

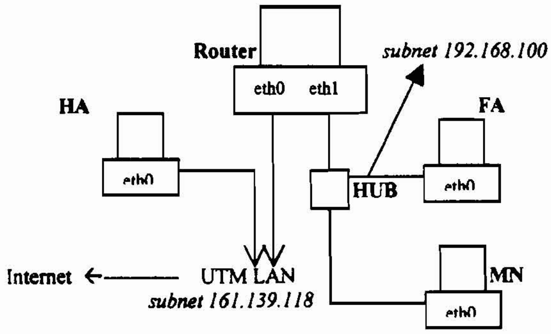

Figure 4: Mobile IP testbed configuration

VI. MOBILE IP IN LAN

Now, we are going to discuss the methods we used in testing the Mobile IP in our LAN. First of all, the communication while MN is at home was tested. The configuration is as shown in figure 5. Before testing the MN communication, first, the Router used in communicating 2 different subnet was checked as explained subsequently. FA was trying to ping from HA, and HA was trying to ping from FA. We found well.

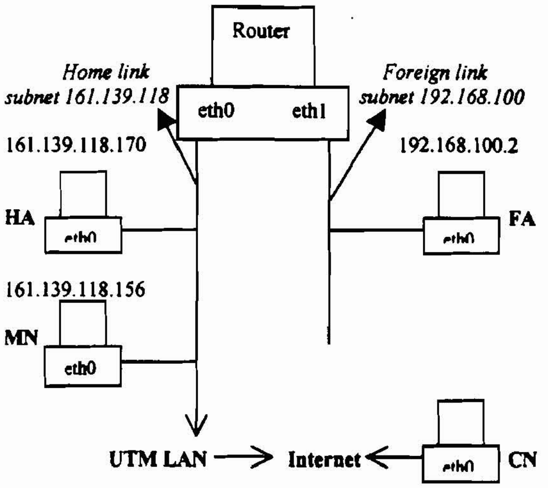

Figure 5: MN on its Home Link

After that, the Dynamics Mobile IP program for MN, HA and FA was executed. From the HA and FA screen, we know that HA and FA was sending Agent Advertisements to their link continuously (we set it every 30 seconds). MN received HA advertisements because it was attached to home link. This can be proved from the MN screen, which tell that MN is at home and received advertisements from HA.

A new PC (Correspond Node, CN), which is connected to Internet with IP 161.139.80.53, was used to test the MN communication to global Internet. From our observation, we found that MN can be ping from CN, and CN can be ping from MN too. This shows that the communication of MN to global Internet is up. Thus we can say that while MN is on its Home link, MN can easily received or send packets (connection is up), as any packet destined to MN will go to 161.139.118 subnet and then MN (161.139.118.156).

After that, as our second step, communication while MN on foreign link was tested. The MN (with permanent IP) was moved to foreign link as shown in figure 6. The MN from subnet 161.139.118 was attached to a subnet with routing prefix 192.168.100.

MN was trying to ping from CN, HA and FA, but found that the MN unreachable. This is because when MN moved to foreign link, it was connected to wrong subnet prefix for the destined subnet. This was going to cause problem because no datagrams for network 161.139.118 would arrive on 192.168.100. The MN communication was down.

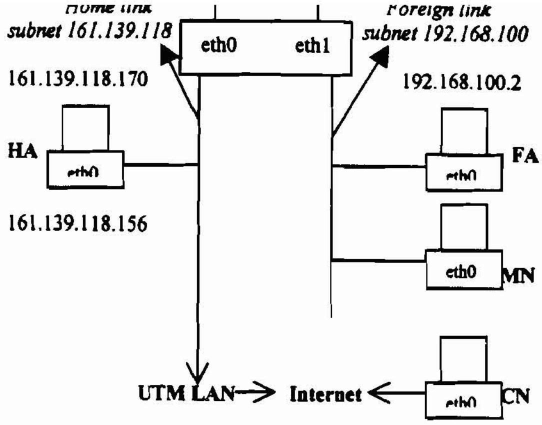

Figure 6: MN on Foreign Link

Next, the MN communication was brought up although it was located on foreign link. This is done as discuss subsequently. The Dynamics Mobile IP program for MN was executed. But, since the Dynamics Mobile IP program for FA was not executed, no Agent Advertisement from FA was sent. From MN screen, we can know that MN could not find FA and thus, Agent Solicitation was sent from MN to solicit FA Agent Advertisement.

Then, the Dynamics Mobile IP program for HA and FA were executed. Agent Advertisements were sent by HA and FA through their links to advertise their presence and inform MN that they were available in the network. But, MN received only the advertisements from FA because it is on foreign link. Advertisement from HA unable to reach MN.

From the FA screen, we know that Registration Request was sent to FA from MN. Then, the FA Registration Request received by FA was forwarded to HA. Registration Reply was sent to FA from HA upon its Registration Request and also to MN from FA upon MN Registration Request. The registration is used to register the care-of-address to FA and HA, which enable HA and FA to determine the location of MN.

After the registration, from HA and FA screen, it shows that FA and HA know the current location of MN. From the MN screen too, it shows that MN know it is connected to HA via FA. Therefore, we can say that the MN communication was successfully setup.

CN was trying to ping from MN (sending packets to MN), and vice versa. We found both could ping to each other and this shows that the communication was up. It is because when the packets from CN went to 161.139.118 subnet, the packets that destined to the MN were intercepted by HA, as it knows MN now is away and located in foreign subnet. Then the packets were tunneled to the FA by using the care-of-address as mentioned above. The original packets were removed from the tunnel when the packets reached FA, and delivered to the MN over the foreign link.

VII. FUTURE WORK

There have been many recent researches to extend Mobile IP to better scale. But none of the research is platform and OS independent. Our future work is to create a Java implementation of Mobile IP that is both platform and OS independent. So the user will face the same user-interface, program design/architecture, and source code (most of it will be the same) even when he/she runs Java Mobile IP on a SUN workstation or on a PC, using either Solaris, Linux or Windows. Java helps to achieve this goal because we can run a Java program on any machine, just as long as it has a Java Virtual Machine on it. Although we can not do Java coding for the platform/OS specific portions such as ARP, routing and tunneling, which will only be a small part of the whole program, but at least it helps in the porting effort. That is, we do not have to rewrite everything from scratch, when we want to program the Java Mobile IP for each new platform/OS.

VIII. CONCLUSION

All of the Mobile IP implementation currently available in the world are just research prototypes, and have a lot of limitations. For instance, none of the Mobile IP implementations allow us to run the FA and the MN on the same machine, which is desirable when it comes to mobile networks/router support. Thus, in spite of creating Java Mobile IP that supports multi-platform and multi-OS, we hope to achieve this goal too by designing from the start that can support such features.

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